Local Sustainability 2

Konrad Otto-Zimmermann *Editor*

Resilient Cities 2

Cities and Adaptation to Climate Change – Proceedings of the Global Forum 2011

ICLEI
Local Governments for Sustainability

Springer

Resilient Cities 2

Local Sustainability

Volume 2

Series Editor: Monika Zimmermann

For other ICLEI publication, go to
http://www.springer.com/series/10034

Konrad Otto-Zimmermann
Editor

Resilient Cities 2

Cities and Adaptation to Climate Change Proceedings of the Global Forum 2011

Springer

I.C.L.E.I
Local Governments for Sustainability

Editor
Konrad Otto-Zimmermann
ICLEI – Local Governments for Sustainability
World Secretariat
Kaiser-Friedrich-Str. 7
53113 Bonn
Germany

ISSN 2211-2782 ISSN 2211-2790 (electronic)
ISBN 978-94-007-4222-2 ISBN 978-94-007-4223-9 (eBook)
DOI 10.1007/978-94-007-4223-9
Springer Dordrecht Heidelberg New York London

Library of Congress Control Number: 2012937995

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword

Preparing for the impacts of climate change on the world's cities, especially in rapidly urbanizing Africa and Asia, is a major challenge of the twenty-first century. It will be those living in poverty who will suffer most in any climate crisis.

The 2011 Resilient Cities Congress stressed that resilience is more than successful climate change adaptation. This is why water, energy, food security and ecosystems are so important in urban areas characterized by high complexity, density and diversity.

Urban planning is an essential instrument to address these related challenges, for which sound vulnerability and risk assessments are essential. In this book of the Congress, we learn that although cities are not waiting to set priorities and create long-term road maps towards resilience, in many cases we are still lacking the sufficient facts and figures on which to base decisions.

The Congress heard from cities as diverse as Lagos, Nigeria; Ho Chi Minh City, Vietnam; Semarang, Indonesia; London, UK – all of which are beginning to find solutions.

All are assessing which communities, places and sectors are most vulnerable. They are investing in climate proofing their infrastructure networks. All are integrating adaptation action in urban planning initiatives and municipal finance scenarios.

Cities are moving from stand-alone plans to building climate adaptation into their ongoing planning, budgeting and infrastructure investments. They focus on smarter land-use planning and building codes as key instruments to pursue resilience.

This book shows how the Congress advanced debate on the need for cities to get their fair share of the adaptation resources pledged – resources cities so desperately need to become more resilient.

It shows a need for new institutional mechanisms to promote local resilience. Local government capacity needs to be strengthened to engage with the private sector, work with academic institutions and harness community knowledge and resources.

The opportunities and challenges are very diverse. Cities are learning to live with rapidly changing conditions.

As a Patron of the 2011 Congress, I would like to congratulate the delegates of the Resilient Cities Congresses with the richness of ideas coming out of this event. I would also like to commend ICLEI for taking the lead in forging the partnership of organizations supporting the Congress.

Dr. Joan Clos
Under-Secretary General United Nations
Executive Director UN-HABITAT

Authors

Carlo Aall holds a master's in nature conservation from the Agricultural University of Norway (1987) and took his Ph.D. at the University of Aalborg in 2002 on the issue of LA21. He has worked at Western Norway Research Institute since 1990.

Beñat Abajo has a bachelor's degree in biological sciences. He works in the Unit of Environment in Tecnalia since 2002, focusing his research on strategic environmental assessment and management, sustainable spatial planning and the application of geospatial technologies to decision support systems through local, regional and European research and innovation projects. From the very beginning, he has been working in the use of ICT applied to the natural environment (Environmental Studies Centre), urban planning (City Council of Vitoria-Gasteiz) and territorial planning (Basque Government). He has also been participating in the development of the research and technological update in the sector of geo-information of the Basque Autonomous Community through a non-profit association.

Yaser Abunnasr is a visiting assistant professor in Landscape Architecture at the American University of Beirut. His academic background includes a BA in architecture, an MA in landscape architecture, and a PhD candidate in regional planning. He teaches design and planning, with research focusing on green infrastructure and climate change.

Gotelind Alber is the head of Sustainable Energy and Climate Policy, a consulting entity based in Germany. She is an independent researcher and advisor on sustainable energy and climate change policy with a special focus on multilevel governance, gender issues and climate justice. Ms. Alber is a physicist by education and has 25 years of working experience in research, policy and management. Previously, she served as managing director of the Climate Alliance of European Cities.

Ana Alcantud Bachelor of Sociology by Autonomous University of Barcelona with post-graduate degree on "Local Government, Participation and Sustainable Development" At the present time, she is a project manager in the non-profit SME Ecoinstitut Barcelona, providing the social dimension and the participatory perspective to applied projects related to sustainable development. She is also participating in international projects like the assessment of the implementation of Marrakesh Taskforce Approach to Sustainable Public Procurement for UNEP and EU projects like the 7th FP European projects such as the EUPOPP "Policies to promote Sustainable Consumption Patterns" and GPPinfonet Life + (Information and Communication Project), carrying out the technical secretary of the Spanish Green Public Procurement Information Regional Network.

Andrés Alonso has been working for Vitoria-Gasteiz City Council since 1985. Currently, he is the head of the Environmental Planning and Waste Management Service in the Environmental and Sustainability Department of Vitoria-Gasteiz City Council. He is responsible for the implementation of several environmental action plans and strategies, like the Air Quality Plan, the Local Energy Plan, Waste Management Plan and the Climate Change Strategy. He is also involved in the Local Agenda 21 process and in the elaboration and implementation of the Environmental Action Plan (Agenda 21) of the City Council.

Alice Balbo holds an M.A. in International Relations and Diplomacy and a specialization in Environmental Communication. After working at the ICLEI European Secretariat supporting the organization of international events, since September 2009 she has been managing the Resilient Cities Congress series project on urban resilience and adaptation at the ICLEI World Secretariat and is currently part of the ICLEI global coordination group on adaptation to climate change.

Hannah Baltes studied spatial planning at the University of Dortmund (Dipl.-Ing.) from 2000 until 2006. Since 2006, she works as an assistant professor at the Institute of City Planning and Urban Design at the University of Duisburg-Essen. Her main research areas are sustainable and energy-efficient urban development, urban development and climate change (adaptation and mitigation) and urban material flows.

Rita Baraldi, graduated in Agricultural Science at the University of Bologna (Italy) in 1981, since 1999 is a senior scientist at IBIMET and from 2009 is also responsible for the detached branch of IBIMET in Bologna. She is a plant physiologist and ecophysiologist affiliated to many national and international projects with sound experience on the effectiveness of vegetation on air depuration with particular emphasis on the CO_2 and particulate uptake from the atmosphere and on the potentiality to emit biogenic volatile organic compounds (VOCs) important for the contribution in ozone production or reduction. Such information is providing useful and innovative protocols for local air-quality management.

Scott Baum is trained in economics and sociology and is currently Professor in the School of Environment, Griffith University, Australia. He is currently involved in a number of competitively funded research projects. His research interests include understanding the impacts of climate change on local community socio-economic and health outcomes.

G.K. Bhat is a hydrogeologist with over two decades of experience in natural resource management, groundwater exploration and urban water supply systems.

He started his career as a geologist in Geological Survey of India and has worked with the private and NGO sectors. His current interests are enabling urban and rural communities to sustainably manage their local natural resources and developing community-managed disaster mitigation systems under changing climate contexts.

Dr. Martin Birke, Sociologist and Economist, is a scientific co-worker at Sozialforschungsstelle Dortmund (Center for Social Research) at the Technical University Dortmund/Germany, Research department "Learning Organizations and Networks". His major fields of work include organizational research and consulting, network management, sustainable development, and climate change.

Marjorie Breyton works as coordinator of Impronta Etica, an Italian non-governmental organization that aims at promoting corporate social responsibility. She graduated from the Institute of Political Science of Lyon (France) in 2002 and then did the European Master's degree on Human Rights and Democratization in the academic year (2002–2003) both in Venice and in the Danish Institute for Human Rights in Copenhagen.

Jeb Brugmann is a leading practitioner and thinker on strategy, focusing particularly on the critical contribution of innovation at the micro-level of the locality, business model, or consumer cluster to achieve macro-level strategy objectives. For 25 years, he has been devising solutions to help local communities access the benefits of globalization and to help global organizations engage in local communities and markets. As the founder and chief executive of major international organizations and programs, as a social entrepreneur and for-profit private sector entrepreneur, and as a corporate and urban strategy consultant, he has worked on the ground in scores of cities and rural regions in 28 countries.

Alejandro Callejas serves as the under-minister of Environment in the Ministry of Environment and Natural History of the State of Chiapas, Mexico. Mr. Callejas, a biologist, is a specialist in bioconservation.

Carlos Castillo Licensed in chemistry in University of the Basque Country UPV/EHU in 2005, Carlos Castillo is project manager in the Area of Biodiversity and Climate Change developing projects concerning climate change and with regard to Regional Inventories, Mitigation and Adaptation.

Faith Chihumbiri holds the position of junior professional officer for Disaster Risk Reduction at ICLEI Africa. She is studying towards a master's in technology in environmental management: evaluating a project on green business initiatives. She holds a BSc (Hons) in forest resources and wildlife management from National University of Science and Technology (Zimbabwe).

Florence Crick is a Research Fellow on the South East Queensland Climate Adaptation Research Initiative in the Urban Research Program at Griffith University, Australia. Her work focuses on investigating climate change adaptation for human settlements in South East Queensland, with a particular emphasis on emergency management. Florence previously worked at the OECD as a climate change adaptation consultant. She has a PhD from the University of Oxford, England.

Julien Custot is facilitator of the ‘Food for the cities’ multidisciplinary initiative at the Food and Agriculture Organization of the United Nations and moderates the food-for-cities@dgroups.org global network, bringing together stakeholders from the public sector, the private sector and the civil society. He has a professional experience in urban planning, housing, utility management and environmental protection within various positions at national and local levels in France.

Martha Delgado graduated with a bachelor’s degree in education and a specialization in environmental and civic education. She has obtained diplomas in Management and Analysis of Environmental Policies (1994); Funding and Institutional Development of Non-Profit Organizations (1986); The Metropolitan Phenomenon: Strategies; and Instruments and Alternatives in Management of the University Program of Studies for the City (2000), PUEC, UNAM. She is also a fellow in the Advanced Studies Program for Sustainable Development and the Environment (LEAD) of the Colegio de Mexico (2004). She is currently the minister of environment of the Mexico City Government and also ICLEI World’s vice president, president of the Network of Environmental Management in Cities of Latin America and the Caribbean and alternate governor of the World Water Council.

José María Ezquiaga Dominguez holds degrees in architecture, planning and social studies from Madrid University and has practiced regional and urban planning for more than three decades, first in the Madrid municipal and regional administration and from 1995 from his private practice. He has worked on most of the large Spanish urban areas in all scales of planning and architecture, and has also worked for the European Commission and various Latin-American cities as Buenos Aires, Medellin or Bogota as consultant on urban issues. His practice has developed specific consulting works for the inclusion of contents regarding climate change and growth control in spatial planning laws. He is a teacher at the Escuela Técnica Superior de Arquitectura de Madrid and has also been a visiting professor in several foreign universities.

Marielle Dubbeling (MSc) is currently the global coordinator of the Resource Center on Urban Agriculture and Food Security (RUAF) From Seed to Table Programme (2009–2011) and was the policy adviser in the RUAF Cities Farming for the Future Programme, supporting 21 cities around the world in multi-stakeholder policy formulation and action planning on urban agriculture. Before joining ETC and RUAF, she worked with the UN-HABITAT Urban Management Programme in Latin America, where she supported the development of municipal programmes on urban agriculture in cities in Ecuador, Peru, Argentina, Brazil and Cuba.

Arthur Getz-Escudero has apprenticed to a traditional urban farmer in Japan while learning about farmer-consumer co-partnership networks and organic markets; he worked with The Nature Conservancy and World Resources Institute, managing projects on biodiversity, biosafety and sustainable development governance and was a policy director in Washington, DC, for Heifer International, working on hunger, poverty and community-led development strategies. He is currently a President’s Scholar at Cardiff University, researching urban-rural linkages and social-ecological resilience in food systems, and co-coordinates a working group within FOODLINKS, an EU collaborative project with the purpose of evaluating knowledge brokerage activities to promote sustainable food consumption and production.

Lucinda Fairhurst is currently the Climate and Disaster Risk Reduction manager for ICLEI Africa whilst also fulfilling the role of the ICLEI Global South co-ordinator. Lucinda holds a master's in science and has been working within the Adaptation Arena in the context of African local governments for a number of years. Lucinda has led the adaption front for ICLEI Africa since late 2008. Lucinda drives the climate and disaster preparedness processes at the local government level through trying to ensure that all key stakeholders, particularly the urban poor (whom she considers most vulnerable and at risk), and local academic researchers and the private sector work together in a transparent process.

Efrén Feliu holds a Building Engineering Degree as well as different postgraduates (spatial planning and development, intercultural studies, social psychology and NGO management). He has a relevant professional background in consultancy and strengthening initiatives for public administrations, specially focused in the fields of local development, spatial planning and sustainable development policies. He has been working at Central America for over 4 years and is involved in European initiatives for more than 8 years. He is currently head of Spatial Development and Urban Sustainability in the Unit of Environment of Tecnalia, coordinating research projects in the fields of climate change adaptation, sustainable spatial development and environmental integration policies.

Jörg Felmeden has been a researcher at ISOE since 2007 where he is working in the research unit Water Infrastructure and Risk Analyses. In his work, he is focussing on water and sustainable environmental planning. He has studied civil engineering at the University of Kassel, Germany, and is currently doing his doctoral work there in the specialist area of urban water management on retention soil filters.

Zach Ferdaña is a Senior Marine Conservation Planner for the Global Marine Initiative (GMI) of The Nature Conservancy (TNC). Zach helps design and support approaches and methods for ecosystem-based management and marine spatial planning in U.S. and international geographies (www.marineplanning.org) and ecosystem-based adaptation planning in climate change arenas (www.coastalresilience.org). Over the past decade Zach has conducted and managed spatial analysis projects in marine conservation planning in coastal, nearshore, and offshore environments. Using Geographic Information System (GIS) and online decision support technology, Zach has focused the organization to adopt marine planning innovations and apply them in conservation projects in North, Central and South America, Asia, the Pacific Islands and in the Caribbean.

Stephen Flood received his Bachelor of Commerce International (German) from the University College Dublin (UCD) Quinn School of Business in 2004. He obtained a MA in European Studies from the UCD School of Politics and International Relations (SPIRe) in 2007. He also holds a postgraduate diploma in Statistics from

Trinity College Dublin (2008). Stephen worked as a policy analyst in Comhar Sustainable Development Council (SDC) from November 2007 to September 2008. He is currently writing up his doctoral thesis at the Irish Climate Analysis and Research UnitS (ICARUS), NUI Maynooth.

Hartmut Fünfgeld is a research fellow for Climate Change Adaptation at the Global Cities Research Institute of the Royal Melbourne Institute of Technology (RMIT) in Australia. His research focuses on planning approaches and frameworks for local and regional level climate change adaptation. Prior to his current role, he led the development and piloting of a local government capacity building program on climate change adaptation at ICLEI Oceania. Hartmut has several years of experience in research and practice on social vulnerability and local sustainability in developed and developing countries. He holds a Ph.D. in human geography from the University of Heidelberg, Germany.

Steve Gawler is director of International Programs for ICLEI Oceania, based in Jakarta. His recent work has included technical support to the GIZ Climate Advice programme (PAKLIM) in Indonesia and developing a dissemination and replication strategy for the next phase of the Rockefeller Foundation ACCCRN project. Steve has extensive experience in local government management. With over 20 years in senior management roles in Australian councils, Steve has had responsibility for most functional areas in local government, including 7 years as city manager.

Birgit Georgi is project manager for urban issues, regional vulnerability and adaptation to climate change at the European Environment Agency since 2007. Acting at the the interface between science and policy, she currently conducts a European study on urban vulnerability and adaptation to climate change. Trained as a landscape architect and planner, she started working with environmental issues at the Federal Environmental Agency of Germany in 1989, where she also gained experience in different areas, such as ecological planning, biodiversity, environmental management and sustainable transport.

Ben Gilmer is a Conservation Geographer with the Global Marine Team of The Nature Conservancy. Ben works to develop innovative spatial analysis and community engagement tools and techniques to help decision makers and coastal communities plan for global climate change, ecosystem-based adaptation, and marine and coastal resource conservation. Ben came to the Conservancy in 2008 with a background in environmental modelling, spatial analysis, and remote sensing. Ben was most recently an instructor in the Radford University Department of Geography and has worked in natural resource conservation with state and local governments, academic research institutes, and NGOs. Ben has a master's degree in geography from West Virginia University and a BSc in geography from Radford University, Virginia.

Iratxe González-Aparicio is researcher on Urban Climate and Air Quality Modelling in Tecnalia. Her background is in chemical engineering specialized in atmospheric environment, gaining her MSc in Impacts and Mitigation of Climate Change in the University of Heriot-Watt, Edinburgh (Scotland). Currently, she is in the last stage of her Ph.D.: “Air Quality and Meteorological Modelling in urban areas.” She is involved in activities with the online regional-scale model (Enviro-HIRLAM) at Danish Meteorological Institute and in teaching courses about integrated modelling of meteorological and chemical transport processes under the framework of the European networking project MUSCATEN. Moreover, she is working in other national and European research projects such as K-EGOKITZEN and in the FP7 MEGAPOLI. Her main fields of interest are the atmospheric chemical transport modelling, mesoscale meteorology, air pollution and mitigation and adaptation measurements for the definition of strategies to climate change in urban areas.

Frank Gössel was more than 20 years mayor of Geising town and went to pension in March 2011. He contributed to the development of the town in a substantial way and received the full appreciation of the Geising inhabitants for his work.

Javier Barros Guerton holds degrees and postgraduates in architecture and planning from Spanish, Belgian and French universities and has practiced regional and urban planning and architecture for more than a decade, first in north-western Spain and later from Madrid. He has been head of projects at Ezquiaga Arquitectura, Sociedad y Territorio since 2001, working in all scales of planning, architecture and consulting, involved in Spanish as well as international projects. He has taught master classes in various Spanish universities.

Raffaella Gueze works as Responsible of Sustainability Office at the Environment Sector of the Municipality of Bologna, specialized in participatory processes and sustainability projects. She is the referent for the Environmental Budget in the city of Bologna. She is the coordinator on behalf of the Municipality of Bologna of several European projects. She graduated in Environmental Engineering in 2001 at the University of Bologna.

Nicole Gurran Dr. Gurran holds a Ph.D. from the University of Sydney in Urban and Regional Planning and is the program head for the department. She teaches and researches in land use, demographics, and climate adaptation for sea change communities.

Elisabeth M. Hamin Dr. Hamin holds a Ph.D. from the University of Pennsylvania in City and Regional Planning and a Master of Management from Northwestern University’s J.L. Kellogg Graduate School of Management. She teaches and researches local level climate adaptation and land use planning at the University of Massachusetts.

Jens U. Hasse Dipl.-Ing (MSc) in Civil Engineering at RWTH Aachen University, M.A. in European Public Affairs (EPA) at Maastricht University; since 2007 working at FiW on future strategies for the water sector, climate change adaptation and project management.

Ann Henderson-Sellers is an ISI “most highly cited” author of over 500 publications on climate and climatic change. Prior to holding her post as an Australian Research Council Fellow at Macquarie University, she was Director of the United

Nations' World Climate Research Programme and Deputy Vice-Chancellor of RMIT. A Fellow of Australia's Academy of Technological Sciences and Engineering, Ann received the Centenary Medal of Australia for Service to Australian Society in 2003.

M. Karmele Herranz-Pascual is researcher in the Unit of Environment of Tecnalia from 1998. She holds a PhD in Social and Environmental Psychology from the University of the Basque Country (1994). Since the beginning of her activity, she has specialized in psychosocial studies concerning environmental subjects working with the top council of scientific investigations (1989–1995). From 1995 up to 2002, she has collaborated with the Department of Social Psychology and Behaviour Science of Methodology of the Basque Country University in several researching projects. She joined Tecnalia in 1998, continuing with her investigation work within the area of the environmental psychology. She has more than 20 relevant publications in books and magazines and has participated in more than 50 communications to national and international congresses and in almost 70 projects, among which should stand out: the organization of desks, workshops and forums.

Ishtiuq Hossain is an urban planner by profession. He graduated in Urban and Rural Planning from Khulna University, Bangladesh, and obtained a master's degree in Urban Management from the Technical University Berlin (TUB), Germany. He has comprehensive experience in the urban planning and urban governance field in Bangladesh and was involved in many urban development, good urban governance, and master plan preparation projects for municipalities in Bangladesh. Mr. Hossain is currently working as an expert on urban governance performance in e-governance on a municipal administration project with GIZ Bangladesh. His field of interest is urban governance and urban planning.

Dr. Matthew Inman is a Research Scientist working for Australia's national science agency – the CSIRO. Within the Sustainable Cities & Coasts Theme of CSIRO's Climate Adaptation Flagship, his research focuses on development of knowledge on the performance of alternative coastal management and adaptation options and practical guidance for their implementation. Matthew's work includes climate change adaptation research within the AusAID/CSIRO Alliance addressing development challenges in Indonesia and Vietnam – as well as sustainable urban development projects in Australia.

Seong Woo Jeon works as a chief researcher in Korea Environment Institute. He researched climate change impacts on forest in Korea. Currently, he makes an effort to set up the integrated information system for climate change adaptation.

Prof. C.M. Kao is a distinguished professor with the Institute of Environmental Engineering at National Sun Yat-Sen University, Kaohsiung, Taiwan. He received his MS and Ph.D. degrees in Civil and Environmental Engineering from North Carolina State University in 1989 and 1993, respectively. Prof. Kao is a fellow member of American Society of Civil Engineers (ASCE), a fellow member of American Association for the Advancement of Science (AAAS), a registered professional engineer in the branch of civil engineering, a certified ground water professional, and a professional hydrologist in the United States. He is also a diplomate of the American Academy of Environmental Engineers and diplomate of American Academy of Water Resources Engineers.

Christoph Kasper is a certified landscape planner and has worked as a project coordinator and research assistant on the Moroccan-German BMBF research project *Urban Agriculture as an Integrative Factor of Climate-Optimised Development, Casablanca, Morocco,* at the TU Berlin since 2006. He is also experienced in teaching and has worked for design offices in Potsdam and Berlin. In 2010, he won the BMBF Young Researchers Award, which focuses on 'Forschung für die nachhaltige Entwicklung der Megastädte von morgen' (Research for the sustainable development of future megacities).

Aleksandra Kaźmierczak is a research associate in the School of Environment and Development at the University of Manchester, UK. Her research concerns adaptation of cities to climate change in Europe and the UK, with a particular focus on the use of urban green spaces in adaptation, vulnerability of urban communities to extreme weather events and planning processes leading to development of adaptation action plans. Aleksandra holds a Ph.D. in urban geography from the University of Salford, UK.

Robert Kehew is a human settlements advisor at the United Nations Human Settlements Programme (UN-Habitat), based in Nairobi, Kenya. He holds a Masters degree in Public Policy from Harvard University (1991) and a Bachelors in City Planning from the University of Virginia (USA; 1982). Mr. Kehew coordinates UN-Habitat's Cities and Climate Change Initiative.

Eunyoung Kim received her Ph.D. from Seoul National University. She works as a post-doctoral fellow in the Korea Environment Institute. Her research interests include landscape ecology, spatial interactions among forest management and natural disturbances, forest fragmentation, and methods of spatial analysis.

Junghee Kim is a staff of Sustainability Management team at Amorepacific Corporation. She studied environmental management and is now in charge of the company's environmental management coping with climate change and water risk.

KyungHyun Kim received his M.Sc. degree in Environmental Technology in 2010 from the Imperial College London in the UK. Since 2011, he has been working in the field of socio-economical vulnerability assessment of sea level rise due to climate change at the Korea Adaptation Centre for Climate Change in the Korea Environment Institute.

Mthobeli Kolisa is an executive director of Municipal Infrastructure and Services at the South African Local Government Association (SALGA). He has been in the public and development management field for more than 15 years as a researcher, a consultant and a senior manager. He holds a Masters Degree in Public and Development Management.

Kerstin Krellenberg is an environmental scientist, holding a Ph.D. in Physical Geography. Since 2007, she is working at the Helmholtz Centre for Environmental

Research – UFZ where she is involved in research on megacities, urban vulnerabilities and urban climate change adaptation. Currently, she coordinates a project on climate change adaptation in Santiago de Chile, including other Latin American cities. Her special interest is on cities and adaptation to climate change.

Adrien Labaeye contributed to the Resilient Cities' congress series project at the ICLEI World Secretariat. He previously worked with ICLEI in supporting the coordination of local governments' advocacy in climate negotiations and conducted research on the way local governments participate in international environmental governance. Adrien completed his education at the Institute of Political Studies of Grenoble, France, with an M.A. (hons) in International Relations.

Jungwon Lee received M.Eng. degree in Department of Environmental System Engineering. She works as a researcher at the Korea Adaptation Center for Climate Change in the Korea Environment Institute.

Dr. M.S. Lee is the Director of Environmental Protection Bureau of Kaohsiung City, Taiwan. Dr. Lee received his M.S. degree in Environmental Engineering from National Central University, Chungli, Taiwan, in 1990 and earned his Ph.D. degree in Environmental Engineering from National Sun Yat-Sen University, Kaohsiung, Taiwan, in 2000. Dr. Lee is a registered professional engineer in the branch of Environmental Engineering in Taiwan. He has earned numerous governmental awards including the distinguished governmental employee award. He is also an adjunct assistant professor at Cheng Shiu University, Kaohsiung, Taiwan.

Lykke Leonardsen has worked for the city of Copenhagen since 1997 mainly with urban development and regeneration issues. Since 2008, she has been the head of Strategy for the Centre for Parks and Nature in the Technical and Environmental Administration where she has among other things been responsible for the city's first climate change adaptation plan.

Norbert Lewald is a project manager at EIFER. He has long-time experiences on renewable and distributed energy systems as well as on the smart-grid approach. He has coordinated the BMWI lead-project EDISon, participated at the European project DISPOWER and the IEA PVPS Task III for stand alone systems. Joining EIFER since 2008, he is in charge of regional energy systems, smart grids and access to energy in developing countries. Aside from these, he is a university lecturer on wind energy at the Karlsruhe Institute of Technology (KIT).

Alexandra Linden has been working as an urban/regional planner and consultant for the private and public sector, NGO's, research institutions and international organizations in Europe, Africa, Asia, and Latin America. Her assignments dealt with urban development, infrastructure and resource management, urban upgrading, institutional capacity building and participation, network development as well as policy advice. She is currently advising the German Federal Ministry for Economic Cooperation and Development, Division 313 "Water, Energy, Urban Development, and Geo Sector", on international urban development issues in the context of development cooperation on behalf of GIZ (Gesellschaft für Internationale Zusammenarbeit GmbH).

Ms. S.F. Liu is the Deputy Mayor of Kaohsiung City Government, Taiwan. Ms. Liu received her M.S. degree in Environmental Engineering from Oklahoma State University in 1985. She has a wealthy professional knowledge in engineering and management. Ms. Liu is always an advocate of environmental protection, human rights, and democracy. She has an outstanding record in her career of public service. Before she became the Deputy Mayor of Kaohsiung City Government in 2010, she had been designated as many important governmental officials including the Chief Secretary of Executive Yuan of Taiwan Government, Deputy Chief Secretary of President Office of Taiwan, Minister of the Executive Yuan of Taiwan Government, and Director of Environmental Protection Agency of Taipei City Government. Ms. Liu is the recipient of many governmental awards including the distinguished governmental official award and outstanding governmental employee medal.

Ralf Löser received an engineer degree in forestry from the Technical University Dresden, Germany, as well as a certificate as waste engineer. He is specialized in modelling of environmental topics. He works as scientific co-worker in the Department of Environmental Remediation Concepts at the C&E Consulting und Engineering GmbH in Chemnitz.

Darryl Low Choy is Professor of environmental and landscape planning in the School of Environment, Griffith University, Australia. His current research is focused on values-led planning and indigenous landscape values, resilience of peri-urban landscapes and climate change adaptation for human settlements.

Ulrich Mans has a background in International Development Studies and is currently working on his Ph.D. for the University of Amsterdam. His research focuses on the role of renewable energy in emerging market cities. Part of this work analyses the participation of the private sector (the green energy business) in urban energy transitions towards carbon-neutral cities.

Julia Marton-Lefèvre has been director general of IUCN (International Union for Conservation of Nature) since January 2007. Prior to this position, she was rector of the University for Peace, executive director of LEAD International and executive director of the International Council for Science. She is a member of several boards in the fields of environment, development, science and international cooperation. In 1999, she received the AAAS Award for International Cooperation in Science. In 2008, she was made “Chevalier de l’Ordre national de la Légion d’Honneur” by the French Government and was named Global Ambassador for Hungarian Culture. She is a fellow of the Royal Geographical Society of the United Kingdom and a fellow of the World Academy of Art and Science. She studied history, ecology and environmental planning in the USA and France.

Supriya Mathew is a PhD student in the Department of Environment and Geography, Macquarie University, Sydney. She also works with researchers in the sustainable ecosystems group of CSIRO, Australia. Her current research focus is in developing an adaptation decision framework for local governments.

Dafne Mazo Bachelor of Environmental Sciences by León University (Spain) with master's degree on "Ecotechnology and Sustainable Development" by Mid Sweden University (Sweden). She is currently project assistant in the non-profit SME Ecoinstitut Barcelona, giving environmental advice for green purchasing and sustainable public procurement to public administrations. But she is mainly taking part in various 7th FP European projects such as the EUPOPP "Policies to promote Sustainable Consumption Patterns", which analyses public policies for sustainable consumption and the efficiency in consumption patterns and the environmental impact of these, and SPREAD Sustainable Lifestyles 2050 "Social Platform Identifying Research and Policy Needs for Sustainable Lifestyles", which aims to develop a vision for sustainable lifestyle models of the future by means of mobilizing existing and available knowledge, experiences, best practices and new models for sustainable lifestyles and by creating a social platform.

Darryn McEvoy is a qualified geographer, with an interest in interdisciplinary 'solutions-oriented' action research. In his early research career, the primary research focus was on the decarbonisation, urbanization and sustainable development agendas. Since 2003, he has increasingly specialized in issues related to climate risks, vulnerability, adaptation and the building of local adaptive capacity. Since July 2009, his role has been as leader of the Climate Change Adaptation Program (CCAP), Global Cities Research Institute, RMIT University, as well as acting as deputy director for the Victorian Climate Change Adaptation Research Centre. His current research and leadership activity is multidisciplinary and multi-institutional, with interests crossing local, regional, national and international scales.

Philipp Meidl is a research engineer at EIFER with expertise in Smart Grid, distributed energy and the prediction of thermal and electrical loads. He has experience in projects about the potential of district heating using large-scale CHP units in Great Britain, funded by the ETI, and a fundamental research project about the acceptance of home owners, landlords and tenants to join a micro-district heating network or share one common heating system.

Nidhi Mittal is working as the climate change adaptation adviser in the Humanitarian Policy Team in Save the Children UK. She supports global climate change adaptation policy, programmes and advocacy. Her policy and research interests include a focus on adaptive capacity, resilient livelihoods, vulnerability and equity and urban resilience.

Marcus Moench is president of ISET. Dr. Moench has extensive experience working with communities, non-government, government and international organizations on climate, water, energy and urban issues in South Asia, the Middle East and the Western United States. He combines a strong technical background with training and experience in the design and initiation of management institutions. Dr. Moench received his Ph.D. from the University of California at Berkeley in 1989. He has published numerous articles and papers.

Philip Monaghan is a recognized writer, speaker, strategist and change manager in the fields of economic development and sustainability. He is acclaimed author of

'Hard to Make, Hard to Break' (2012) and 'Sustainability in Austerity' (2010). In April 2011, 'Sustainability in Austerity' was named as one of the 'The 2010 Top 40 Sustainability Books' by the University of Cambridge Programme for Sustainability Leadership.

Daniel Morchain has an M.Sc. in Environmental Management and Policy from Lund University's IIIEE and has completed postgraduate courses on climate change adaptation at the UN University in Tokyo. Daniel's focus of research has been on adaptation of European and Asian cities to climate change and to other environmental and socio-economic pressures. He has led and collaborated in writing reports on the issues of climate change adaptation, resilience and disaster risk that have been published by the EEA, the ETC/ACC (now ETC/CCA), the Council of Europe and the Committee of the Regions. Before joining SEI Daniel was working with ICLEI – Local Governments for Sustainability.

Dr. Carlos Afonso Nobre has a Ph.D. in Meteorology from Massachusetts Institute of Technology. He is a professor and senior researcher at Center for Earth System Science (CSST) from National Institute for Space Research (INPE).

Marta Olazabal is researcher in the Unit of Environment of Tecnalia from 2006 where she has been actively participating in diverse local and European projects related to environmental management and spatial planning. She gained an M.Sc. on environmental engineering (2007) at the School of Engineering of Bilbao (Spain) where she originally studied Chemical Engineering from 1999 to 2004. After graduation, a 2-year abroad training scholarship allowed her to undertake scientific stays in Germany and The Netherlands. Marta is also developing her PhD thesis in the Department of Land Economy of the University of Cambridge (UK). Her main fields of interest and research are in relation to sustainable spatial planning, urban ecological services and urban resilience and adaptation to climate change.

Konrad Otto-Zimmermann is the Secretary General of ICLEI – Local Governments for Sustainability. He holds Masters' Degrees in Architecture & Urban Planning and in Public Administration. He has held positions in national and local governments as well as an inter-municipal consultancy. He is a Member of the World Economic Forum's Global Agenda Council on Infrastructure and Urban Development, the German Association of Town and Regional Planners and the German Environmental Law Society. Mr. Otto-Zimmermann is the initiator and Chair of the 'Resilient Cities' global forum on urban resilience and cities' adaptation to climate change.

Jon Padgham is the Director of the International START Secretariat's vulnerability and adaptation programme. START's V&A programmes includes climate change and Asian coastal megacities; biodiversity conservation in East Africa; global environmental change, agriculture and food security in Sub-Saharan Africa; and climate change and urban and peri-urban agriculture in Africa and South Asia. Prior to joining START in 2008, Jon worked at the World Bank and USAID. He holds a PhD in soil science from Cornell University, USA.

Yong-Ha Park received a Ph.D. in Plant Pathology and Microbiology. He works as a Chief Research Fellow in the Korea Environment Institute.

Florian Rapp is working as researcher and urbanist since 2007 at EIFER in the field of integrated urban planning and sustainable development (Energy in Urban Context). His main working fields are the conceptualization of energy concepts for cities and quarters in Europe and Asia. He has several experiences in urban design and master planning, for example, in India, Ethiopia and Latin America. As an architect and urban planner, he held seminars at the Karlsruhe Institute of Technology (KIT) at the Institute of Urban and Regional Planning since his graduation in 2005.

Christoph Rat-Fischer is a researcher at EIFER since 2010 and actually project manager of a ‘smart city’ research and survey project. He studied politics at ‘Sciences Po’ in Strasbourg; then, he was in charge of the European Affairs for the city of Mulhouse (France) with a major focus on climate policies, to which he was introduced during his internship at the city of Freiburg im Breisgau (Germany). He is focusing at EIFER on urban systems and municipal climate policies.

Andrea Rau is a certified landscape planner and has worked as a pilot project coordinator and research assistant on the Moroccan-German BMBF research project *Urban Agriculture as an Integrative Factor of Climate-Optimised Development, Casablanca, Morocco,* at the TU Berlin. She finished her studies in 2006 at the Leibniz Universität Hannover. She also studied in Jerusalem and at the Norwegian University of Life Sciences (UMB) in Norway. She gained her scientific experience from her work at the TU München as a teaching assistant and a research assistant. She also worked at the Leibniz Universität Hannover as a research assistant and is a qualified gardener as a result of a 2-year apprenticeship at a nursery.

Christopher Rollo currently serves as the officer in charge and knowledge management specialist of the Philippine Country Office of the United Nations Human Settlements Programme (UN-Habitat). He developed and led the implementation of the knowledge management framework of the agency as well as the climate change project in partnership with the City of Sorsogon, the Department of Interior and Local Government and the Housing and Urban Development Coordinating Council. Mr. Rollo studied business management, economics and law.

Peter Rooney has an M.Eng. in civil engineering and is a member of the UK Institution of Civil Engineers (MICE). He is a senior technical expert and procurement specialist at KfW Development Bank in Germany, where he is responsible for a range of transportation and other civil infrastructure projects in Asia and Latin America.

Priscilla Rowswell currently holds the position of professional officer within the Adaptation Workstream, Energy and Climate Change at ICLEI Africa. She began her career with ICLEI Africa in February 2010 after graduating from the University of Cape Town with BSc Honours in atmospheric science at the end of 2009. Her thesis research was analysing and calculating South African seasonal forecast skill and comparing it to the respective observed seasonal rainfall for South Africa.

Marcello Sano is a Postdoctoral Research Fellow at Griffith Centre for Coastal Management, Griffith University, Australia. He holds a PhD from the University of Cantabria, Spain, and a combined BSc/MSc in marine environmental science from the University of Genova, Italy. His current research interests include coastal policy analysis, complex systems thinking and climate change adaptation.

Giulia Sateriale works with Indica Srl as an expert in climate change policies for several projects including the support of carbon neutral processes for both public administrations and private companies and LIFE projects. She graduated with an M.Sc. in Environmental Policy and Regulation at London School of Economics and Political Science in 2008.

Ulrike Schinkel is a research associate engaged in the *Megacity Research Project TP. Ho Chi Minh*, based at the Brandenburg University of Technology Cottbus (BTU), funded by the German Ministry for Education and Research (BMBF). Within the project, she is responsible for the work package *Liveable City HCMC – Urban Regeneration and Community-Based Adaptation*; her work mainly focuses on social vulnerability assessments, structural climate change adaptation measures on the neighbourhood level, capacity building among relevant stakeholders, community action planning and consultancy services for local government institutions.

J. Alexander Schmidt studied architecture, city planning and urban design and environmental psychology at the University of Stuttgart, Germany. He graduated at the University of California, Berkeley, USA, (M.Arch.) and received his Ph.D. from the University of Stuttgart. He is the chair of city planning and urban design, Department of Building Sciences, Faculty of Engineering Sciences, University of Duisburg-Essen and speaker of the university's joint centre "Urban Systems". He is the co-principal in urban design firm working in the fields of urban development, urban design and open space design. His key research areas include urban energy efficiency, city and climate change, city and health, city and beauty and urban infrastructure.

Petra Schneider received a PhD in hydrogeology from the Mining Academy in Freiberg, Germany. She has a long-term experience in the field of environmental assessment, analysis and planning. She works as chief of the Department of Environmental Remediation Concepts at the C&E Consulting und Engineering GmbH in Chemnitz.

Christian Schönhofen, M.Phil., M.Sc., works as a project manager in the Transport and Communication Asia Team of KfW in Frankfurt. His projects include rural and urban transport infrastructure projects of the German Development Cooperation with Bangladesh, Laos, Indonesia, and Timor-Leste. He started working for KfW in 2007. Before that he did post-graduate training and research at the German Development Institute in Bonn. His academic background is economics and philosophy, which he read in Bayreuth, London, and Cambridge.

Engelbert Schramm is a co-founder of ISOE and head of the research unit Water Infrastructure and Risk Analyses. He studied biology, chemistry and education at Goethe University, Frankfurt am Main. Engelbert Schramm received his doctorate in 1995 from Darmstadt Technical University, with a thesis on the history of the concept of circulation. His research focuses on sustainable resource management, support research and regional sustainability.

Dr. Michael Schwarz, Sociologist, is a scientific co-worker at Sozialforschungsstelle Dortmund (Center for Social Research) at the Technical University Dortmund/Germany, Research department "Learning Organizations and Networks." His major fields of work include organizational research and consulting, network management, sustainable development, climate change, and social innovations.

Silvia Serrao-Neumann is a Research Fellow in the Urban Research Program, Griffith University, Brisbane, Queensland. She is currently involved in the South East Queensland Climate Adaptation Research Initiative. Her role is the investigation of climate adaptation related to human settlements in South East Queensland, particularly focused on urban planning and management.

Jiyoung Shin received a Ph.D. in Engineering (Environment and Landscape Planning). Currently, she works as a senior researcher at Korea Adaptation Center for Climate Change in Korea Enviornment Institute. She is now coordinating and supporting local government's adaptation planning.

Purnomo Sidi (Mr) currently works with the Indonesia-Germany Cooperation Programme Policy Advice on Environment and Climate Change being responsible for the development of an integrated climate change strategy for several cities on Java focusing on adaptation.

Andrés Simón-Moral is researcher in the Unit of Environment of Tecnalia from 2008, where he focuses on urban air quality and climate. He has studied physical science at the Complutense University of Madrid, focusing on atmospheric physics from 2000 to 2007. After graduation, he has gained an M.Sc. on climatic risks and environmental evaluation (2008) and an M.Sc. on climatic sciences (2010). Nowadays, he is developing a Ph.D. thesis in Tecnalia, with the collaboration of the CIEMAT (Spain). His main fields of interest are air quality and climate in general, with special focus on the urban scale.

Richard Simpson leads the urban research team of the Capacity Center in the ICLEI World Secretariat. Previously he worked as a researcher at the Urban Age programme at the London School of Economics. Richard holds an M.Sc. in Human Geography Research and in Cities, Space and Society from the London School of Economics, and a B.Sc. (hons) degree in Environment and Development from the University of Durham, UK.

Bach Tan Sinh is the director of the Department of Science and Technology Human Resource Policy and Organization, National Institute for Science and Technology Policy and Strategic Studies – a policy advisory institution to the Ministry of Science and Technology. He has more than 20 years' experience on policy analysis and governance in science, technology, environment and development in Vietnam. He has currently coordinated research for the Asian City Climate Change Resilience Network supported by Rockefeller Foundation. Dr. Sinh received his Ph.D. in environmental social science at Aalborg University, Denmark, in 1998. He was awarded as Fulbright postdoctoral visiting Scholar at University of California, Berkeley, during 1999–2000.

Dr. Wendy Steele is a research fellow co-located within the Urban Research Program and Climate Change Response Program at Griffith University, Australia. Her current research focuses on urban governance, policy and planning in climate change with an emphasis on issues of justice and security.

Dr. Harry Storch is a senior researcher at the Department of Environmental Planning at the Brandenburg University of Technology Cottbus, Germany, since 2008. He is scientific coordinator of the Action Field 'Urban Environment' and co-leader of the work package 'Adaptation Planning Framework' within the 'Megacity Research Project TP. Ho Chi Minh: Integrative Urban and Environmental Adaptation Planning Framework', funded by the German Federal Ministry of Research and Education (BMBF). Additionally, he acted as coordinator of the MSc. Programme 'Urban Development Planning' at the Vietnamese-German University in Ho Chi Minh City from December 2009 to April 2010 and from November 2010 to March 2011.

Professor John Sweeney has been a lecturer at the Geography Department NUI Maynooth since 1978. He received a First Class Honours B.Sc. from the University of Glasgow in 1974 and was awarded a Ph.D. also from Glasgow in 1980. John has taught courses primarily related to climatology, but he has also taught biogeography, geomorphology, and environmental resource management and has taught and researched at a number of universities in North America and Africa. He currently leads a number of nationally funded research projects examining various aspects of climate change in Ireland. As one of the contributing authors and review editors of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), John shared with several hundred other climatologists the 2007 Nobel Peace Prize. John is currently President of An Taisce, the National Trust of Ireland.

Dr. Bao Thanh is Director of the Sub-Institute of Hydrology, Meteorology and Environment (SIHYMETE) of South Vietnam, a sub-institute of the Vietnam Institute of Meteorology, Hydrology and Environment of the Ministry of Natural Resources and Environment in Hanoi explicitly responsible for the coordination of major international research activities in the field of adaptation to climate change within the southern regions of Vietnam.

Ly Khanh Tam Thao is vice chief of the Division of General Planning Management at the Department of Planning and Architecture (DPA) in Ho Chi Minh City, Vietnam. He is also a member of the Ho Chi Minh City Climate Change Steering Group and responsible for the implementation of the Program to Respond to Climate Change within the Department of Planning and Architecture.

Dr. Nguyen Anh Tuan is Head of the Research and Training Division of the Architectural Research Center at the Department of Planning and Architecture (DPA) in Ho Chi Minh City, Vietnam. He is also a member of the Ho Chi Minh City Climate Change Steering Group.

Rafael Tuts is Chief of the Urban Environment and Planning Branch of the United Nations Human Settlements Programme, UN-HABITAT, based in Nairobi. He is responsible for the Cities and Climate Change Initiative, with activities in Africa, Asia and Latin America. He earlier headed the Training and Capacity Building Branch, the Urban Governance Section and the Localizing Agenda 21 Programme of UN-HABITAT. Local government capacity development and environmental planning and management are key focus areas of his work.

Agate Goyarrola Ugalde has a degree in management and business administration UPV/EHU in 2001. Currently, Agate Goyarrola Ugalde is project coordinator of the Technical Secretariat of Udalsarea 21, Basque Network of Municipalities Towards Sustainability. Her principal tasks involve the coordination and management of the services offered under the Network, promoting the implementation of Local Agenda 21 processes and consolidating the Local Action Plans as a integrated management tool of municipal policies for sustainability.

Nguyen Van Phuoc is vice-director of the Department of Natural Resources and Environment (DONRE) in Ho Chi Minh City, Vietnam. DONRE is responsible for the preparation of the Ho Chi Minh City land-use strategy and action plan, reviewing and commenting on all other sectoral and spatial plans for the city with regards to their environmental sustainability and their effectiveness in meeting climate change adaptation requirements.

Carmen Vogt is the Senior Policy Advisor for the Sector Project "Urban Development Policy Advice" with the German Development Cooperation (GIZ). She is coordinating on behalf of BMZ the Cities and Climate Change component of the Urban Sector Programme, including the development of new tools and instruments, and participating actively in international conferences and debates. Besides analysis on urbanization and urban development, her thematic priorities focus on climate-friendly city development, particular in creating "resilient cities" and dealing with "urban vulnerabilities". She was coordinating several GIZ projects in Latin America (and Asia) in the field of decentralization, urban and municipal development, disaster risk management, and environmental management.

Sylvie Wabbes is one of Food and Agriculture Organization of the UN (FAO) focal person for UNISDR working on food and nutrition security disaster risk reduction and management in the Emergency and Rehabilitation division. She co-leads FAO agriculture and food emergency efforts in urban and peri-urban crisis and has extensive experience in responses to large disasters such as the Indian Ocean tsunami and the Haiti earthquake. She is actively supporting the right to food in humanitarian context, promoting self-reliance and local food systems.

Dipl.-Ing. Christian Walloth studied electrical engineering with focus on renewable and decentralized energies at RWTH Aachen University of technology, which led him to begin his career working for Eurospace, a consultancy to high-tech firms. Before starting his PhD, he worked as senior consultant for Roland Berger Strategy Consultants on various national and international projects during 3 years. In his PhD thesis, he is seeking to combine interdisciplinary and system thinking approaches to facilitate sustainable urban development of Central and Eastern European cities.

Bob Webb is convenor for Integration and Projects with the Climate Change Institute and visiting fellow with the Fenner School of Environment and Society at the Australian National University (ANU), where he has focused on integrated and interdisciplinary approaches to adaptation drawing on local, national and international experience. He joined the ANU in 2009 following senior leadership positions in the private (resource and manufacturing) and public (Australian government) sectors, which included strategy and change management, large-scale program delivery, policy development, economics, finance and investment. He holds a Ph.D. in physics from Sydney University and a Masters in political science and international relations from the ANU.

Monika Wiebusch urban planner by profession, with long-standing experiences in German urban policies and development cooperation in African cities is now working on urban strategies for KfW Entwicklungsbank.

Assoc. Prof. Annemie Wyckmans PhD, is an architect with 13 years of experience in interdisciplinary and cross-institutional project development and research related to zero emission buildings and built environments. She is the head of the international, interdisciplinary MSc programme in Sustainable Architecture at NTNU.

Mr. B.M. Yang is a Ph.D. candidate of the Institute of Environmental Engineering at National Sun Yat-Sen University, Kaohsiung, Taiwan. He received his M.S. degree in Environmental Engineering from Tajen University, Pingtung, Taiwan, in 2007. Mr. Yang has received numerous distinguished research paper awards from the Chinese Environmental Engineering Association. Currently he is working on water and wastewater reclamation projects funded by the Taiwan National Science Council and Taiwan Water Resources Administration, Taiwan Water Treatment.

Dr. Andrea Ferraz Young is an architect and has a Ph.D. in Agriculture Engineering from State University of Campinas. She is a researcher of the Brazilian Network for Climate Change (REDE CLIMA).

Kristina Yuzva graduated with a Bachelor of Science degree from the University of Toronto, focusing on environmental science and biology. After that she obtained a master's degree in Public Administration at Queen's University with main interests in environmental and energy policy. Upon completion of her studies and after doing an internship with the United Nations Volunteers program, Kristina actively took part in the Resilient Cities Congress in 2011 as a congress assistant. Currently, she is working as a research assistant at the United Nations University Institute for Environment and Human Security (UNU-EHS) on the MRF Chair Project on Social Vulnerability.

Monika Zimmermann is Director of the Capacity Center at the World Secretariat of ICLEI – Local Governments for Sustainability dealing with knowledge management, urban research, organization of ICLEI's global events, and capacity building within the organization and within ICLEI's membership. Until June 2010, Monika was director of the until then existing International Training Centre (ITC) of ICLEI, based at the European Secretariat in Freiburg, Germany, which she had built up and managed for 18 years. Having done studies in political and administrative sciences and journalism at the universities of Konstanz and Berlin, Germany, Monika holds a master's degree in Political Science (FU Berlin).

Acknowledgements

The second annual global forum on cities and adaptation to climate change, Resilient Cities 2011, took place from 3 to 5 June 2011 in Bonn, Germany, back to back with the United Nations Climate Talks. Hosted by ICLEI-Local Governments for Sustainability, the World Mayors Council on Climate Change and the City of Bonn, the congress built on discussions and insights of Resilient Cities 2010 with widened focus on resilient urban development and responsive finance for adaptation.

With 535 participants from 65 countries worldwide, this event far surpassed our expectations, generating significant interest and demonstrating the continued need for such a global platform.

A special thank you goes to the contributors of this book that took the time to share their knowledge and expertise, as well as good practice techniques on urban resilience and adaptation strategies.

I would like to express my gratitude to the members of the Resilient Cities 2011 Steering Board for their strategic advice on the profile and positioning of the forum: Joan Clos, Monique Barbut, David Cadman, Marcelo Ebrard, Jürgen Nimptsch, Achim Steiner, Kadir Topbaş, Veerle Vandeweerd and Margareta Wahlström.

Special thanks are owed to the programme committee members who assisted with the development of the programme structure and the review of papers submitted: Joern Birkmann, Jeb Brugmann, Martha Delgado Peralta, David Dodman, Mikaela Engert, Pan Jiahua, Abha Joshi Ghani, Arab Hoballah, Alex Nickson, Gregg Oelofse, Andreas Rechkemmer, Violeta Seva, Anthony Socci, Rafael Tuts, Thorsten Schlurmann, Helena Molin Valdés and Carlos Villacis.

I would also like to thank our endorsing partners for their support: UN-HABITAT, UNEP, UNDP, UNISDR, UNFCCC, UNU-EHS, UNESCAP, ADB, WB, CLRAE, IDB, PIK, EEA, BMU, BMZ, Rockefeller Foundation, IIED, IUCN, IWA, DIE, ISOCARP, EMI, GRF, TERI, REEEP, DKKV, ICCIP, CDKN, Urban Age and nrg4SD.

The second congress could not be held without the financial support of the following institutions: EU European Regional Development Fund, State of North-Rhine Westphalia, Swiss Re and Foundation for International Dialogue of the Savings Bank in Bonn.

Our media partner, Springer, has delighted us with the publication of this book.

The City of Bonn should also be acknowledged for hosting the Resilient Cities congress series and for providing support to ICLEI throughout its organization.

Lastly, I would like to thank the Resilient Cities 2011 core team, including Alice Balbo, Monika Zimmermann, Aurore Colella, Adrien Labaeye, Tanya Paglia, Kristina Yuzva and Ugne Vaitiekunaite, whose dedication was essential in the realization of the event.

For the preparation of the book, I would like to thank Kristina Yuzva and Vildan Aydin for editing the contributions, Maarten De Cock for the proof review process, Alice Balbo for the overall coordination and Richard Simpson for the finance chapter.

A special thank you goes to Kristina Yuzva whose commitment and hard work made this book happen.

All of us look forward to continuing the exchange and dialogue at Resilient Cities 2012.

Konrad Otto-Zimmermann
Congress Chair
ICLEI Secretary General

Contents

List of Figures

List of Tables

Contributors

Carlo Aall Western Norway Research Institute, Sogndal, Norway

Beñat Abajo TECNALIA Unit of Environment, Derio, Spain

Yaser Abunnasr American University of Beirut, Beirut, Lebanon

University of Massachusetts, Beirut, Lebanon

Gotelind Alber Sustainable Energy and Climate Policy, Berlin, Germany

Ana Alcantud Ecoinstitut Barcelona, Barcelona, Spain

Andrés Alonso Environment Department, Vitoria-Gasteiz City Council, Vitoria-Gasteiz, Spain

Alice Balbo ICLEI – Local Governments for Sustainability, World Secretariat, Bonn, Germany

Hannah Baltes Institute of City Planning and Urban Design, University of Duisburg-Essen, Essen, Germany

Rita Baraldi Urban Forest Mitigation, Institute of Biometeorology (IBIMET), National Research Council, Bologna, Italy

Scott Baum Urban Research Program, Griffith University, Nathan, QLD, Australia

G.K. Bhat TARU Leading Edge, Gurgaon, India

Martin Birke Sozialforschungsstelle Dortmund, ZWF of Technical University Dortmund, Dortmund, Germany

Marjorie Breyton Impronta Etica, Bologna, Italy

Jeb Brugmann Founder of ICLEI, The Next Practice, Bonn, Germany

Alejandro Callejas Government of Chiapas, Segundo Piso, Tuxtla Gutierrez, Chiapas, Mexico

Carlos Castillo Basque Government, IHOBE-Sociedad Pública Gestión Ambiental, Bilbao, Spain

Faith Chihumbiri ICLEI – Local Governments for Sustainability, Africa Secretariat, Cape Town, South Africa

Florence Crick Urban Research Program, Griffith University, Nathan, QLD, Australia

Julien Custot FAO – Food and Agriculture Organization of the United Nations, Rome, Italy

Martha Delgado Ministry of Environment, Mexico City Government, Mexico City, Mexico

José María Ezquiaga Dominguez Ezquiaga Arquitectura, Sociedad y Territorio S.L., Madrid, Spain

Marielle Dubbeling Senior programme officer RUAF Foundation (International network of Resource centres on Urban Agriculture and Food security), AN Leusden, The Netherlands

Arthur Getz-Escudero School of City & Regional Planning/Sustainable Places Research Institute, Cardiff University, Cardiff, UK

Lucinda Fairhurst ICLEI – Local Governments for Sustainability, Africa Secretariat, Cape Town, South Africa

Efrén Feliu Unit of Environment, TECNALIA, Derio, Spain

Jörg Felmeden Water Infrastructure and Risk Analyses, Institute for Social-Ecological Research (ISOE) GmbH, Frankfurt am Main, Germany

Zach Ferdaña The Nature Conservancy, Seattle, WA, USA

Stephen Flood Irish Climate Analysis and Research UnitS (ICARUS), National University of Ireland, Maynooth, County Kildare, Ireland

Hartmut Fünfgeld Climate Change Adaptation Program, Global Cities Research Institute, RMIT University, Melbourne, VIC, Australia

Steve Gawler ICLEI – Local Governments for Sustainability, Oceania Secretariat, Jakarta, Indonesia

Birgit Georgi Project manager, Regional vulnerability and adaptation, European Environment Agency, Copenhagen, Denmark

Ben Gilmer The Nature Conservancy, Seattle, WA, USA

Iratxe González-Aparicio TECNALIA Unit of Environment, Derio, Spain

Frank Gössel Mayor Office at Geising town, Geising, Germany

Javier Barros Guerton Ezquiaga Arquitectura, Sociedad y Territorio S.L., Madrid, Spain

Raffaella Gueze Responsible Sustainability Office, Municipality of Bologna, Bologna, Italy

Nicole Gurran Urban and Regional Planning Program, University of Sydney, Sydney, Australia

Elisabeth M. Hamin Department of Landscape Architecture and Regional Planning, University of Massachusetts Amherst, Amherst, USA

Jens U. Hasse FiW Research Institute for Water and Waste Management, Aachen University, Aachen, Germany

Ann Henderson-Sellers Environment and Geography, Macquarie University, Sydney, Australia

M. Karmele Herranz-Pascual TECNALIA Unit of Environment, Derio, Spain

Ishtiuq Hossain Good Urban Governance Advisor, German Development Cooperation (GIZ), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Dhaka, Bangladesh

Matthew Inman Urban Systems Program, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Sydney, Australia

Alexander Jachnow Good Urban Governance Principal Advisor, German Development Cooperation (GIZ), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Dhaka, Bangladesh

Seong Woo Jeon Korea Adaptation Center for Climate Change, Korea Environment Institute (KEI), Seoul, Republic of Korea

C.M. Kao Institute of Environmental Engineering, National Sun Yat-Sen University, Kaohsiung, Taiwan

Christoph Kasper Department of Landscape Architecture and Environmental Planning, Chair of Landscape Architecture. Open Space Planning, Technische Universität Berlin, Berlin, Germany

Aleksandra Kaźmierczak School of Environment and Development, University of Manchester, Manchester, UK

Robert Kehew Leader, Climate Change Planning Unit Urban Planning and Design Branch, UN-HABITAT, Nairobi, Kenya

Eunyoung Kim Korea Adaptation Center for Climate Change, Korea Environment Institute (KEI), Seoul, Republic of Korea

Junghee Kim Korea Adaptation Center for Climate Change, Korea Environment Institute (KEI), Seoul, Republic of Korea

KyungHyun Kim Korea Adaptation Center for Climate Change, Korea Environment Institute (KEI), Seoul, Republic of Korea

Mthobeli Kolisa Department of Municipal Infrastructure and Services, SALGA (South African Local Government Association), Pretoria, South Africa

Kerstin Krellenberg Department of Urban and Environmental Sociology, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Adrien Labaeye ICLEI – Local Governments for Sustainability, World Secretariat, Bonn, Germany

Jungwon Lee Korea Adaptation Center for Climate Change, Korea Environment Institute (KEI), Seoul, Republic of Korea

M.S. Lee Environmental Protection Bureau, Kaohsiung City Government, Kaohsiung, Taiwan

Lykke Leonardsen Technical and Environmental Administration, Centre for Parks and Nature, Copenhagen, Denmark

Norbert Lewald European Institute for Energy Research (EIFER), Karlsruhe, Germany

Alexandra Linden Division 313 – Water, Energy, Urban Development, Geoscience Sector, Federal Ministry for Economic Cooperation and Development (BMZ), Bonn, Germany

S.F. Liu Deputy Mayor Office, Kaohsiung City Government, Kaohsiung, Taiwan

Ralf Löser Environmental Remediation Concepts, C&E Consulting and Engineering GmbH, Chemnitz, Germany

Darryl Low Choy Urban Research Program, Griffith University, Nathan, QLD, Australia

Ulrich Mans Department of Geography, University of Amsterdam, Amsterdam, Netherlands

Julia Marton-Lefèvre IUCN, International Union for Conservation of Nature, Gland, Switzerland

Supriya Mathew Environment and Geography, Macquarie University, Sydney, Australia

Dafne Mazo Ecoinstitut Barcelona, Barcelona, Spain

Darryn McEvoy Global Cities Research Institute, RMIT University, Melbourne, VIC, Australia

Philipp Meidl European Institute for Energy Research (EIFER), Karlsruhe, Germany

Nidhi Mittal Humanitarian Policy Team, Save the Children UK, London, UK

Marcus Moench Institute for Social and Environmental Transition (ISET), Boulder, CO, USA

Philip Monaghan Infrangilis, Manchester, UK

Daniel Morchain ICLEI – Local Governments for Sustainability, European Secretariat, Freiburg, Germany

Stockholm Environmental Institute, Oxford, UK

Carlos Afonso Nobre CCST – Center for Earth System Science, INPE (National Institute for Space Research), São José dos Campos, Brazil

Marta Olazabal TECNALIA Unit of Environment, Derio, Spain

Konrad Otto-Zimmermann ICLEI – Local Governments for Sustainability, World Secretariat, Bonn, Germany

Jon Padgham International START Secretariat, Washington, DC, USA

Yong-Ha Park Korea Adaptation Center for Climate Change, Korea Environment Institute (KEI), Seoul, Republic of Korea

Florian Rapp European Institute for Energy Research (EIFER), Karlsruhe, Germany

Christoph Rat-Fischer European Institute for Energy Research (EIFER), Karlsruhe, Germany

Andrea Rau ZEWK Kubus – Cooperation and Consulting for Environmental Questions, Technische Universität Berlin, Berlin, Germany

Christopher Rollo Philippines Country Office, UN-HABITAT, Makati City, Philippines

Peter Rooney Sector Team Transport and Communication, Asia, KfW Development Bank, Frankfurt am Main, Germany

Priscilla Rowswell ICLEI – Local Governments for Sustainability, Africa Secretariat, Cape Town, South Africa

Marcello Sano Griffith Centre for Coastal Management, Gold Coast Campus, Griffith University, Nathan, QLD, Australia

Giulia Sateriale Climate Change Policies, Indica srl, Ferrara, Italy

Ulrike Schinkel Department of Urban Planning and Spatial Design, Brandenburg University of Technology Cottbus, Cottbus, Germany

J. Alexander Schmidt Institute of City Planning and Urban Design, University of Duisburg-Essen, Essen, Germany

Petra Schneider Environmental Remediation Concepts, C&E Consulting and Engineering GmbH, Chemnitz, Germany

Christian Schönhofen Sector Team Transport and Communication, KfW Development Bank, Frankfurt am Main, Germany

Engelbert Schramm Water Infrastructure and Risk Analyses, Institute for Social-Ecological Research (ISOE) GmbH, Frankfurt am Main, Germany

Michael Schwarz Sozialforschungsstelle Dortmund, ZEF of Technical University Dortmund, Dortmund, Germany

Silvia Serrao-Neumann Urban Research Program, Griffith University, Nathan, QLD, Australia

Jiyoung Shin Korea Adaptation Centre for Climate Change, Korea Environment Institute (KEI), Seoul, Republic of Korea

Purnomo Sidi PAKLIM – GIZ, Semarang, Indonesia

Andrés Simón-Moral TECNALIA Unit of Environment, Derio, Spain

Richard Simpson ICLEI – Local Governments for Sustainability, World Secretariat, Bonn, Germany

Bach Tan Sinh National Institute for Science and Technology Policy and Strategic Studies (NISTPASS), Hanoi, Vietnam

Wendy Steele Urban Research Program/Climate Change Response Program, Griffith University, Brisbane, Australia

Harry Storch Department of Environmental Planning, Brandenburg University of Technology Cottbus, Cottbus, Germany

John Sweeney Irish Climate Analysis and Research UnitS (ICARUS), National University of Ireland, Maynooth, County Kildare, Ireland

Bao Thanh Sub-Institute of Hydrology, Meteorology and Environment of South Viet Nam, Ho Chi Minh City, Viet Nam

Ly Khanh Tam Thao Division of General Planning Management, Department of Planning and Architecture, Ho Chi Minh City People's Committee, Ho Chi Minh City, Viet Nam

Nguyen Anh Tuan Research and Training Division, Architectural Research Center, Department of Planning and Architecture, Ho Chi Minh City People's Committee, Ho Chi Minh City, Viet Nam

Rafael Tuts Urban Environment and Planning Branch, United Nations Human Settlements Programme – UN-HABITAT, Nairobi, Kenya

Agate Goyarrola Ugalde Basque Government, IHOBE-Sociedad Pública Gestión Ambiental, Bilbao, Spain

Nguyen Van Phuoc Department of Natural Resources and Environment, Ho Chi Minh City People's Committee, Ho Chi Minh City, Vietnam

Carmen Vogt Division of Planning and Development/State and Democracy, German Development Cooperation (GIZ), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany

Sylvie Wabbes Emergency Operations and Rehabilitation Division, Food and Agriculture Organization of the United Nations, FAO, Rome, Italy

Christian Walloth Institute of City Planning and Urban Design and Main Research Area "Urban Systems", University Duisburg-Essen, Essen, Germany

Bob Webb Climate Change Institute and Fenner School of Environment and Society, Australian National University, Canberra, ACT, Australia

Monika Wiebusch Sector and Policy Division Urban Development, KfW-Bankengruppe Entwicklungsbank, Frankfurt am Main, Germany

Annemie Wyckmans Department of Architectural Design, History and Technology, NTNU Norwegian University of Science and Technology, Trondheim, Norway

B.M. Yang Institute of Environmental Engineering, National Sun Yat-Sen University, Kaohsiung, Taiwan

Andrea Ferraz Young CEPAGRI, State University of Campinas, Campinas, Brazil

Kristina Yuzva ICLEI – Local Governments for Sustainability, World Secretariat, Bonn, Germany

United Nations University, Bonn, Germany

Monika Zimmermann ICLEI – Local Governments for Sustainability, World Secretariat, Bonn, Germany

Part I
Introduction

The Global Adaptation Community Expands Its Scope

Konrad Otto-Zimmermann and Alice Balbo

How can a city be truly 'sustainable' if it lacks the capacity to reduce vulnerability to crisis and to respond creatively to change?

This essential capacity can be described as 'local resilience'. Therefore, a new agenda must be introduced in the sustainable cities movement. A Sustainable City must be a Resilient City. A Sustainable Community must be a Resilient Community.

Resilient Communities and Cities Partnership Program proposal, ICLEI (2004)

This was what ICLEI proposed in 2004 as a concrete follow-up to the partnership launched at the 2002 World Summit on Sustainable Development in Johannesburg. Unfortunately, the time was not yet ripe. Now the time has come, and most of the actors in the sustainable development field have come to similar conclusions.

As a forerunner organization linking urban resilience to sustainable urban development, we are glad to see that this approach has reached momentum. The Resilient Cities congress, having established itself as the global forum on urban resilience and adaptation to climate change, is now moving into this direction. While the 2010 event focused mainly on cities and climate change adaptation, the 2011 edition has widened the scope of the discussion to areas such as water, energy and food security as a contribution to making a city resilient. The general goal is to progressively include all aspects of sustainability into the urban resilience debate. As stressed at the congress and in its comprehensive analytical report (ICLEI – Local Governments for Sustainability 2011), at the city level, resilience building needs to be integrated into all dimensions of urban development.

K. Otto-Zimmermann • A. Balbo (✉)
ICLEI – Local Governments for Sustainability, World Secretariat, Kaiser-Friedrich-Str. 7, 53113, Bonn, Germany
e-mail: resilient.cities@iclei.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_1,

1 Urbanization and Climate Change: The Interlinked Challenges of the Twenty-First Century

As confirmed by the UN-HABITAT's Cities and Climate Change report launched at the Resilient Cities 2011 event, urban areas are significantly contributing to climate change and, at the same time, climate change has potentially devastating effects on urban populations. Urban areas have a pivotal role in both climate change mitigation and adaptation, a role that must be strengthened.

The occurrence of climate change and natural disasters and the responses necessary for its management are inherently local. While policies for climate change mitigation and adaptation and for disaster prevention require national attention, effective action towards more resilient cities must be local and responsive to specific local conditions. There is a strong need for greater attention to locally based efforts reducing vulnerability and increasing the resilience of local systems and institutions to climate change, crisis and possible disasters.

As the OECD's Cities and Climate Change report stresses, long-term strategic planning needs to take into account the interaction between urban development and vulnerabilities to climate change and natural disasters. However, current adaptation efforts are challenged by the uncertainty about future climate change impacts, especially given that adaptation costs are paid upfront while the benefits are only felt in the future. Vulnerability assessments can help, but a high degree of uncertainty remains the main challenge.

2 Urban Resilience: Beyond Climate Adaptation and Towards Sustainable Urban Development

As highlighted in the congress report, one of the key messages of Resilient Cities 2011 underpins that resilience is more than successful climate change adaptation. Resilience goes beyond addressing only climate impacts and overcomes the only risk-oriented approach of disaster risk reduction.

The concept of resilience, as a development approach, is able to address the complexity and the interlinkages of challenges confronting local governments in cities of both developed and developing countries. In order to host three billion additional urban dwellers, the urban capacity will need to double within 40 years. Moreover, risks are increasingly complex and interconnected. As pointed out in ICLEI's definition of urban resilience,[1] urban systems and communities need to be able to withstand stress and survive, adapt, bounce back from a crisis or disaster and rapidly move forward.

[1]For the complete definition and related research on the theme of urban resilience, see ICLEI (2011), Towards urban resilience, Briefing Sheet.

Resilience building needs to be integrated into urban development: technical definitions of goals and targets, assessments, infrastructure and investment planning, as well as stakeholder consultation and participation, among others. At the city level, an integrated framework needs to account for, but not exclusively, water, energy and food security, greenhouse gas reductions, ecosystem protection and urban poverty.

On the path towards urban sustainability, current and future risks have to be accounted for in the trajectory of local development. If future conditions are not accounted for, infrastructure provisions or plans that are designed now can become redundant in a few decades. More effective data collection and analysis is required to inform the local decision-making processes. Costs and savings can fundamentally change over long periods of time. Taking a long-term perspective can prevent seemingly unviable options being dismissed. Moreover, as it is the urban poor who are typically living in the most vulnerable conditions, building urban resilience should also be taken as an additional opportunity to alleviate urban poverty. Spanning across economic, social and environmental dimensions, urban resilience contributes to sustainable urban development.

3 Resilient Cities: The Goal of a Growing Community

Low-risk cities show low vulnerability to climate change, natural and industrial disasters and economic shocks. Climate change adaptation and disaster risk reduction planning by local governments and in cooperation with all government levels are key to the facilitation of resilient and sustainable communities.

It is from this approach that ICLEI's strategic plan 2010–2015 sets 'building resilient communities' as one of eight goals for cities in order to develop sustainability, and it is within this framework that the Resilient Cities annual global forum was launched in May 2010.

Resilient Cities 2010[2] gathered a global community of researchers and practitioners in the urban resilience and climate adaptation field. ICLEI felt it was time to take stock of the players, actions and challenges in this field, to share views on the challenges ahead and to assess the gaps between knowledge and capacity, between need and action.

With an overwhelming response to our public call for contributions, the congress surpassed every expectation. The congress demonstrated that such a meeting and exchange opportunity was very much needed, particularly to connect the leaders in urban adaptation and resilience, to accelerate the transfer of knowledge and experiences between the various actors and to look into innovative solutions for local communities.

Moreover, the event hosted a special leadership segment, the Mayors Adaptation Forum, where local leaders discussed the policymaking aspects and challenges in

[2]For more information on Resilient Cities 2010, visit www.iclei.org/bonn2010.

the field of urban adaptation and resilience. The outcome of the forum, the 2010 Bonn Declaration of Mayors,[3] pressed for enhanced recognition and involvement of local governments within a 'globally coordinated local climate action'. It also sought to facilitate direct access of cities to global climate funds.

Resilient Cities 2011[4] was cultivated on the basis of such a success.

Through the open call for contributions, over 200 proposals came from practitioners, academics and local governments across the world. The congress was endorsed by an even larger partnership of global institutions on urban adaptation and resilience, with key international organizations, from UN bodies and development banks to professional networks but also national governments and NGOs.

The final programme consisted of three plenaries, three strategy dialogues on urgent issues for resilience, eight Cities in Focus sessions and 26 theme sessions surrounding topics such as vulnerability and risk assessment, inclusive adaptation planning, tools and implementation and multilevel governance. A special focus was given to responsive finance for local resilience where a bottom-up approach to local financing, developed by ICLEI upon the mandate of the Resilient Cities 2010 congress, was presented to the international community in the form of the Global Report *Financing the Resilient City*.[5]

The Reality Check Workshops,[6] flagship of the forum, featured in-depth case studies of the challenges faced and measures taken by four cities attempting to adapt to climate change: Ho Chi Minh City, Vietnam; Lagos State, Nigeria; Semarang, Indonesia; and London, the United Kingdom.

The 2-day Mayors Adaptation Forum saw over 30 city leaders sharing experiences, knowledge and challenges among others with Andrew Steer, World Bank; Christiana Figueres, UNFCCC; Joan Clos, UN-Habitat; and Michel Liès, Swiss Re. The forum concluded by agreeing on the 2011 Bonn Declaration of Mayors,[7] calling for local access to global climate funds and recognizing the carbon*n* Cities Climate Registry[8] as a global response by local governments to the call for measurable, reportable, verifiable climate action.

With 535 participants from 65 countries, Resilient Cities 2011 was the place to launch new publications, create cooperation and sign partnerships but also to move the urban adaptation and resilience debate a step forward.

---

[3] The full text of the 2010 Bonn Declaration of Mayors is available at www.iclei.org/bonn2010.

[4] For more information on Resilient Cities 2011, check www.iclei.org/bonn2011.

[5] For the full report, see ICLEI (2011), Financing the Resilient City: A demand driven approach to development, disaster risk reduction and climate adaptation – An ICLEI White Paper, ICLEI Global Report.

[6] For a detailed description of the Reality Check Workshops, check ICLEI (2011), Resilient Cities 2011: Congress Report, available at http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Resilient_Cities_2011/RC2011_Congress_report.pdf.

[7] The full text of the 2011 Bonn Declaration of Mayors is available at www.iclei.org/bonn2011.

[8] For more information on the carbon*n* Cities Climate Registry, check www.citiesclimateregistry.org.

Achieving resilient cities should be everyone's goal, and we are glad to see that a growing community is putting it on top of its agenda. A global campaign such as the World Disaster Reduction Campaign 'Making Cities Resilient',[9] globally launched at Resilient Cities 2010 by the United Nations International Strategy for Disaster Reduction (UNISDR), is another powerful example.

However, more people can be mobilized and more resources, both human and financial, need to be invested in implementing actions to build resilient cities. Financing the resilient city with the help of the public but also of the private sector, as well as combining urban resilience in local sustainable development, will be key themes, among many others, to further explore and analyze at Resilient Cities 2012.

4 This Publication

The field of urban resilience and adaptation is important and highly dynamic. This book aims at advancing knowledge in this field by providing timely insights and disseminating new information in a highly accessible fashion.

This publication brings together selected contributions of the second global forum on urban resilience and adaptation, Resilient Cities 2011. Submissions[10] highlight the current themes and approaches being explored by leaders emerging from the field of urban adaptation and resilience – academics, municipal experts and private sector practitioners. Moreover, this book presents examples from local governments worldwide illustrating the different vulnerabilities, sectors of action, framework conditions and the different ways and resources identified to tackle and solve regional and local challenges. It is the peculiarity but also the common lessons that can be drawn from each local case that show how much sharing knowledge is important to find the way forward, and it is this invaluable mix of approaches, sources and points of view that makes this publication unique.

Including 39 contributions organized in four main chapters, the book starts by exploring urban risk and vulnerability assessments, then moves to the challenges and experiences of designing an overall resilient city and looks into the different areas in which resilience needs to be achieved. Then the focus shifts to the framework conditions of local resilient action and finally to how the resilient city can be financed.

Despite offering a good overview of the status of urban resilience and adaptation in local governments worldwide, the contributions of this book only address select aspects of a vital debate to ensure the survival of our cities. We have only begun to understand what it means for a city to be truly resilient, and there are still gaps that need to be addressed from financing mechanisms of local resilient action to its economic and social aspects and implications.

[9] For more information on the campaign, visit www.unisdr.org/campaign.

[10] Please note that the content of the single submissions does not necessarily reflect the view of the organizer and of the congress.

Finally, we would like to note that local cases from both developing and developed countries are featured in this publication stressing the 'ironic equality' of climate change impacts and natural disasters: they do not know boundaries, affect all communities and therefore require everyone's attention.

Reference

ICLEI – Local Governments for Sustainability. (2011). *Resilient Cities 2011: Congress Report*. Bonn: ICLEI. http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Resilient_Cities_2011/RC2011_Congress_report.pdf

Part II
Urban Risk and Assessing Vulnerability at the Local Level

Introduction: Urban Risk and Assessing Vulnerability at the Local Level

Kristina Yuzva

Climate change is already beginning to transform the world we live in. Cities and regions around the world are experiencing seasonal shifts, rising temperatures, fluctuations in rainfall patterns and precipitation (leading to drought and floods), changes in the severity and frequency of extreme events, and accelerated sea level rise. The most pronounced changes are expected to occur in cities, particularly in developing countries as they have fewer resources to adapt socially and technically.

Urban areas are amongst the most vulnerable to the effects of climate change. Due to rapid urbanization, more than 50% of the world's population now live in cities, reaching almost three-quarters of the world's population by 2050 (Pierce and Johnson 2008). Many of these urban areas are located in coastal zones. As Sanchez-Rodriguez et al. (2007) pointed out, "some of the largest cities (with five million or more people) have on average one-fifth of their population and one-sixth of their land area within the coastal zone". With the rise in sea levels and greater storm intensity, coastal settlements will be put under a significant amount of risk. Lastly, urban areas are central to national and international economies and host a large portion of their countries' critical infrastructure. As such, it is no surprise that many of the most important and significant changes associated with the impacts of climate change will take place in and around cities.

Helping cities to strengthen their resilience in the face of climate change is essential. Local governments, due to their proximity to the public and their role in providing day-to-day services, are uniquely positioned to take the lead in climate change mitigation and adaptation actions. However, without knowing exactly what these changes may be or their scope, it is extremely difficult to garner political

K. Yuzva (✉)
ICLEI – Local Governments for Sustainability, World Secretariat, Kaiser-Friedrich-Str. 7, 53113 Bonn, Germany
(Now United Nations University)

United Nations University, Bonn, Germany
e-mail: resilient.cities@iclei.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_2,

will for pre-emptive action. As such, the first step is to obtain spatially explicit information regarding vulnerability to climate change at the local and regional levels.

With the proliferation of geospatial tools and data, climate change vulnerability assessments are increasingly helping cities to better identify which areas and systems are most vulnerable to climate change through a process of data collection and analysis. As Preston et al. (2011) stated, it involves "the development of representative metrics of the potential for harm to occur to assets and systems of value in response to climate change and its interactions with other system drivers". Understanding the geography of climate change vulnerability not only assists with risk and disaster management but also informs climate change adaptation.

Today, climate change vulnerability assessments are viewed as an essential first step in developing adaptation initiatives. This is demonstrated by ICLEI's own climate change adaptation methodology in which the first step is to perform a vulnerability assessment, serving as a foundation for the other steps that follow.

Within this context, the Resilient Cities 2011 Congress featured two sessions in which city representatives and researchers came together to discuss a variety of vulnerability approaches in four different countries—Australia, the United States, Brazil, and Ireland. These chapters will elaborate on these approaches, emphasizing the differences in the methodology and data used, including:

- Sea level rise mapping at regional scales
- Identification of vulnerability hotspots within a region
- Regional, participatory vulnerability assessment
- Combined use of digital elevation modelling with geospatial address mapping to identify the impacts of sea level rise and areas affected by floods
- Socio-economic vulnerability assessment

Given the wide implications of climate change for a number of different geographical areas and human communities, these assessments target a broad range of potential vulnerabilities (including assessing vulnerability of coastal systems and more generally of human well-being). Moreover, these chapters will focus not only on the physical dimensions of vulnerability but also incorporate the social and economic dimensions related to the sensitivity and adaptive capacity of the potentially affected regions and their populations.

Climate change vulnerability assessment kick-starts the first set of chapters as it forms the early stage of adaptation planning. The proceeding chapters will then take a closer look at the impacts of climate change and the range of solutions offered to local governments to foster resilience.

References

Pierce, N. R., & Johnson, C. W. (2008). *Century of the city: No time to lose*. New York: The Rockefeller Foundation.

Preston, B. L., Yuen, E. J., & Westaway, R. M. (2011). Putting vulnerability to climate change on the map: A review of approaches, benefits and risks. *Sustainability Science*. doi:10.1007/s11625-011-0129-1.

Sanchez-Rodriguez, R., Pacyna, J., O'brien, K., Fragkias, M., Rosentrater, L., & Weichselgartner, J. (2007). Introduction to the "Global environmental change, natural disasters, vulnerability and their implications for human security in coastal urban areas" issue. *IHDP update: Magazine of the international human dimensions programme on global environmental change, 2*, 4–5.

A Region at Risk: Policy Determination Through Vulnerability Hotspot Assessment

Florence Crick, Silvia Serrao-Neumann, Darryl Low Choy, Marcello Sano, and Scott Baum

Abstract This chapter presents a 'first cut' regional vulnerability assessment that was undertaken for the South East Queensland (SEQ) region of Australia as part of a broader Climate Adaptation Research Initiative investigating adaptation of human settlements to climate change in SEQ. Despite the well-known shortcomings of vulnerability assessments, it is argued that regional vulnerability assessments of this type can be used as a starting point to enable the identification of vulnerability hotspots within a region and thus inform climate change adaptation planning and policy determination. Regional vulnerability assessments and the identification of vulnerability hotspots can provide insights and focus for policymakers across all sectors. They enable the identification of the circumstances that put people and places at risk as well as the factors that reduce people's ability to respond to changes.

Keywords Australia • Climate change adaptation • SEQ • Vulnerability assessment • Vulnerability hotspots

1 Introduction

The region of South East Queensland (SEQ) has been identified by the Intergovernmental Panel on Climate Change (IPCC) as one of six most vulnerable regions in Australia (Hennessy et al. 2007). SEQ's vulnerability to climate change is greatly

F. Crick (✉) • S. Serrao-Neumann • D.L. Choy • S. Baum
Urban Research Program, Griffith University, 170 Kessels Road, Nathan 4111, QLD, Australia
e-mail: f.crick@griffith.edu.au; s.serrao-neumann@griffith.edu.au; d.lowchoy@griffith.edu.au; s.baum@griffith.edu.au

M. Sano
Griffith Centre for Coastal Management, Gold Coast Campus, Griffith University, Southport 4222, QLD, Australia
e-mail: m.sano@griffith.edu.au

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_3,

associated with its high exposure to natural hazards, coastal location and ongoing population growth. Despite being a region at risk and having, to some extent, experience in dealing with natural hazards, climate change adaptation in SEQ is still in its embryonic stages across all sectors due to a number of barriers, including: the lack of national guidelines (Christoff 2005; Fünfgeld 2010), lack of necessary skills and resources to address climate change (Commonwealth of Australia 1991; Harvey and Caton 2003) as well as litigation threats, particularly to local governments (England 2008). It is under this context that a 'first cut' regional vulnerability assessment was undertaken for SEQ as part of the broader SEQ Climate Adaptation Research Initiative (SEQCARI) investigating adaptation of human settlements to climate change.

In this chapter, we argue that regional vulnerability assessments, despite their well-known shortcomings, comprise a useful tool for policy makers. In particular, we suggest that vulnerability assessments can be used to enable the identification and further investigation of vulnerability hotspots, defined as areas of high to extreme vulnerability. We propose that the identification of vulnerability hotspots through vulnerability assessments should be an iterative process that increasingly improves our understanding of a region's vulnerability to climate change as we progressively step through a series of more detailed assessments. This iterative process occurs in response to improved accessibility to best available science and experience (learnings) and is ideally facilitated by an adaptive management planning process. The intention of such an assessment is to facilitate a progressive refinement of our focus on areas at risk in a region. Consequently, it assists in the identification of locations that require priority adaptation intervention through policies/programmes addressing the potential impacts (positive or negative) of climate change. This can occur at a range of assessment and planning scales from regional to site-specific.

This chapter is structured in three parts. In the first, we quickly review vulnerability assessments and their increasing use within climate change research. We then provide a brief overview of our 'first cut' regional vulnerability assessment for SEQ. Finally, we discuss the context within which we believe regional vulnerability assessments and the identification of vulnerability hotspots can play an important role for adaptation decision making.

2 Climate Change Vulnerability Assessments

Vulnerability has emerged as a central concept in a variety of research fields, which has led to a proliferation of studies aimed at conceptualizing, understanding, assessing and mapping vulnerability. The assessment and mapping of vulnerability, in particular, have become increasingly popular and in-demand approaches, especially within the climate change research community, as they enable the visualization of the 'vulnerability of place' and facilitate communication amongst and between stakeholders and researchers (Preston et al. 2011). Nevertheless, despite the proliferation of vulnerability assessments, there is no standardized methodology or agreement on what represents 'best practice' (Turner et al. 2003; Ionescu et al. 2009; Preston et al. 2011).

Despite this lack of consensus, there has been an increasing demand within the climate change community for the development of vulnerability assessments and indices at all scales in order to better understand the vulnerability of local communities, regions and countries and to inform climate change adaptation decision making. Vulnerability assessments are considered an essential first step in the development of climate change adaptation measures (Smith 1996; Smith and Lenhart 1996; OECD 2009). Furthermore, at the international level, negotiators of international climate policy and national decision makers have been calling for the development of global vulnerability indices to compare countries' vulnerability and inform the allocation of funds for adaptation (Klein 2009). However, given the scarcity and quality of data available at the national and international scales, caution should be employed in their use, in particular with regard to their role in ranking countries' vulnerability and in informing the allocation of adaptation funds (Eakin and Luers 2006; Eriksen and Kelly 2007; Barnett et al. 2008; Füssel 2010). In addition, as argued by Barnett et al. (2008), vulnerability is not a 'generic national condition' but specific in space and time and influenced by a variety of local level processes.

3 Regional Vulnerability Assessment for SEQ

The approach developed for this 'first cut' regional vulnerability assessment of SEQ adopted the definition of vulnerability and its components – exposure, sensitivity and adaptive capacity – proposed by the IPCC's *Fourth Assessment Report* (IPCC 2007). The regional vulnerability assessment therefore followed one of the most common approaches in climate change vulnerability research (Füssel and Klein 2006; Füssel 2007; Preston et al. 2011). The aim of this assessment was to provide a starting point for discussions involving climate change vulnerabilities in SEQ. It presents preliminary regional spatial vulnerabilities based on a set of indicators identified to illustrate the region's exposure, sensitivity and adaptive capacity to extreme heat, extreme rainfall and coastal hazards – that is, a first approximation of regional vulnerability.

The selection of variables as indicators for the exposure, sensitivity and adaptive capacity components was informed by the existing literature on vulnerability assessment and mapping (Cutter et al. 2000, 2003; Preston et al. 2008; Baum et al. 2009) and limited by the availability of data for disaggregated spatial units in SEQ. The spatial unit used in this study was the suburb level. Within each component, the scores for each individual variable in each suburb were first standardized and then added together to provide an overall score for that component (i.e. each suburb had a separate score for exposure, sensitivity and adaptive capacity). As the goal of the vulnerability mapping was to develop an overall measure of vulnerability for each hazard considered, the individual components comprising vulnerability had to be combined in a meaningful way. Vulnerability was measured by taking an indicator of exposure and having exposure mediated by degrees of sensitivity and adaptive capacity (based on Baum 2004, 2008). As a result, a simple weighted index was created that represented the vulnerability of SEQ suburbs to the three selected climate-related hazards of extreme heat, extreme rainfall and coastal hazards (see Low Choy et al. 2010). A total vulnerability map was then developed by combining the indices of vulnerability to these three hazards. The level of vulnerability was then divided into the four categories of low, medium, high and extremely high to enable the first-order identification of vulnerability hotspots. Examples of the first iteration of such vulnerability hotspots are shown in Fig. 1.

However, it is important to highlight that producing detailed and robust vulnerability assessments at the regional scale is challenging due to the paucity and quality of data available, particularly in Australia. Although in the last decade Australia has made some significant efforts to create better databases, a number of challenges still remain, including (a) data collection and custodianship by government agencies at different scales as well as by non-governmental agencies (Jacoby et al. 2002); (b) traditionally disparate national, state and local governments' mapping systems (Jacoby et al. 2002); and (c) the complexity involved in accurately measuring the extent, potential impacts and interplay between localities' exposure and sensitivity to extreme events (Brisbane City Council 2011). Thus, this 'first cut' SEQ regional vulnerability assessment entailed the production of a series of first-order maps to predominantly depict the region's susceptibility to climate-change-related harms, rather than provide a measure of those harms. Such maps could be used as a guide to identify the locations within SEQ that require further investigation in terms of their vulnerability to climate change. More detailed studies could then provide a measure of climate change harms specific to each investigated location and therefore inform policy development to address those harms.

4 Policy Determination Through Vulnerability Hotspot Assessments

While we recognize that vulnerability assessments have specific limitations, we argue that regional vulnerability assessments, such as the one presented in this chapter, can play an important role as a first step towards the development of adaptation options. As noted by the Organisation for Economic Cooperation and Development, the importance of vulnerability assessments is not to develop perfect information on the system or region of concern but to provide sufficient information to enable a thorough consideration and examination of policy options for adaptation (from regional to site scale) (OECD 2009). In particular, we believe that they represent a useful approach in regions with the following characteristics: (a) presence of institutional arrangements at the regional level, (b) lack of integrated

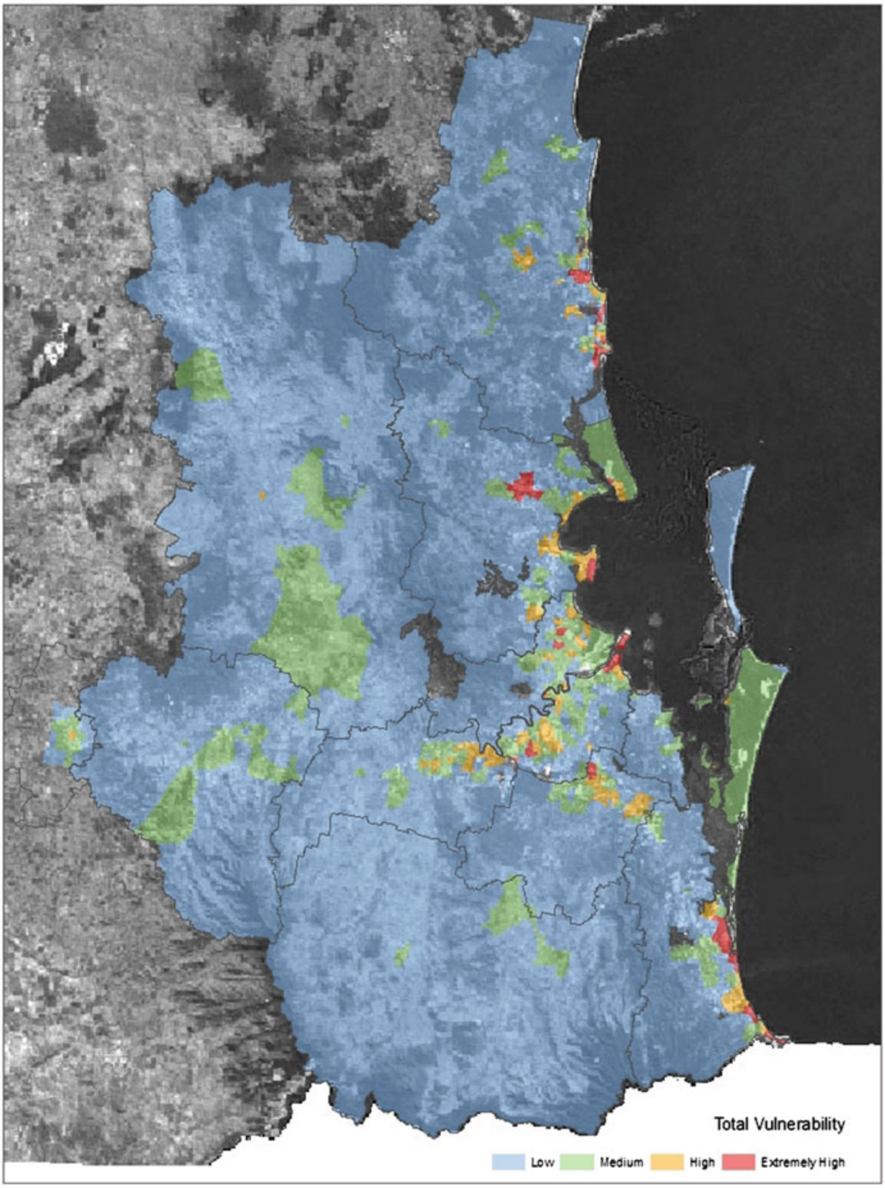


Fig. 1 Map depicting total vulnerability (combined vulnerability for extreme heat, extreme rainfall and coastal hazards) to climate-related hazards for SEQ (Low Choy et al. 2010)

data at the regional level to enable informed regional climate change adaptation decision making and (c) a planning and management system with established vertical links between regional and site scales. The SEQ region fits all of the criteria. First, it has a prior history of decisions being made at the regional scale for a range of sectors. Institutional arrangements are already in place to guide strategic planning to manage unprecedented growth at the regional scale (Department of Infrastructure and Planning 2009) and set out decisions related, but not limited, to infrastructure planning (Department of Infrastructure and Planning 2010) and water supply strategies (Queensland Water Commission 2010) at the local scale. Second, there is a lack of integrated data, especially regarding natural hazards and climate change, at the regional scale. For example, SEQ local authorities use different methods to develop their local flood models, as there are no requirements on local governments to use a standard method for flood studies (Department of Environment and Resource Management 2010). In addition, downscaled climate change data have not yet been produced for SEQ at a high enough resolution to inform both local and regional decision making. The 'first cut' regional vulnerability assessment we have undertaken represents, to date, the first attempt at providing a regional perspective of SEQ's vulnerability to climate change. This 'first cut' can inform current regional decision-making processes by filling an important data and knowledge gap at the regional scale. Third, the region's institutional arrangements link the various levels of statutory and non-statutory planning and landscape/environmental management vertically, from regional to site scale. This can facilitate the generation of assessment outcomes, policies and actions at all levels, consistent with the vulnerability hotspot assessment approach under discussion.

Regional vulnerability assessments can inform regional climate change adaptation decision making, as they enable the identification of vulnerability hotspots as well as the examination of the role of the different factors creating the hotspot. The process of identifying vulnerability hotspots through regional vulnerability assessments not only integrates all components of vulnerability at the regional scale but also narrows the focus to key areas of analysis and decisions at the local scale. Decision makers can use the outputs from this method to focus on localities across the region that require further investigation and to guide the development and implementation of measures to reduce their vulnerability to climate change and extreme events. For instance, a number of suburbs across the SEQ region have shown high to extreme vulnerability to extreme heat, extreme rainfall and/or coastal hazards (see Fig. 1). Consequently, these suburbs could be the target of further investigations which would provide more detailed and robust information for decision making. Suburbs' vulnerability could then be addressed through informed proactive decisions focused on planning ahead of extreme events rather than through reactive measures in the post-disaster phase. In this way, vulnerability assessments can provide insights to policy makers across all sectors in terms of identifying the circumstances that put people and places at risk. Nevertheless, this identification of vulnerability hotspots using regional vulnerability assessments should only be seen as the first step towards understanding the vulnerability of the region. Furthermore, it should only be considered as one of the multiple layers of information required to inform regional adaptation decision making.

The identification of vulnerability hotspots can influence policy determination for climate change adaptation in a range of sectors, including urban planning, coastal management and emergency management. For example, as planning has a central role in reducing climate change risks through both adaptation and mitigation (Wilson 2006; Blanco et al. 2009), the identification of vulnerability hotspots can be useful to guide planning decisions in terms of the location of future developments and major assets, as well as the management of risks associated with existing settlements. These include, for example, the placement of critical infrastructure and populations outside areas at risk and the retrofitting of vulnerable settlements.

In terms of coastal management, vulnerability assessments can be used to provide an integrated vision of a local system subject to sea level rise and changing storm conditions (Sano et al. 2011). In parallel, the spatial distribution of vulnerability across coastal units (e.g. suburbs or physiographic units) can be used to (a) inform the allocation of investments for climate change adaptation across coastal regions or (b) assess the progress towards adaptation at the local level against the actual level of vulnerability in places where the adaptation process has already started.

Finally, vulnerability assessments comprise a useful tool to inform disaster management (Clark et al. 1998; Cutter et al. 2000; Weichselgartner 2001; Cutter and Finch 2008). Emergency management to date has focused primarily on risk assessment with a lack of consideration of social dimensions of disasters. Vulnerability assessments, thus, can provide an extra layer of information to emergency management services and can help them better inform and target their preparedness, response and recovery activities. Additionally, Meyer et al. (2010) argue that a comprehensive vulnerability assessment is a key component of a post-disaster redevelopment plan to target assistance to those most vulnerable and to focus the discussion on long-term recovery instead of response issues.

5 Conclusion

The identification of vulnerability hotspots through regional vulnerability assessment can play an important role in planning for climate change adaptation in the light of uncertainty. While we will never be able to plan and implement climate adaptation with perfect knowledge, it could be argued that a prudent course of action would be to adopt a 'worst case' approach. As a first step, the vulnerability hotspot assessment approach outlined in this chapter can be useful in assisting the identification of highly vulnerable groups, communities and/or regions and can assist decision making by facilitating the implementation of local/regional adaptation policy through flexible and adaptive management processes.

The types of approaches suggested in this chapter have developed significantly during a relatively short period of time. While they have been shown to advance climate adaptation considerations in the light of high degrees of uncertainty and lack of reliable climate science at local and regional scales, for many jurisdictions, questions about data reliability, data availability and methodology will hamper the potential effectiveness of these approaches as an initial step in vulnerability assessment. In Australia, as elsewhere, ongoing research will be required to address these questions. Moreover, further research on how adaptive management processes can contribute effectively to addressing climate adaptation needs to be undertaken. This will give greater clarity to policy determination through vulnerability hotspot assessment for regions at risk.

Acknowledgements This chapter is part of the South East Queensland Climate Adaptation Research Initiative, a partnership between the Queensland and Australian Governments, the CSIRO Climate Adaptation National Research Flagship, Griffith University, University of the Sunshine Coast and University of Queensland. The Initiative aims to provide research knowledge to enable the region to adapt and prepare for the impacts of climate change.

References

Barnett, J., Lambert, S., & Fry, I. (2008). The hazards of indicators: Insights from the environmental vulnerability index. *Annals of the Association of American Geographers, 98*(1), 102–119.

Baum, S. (2004). Measuring socio-economic outcomes in Sydney: An analysis of census data using a general deprivation index. *Australasian Journal of Regional Studies, 10*, 105–133.

Baum, S. (2008). *Suburban scars: Australian cities and socio-economic deprivation* (Urban Research Program, Research Paper 15). Griffith University, Brisbane.

Baum, S., Horton, S., Low Choy, D., & Gleeson, B. (2009). *Climate change, health impacts and urban adaptability: Case study of Gold Coast City* (Urban Research Program, Research Monograph 11). Griffith University, Brisbane.

Blanco, H., Alberti, M., Forsyth, A., Krizek, K., Rodriguez, D., Talen, E., & Ellis, C. (2009). Hot, congested, crowded and diverse: Emerging research agendas in planning. *Progress in Planning, 71*, 153–205.

Brisbane City Council. (2011). Joint Flood Taskforce Report March 2011. Prepared for Brisbane City Council by the Joint Flood Taskforce. http://www.brisbane.qld.gov.au/prdc/groups/corpwebcontent/documents/documents/036148.pdf. Accessed 16 May 2011.

Christoff, P. (2005). Policy autism or double-edged dismissiveness? Australia's climate policy under the Howard government. *Global Change, Peace & Security, 17*, 29–44.

Clark, G. E., Moser, S. C., Ratick, S. J., Dow, K., Meyer, W. B., Emani, S., Jin, W., Kasperson, J. X., Kasperson, R. E., & Schwarz, H. E. (1998). Assessing the vulnerability of coastal communities to extreme storms: The case of Revere, MA., USA. *Mitigation and Adaptation Strategies for Global Change, 3*(1), 59–82.

Commonwealth of Australia. (1991). *The injured coastline: Protection of the coastal environment*. Report of the House of Representatives Standing Committee on Environment, Recreation and the Arts, Australian Government Publishing Service, Canberra.

Cutter, S. L., & Finch, C. (2008). Temporal and spatial changes in social vulnerability to natural hazards. *Proceedings of the National Academy of Sciences of the United States of America, 105*(7), 2301–2306.

Cutter, S. L., Mitchell, J. T., & Scott, M. S. (2000). Revealing the vulnerability of people and places: A case study of Georgetown County, South Carolina. *Annals of the Association of American Geographers, 90*(4), 713–737.

Cutter, S., Boruff, B., & Shirley, W. (2003). Social vulnerability to environmental hazards. *Social Science Quarterly, 82*, 242–261.

Department of Environment and Resource Management, Department of Infrastructure and Planning and Local Government Association of Queensland. (2010). Increasing Queensland's resilience to inland flooding in a changing climate: Final report on the Inland Flooding Study.

Department of Infrastructure and Planning. (2009). South East Queensland regional plan 2009–2031. Brisbane: The State of Queensland. http://www.dlgp.qld.gov.au/regional-planning/regional-plan-20092031.html. Accessed 16 May 2011.

Department of Infrastructure and Planning. (2010). South East Queensland infrastructure plan and program 2009–2031. Brisbane: The State of Queensland. http://www.dip.qld.gov.au/seqipp. Accessed 16 May 2011.

Eakin, H., & Luers, A. L. (2006). Assessing the vulnerability of social-environmental systems. *Annual Review of Environment and Resources, 31*, 365–394.

England, P. (2008). Heating up: Climate change law and the evolving responsibilities of local government. *Local Government Law Journal, 13*, 209–223.

Eriksen, S., & Kelly, P. M. (2007). Developing credible vulnerability indicators for climate adaptation policy assessment. *Mitigation and Adaptation Strategies for Global Change, 12*(4), 495–524.

Fünfgeld, H. (2010). Institutional challenges to climate risk management in cities. *Environmental Sustainability, 2*, 156–160.

Füssel, H.-M. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change, 17*, 155–167.

Füssel, H.-M. (2010). How inequitable is the global distribution of responsibility, capability, and vulnerability to climate change: A comprehensive indicator-based assessment. *Global Environmental Change, 20*, 597–611.

Füssel, H.-M., & Klein, R. J. T. (2006). Climate change vulnerability assessments: An evolution of conceptual thinking. *Climatic Change, 75*(3), 301–329.

Harvey, N., & Caton, B. (2003). *Coastal management in Australia*. Melbourne: Oxford University Press.

Hennessy, K., Fitzharris, B., Bates, B. C., Harvey, N., Howden, M., Hughes, L., Salinger, J., & Warrick, R. (2007). Australia and New Zealand. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. Van Der Linden, & C. E. Hanson (Eds.), *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change* (pp. 507–540). Cambridge: Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC). (2007). In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, & C. E. Hanson (Eds.), *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change.* Cambridge: Cambridge University Press, 976 pp.

Ionescu, C., Klein, R., Hinkel, J., Kavi Kumar, K., & Klein, R. (2009). Towards a formal framework of vulnerability to climate change. *Environmental Modeling and Assessment, 14*(1), 1–16.

Jacoby, S., Smith, J., Ting, L., & Williamson, I. (2002). Developing a common spatial data infrastructure between State and Local Government—An Australian case study. *International Journal of Geographical Information Science, 16*, 305–322.

Klein, R. (2009). Identifying countries that are particularly vulnerable to the adverse effects of climate change: An academic or a political challenge? *Carbon and Climate Law Review, 3*, 284–291.

Low Choy, D., Baum, S., Serrao-Neumann, S., Crick, F., Sanò, M., & Harman, B. (2010). *Climate change vulnerability in South East Queensland: A spatial and sectoral assessment.* Unpublished report for the South East Queensland Climate Adaptation Research Initiative, Griffith University.

Meyer, S., Henry, E., Wright, R. E., & Palmer, C. A. (2010). Post-disaster redevelopment planning: Local capacity building through pre-event planning. *Journal of Disaster Research, 5*(5), 552–564.

OECD. (2009). *OECD/DAC policy guidance on integrating climate change adaptation into development co-operation.*

Preston, B. L., Smith, T., Brooke, T., Gorddard, R., Measham, T., Withycomber, G., McInnes, K., Abbs, D., Beveridge, B., & Morrison, C. (2008). *Mapping climate change vulnerability in the Sydney Coastal Councils Group.* Prepared for the Sydney Coastal Councils Group by the CSIRO Climate Adaptation Flagship, Canberra.

Preston, B. L., Yuen, E. J., & Westaway, R. M. (2011). Putting vulnerability to climate change on the map: A review of approaches, benefits and risks. *Sustainability Science*. doi:10.1007/s11625-011-0129-1.

Queensland Water Commission. (2010). South East Queensland water strategy. The State of Queensland. http://www.qwc.qld.gov.au/planning/pdf/seqws-full.pdf. Accessed 16 May 2011.

Sano, M., Golshani, A., Splinter, K., Strauss, D., & Tomlinson, R. (2011). A detailed assessment of vulnerability to climate change in the Gold Coast, Australia. *Journal of Coastal Research, SI 64,* 245–249. ISSN 07490208.

Smith, J. B. (1996). Development of adaptation measures for water resources. *Water Resources Development, 12*(2), 151–163.

Smith, J. B., & Lenhart, S. S. (1996). Climate change adaptation policy options. *Climate Research, 6*, 193–201.

Turner, B. L. I. I., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A. L., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences of the United States of America, 100*(14), 8074–8079.

Weichselgartner, J. (2001). Disaster mitigation: The concept of vulnerability revisited. *Disaster Prevention and Management, 10*(2), 85–94.

Wilson, E. (2006). Adapting to climate change at the local level: The spatial planning response. *Local Environment, 11*, 609–625.

Developing a Framework for Assessing Coastal Vulnerability to Sea Level Rise in Southern New England, USA

Ben Gilmer and Zach Ferdaña

Abstract Scientists predict that sea level rise will intensify wetland loss, saltwater intrusion, and the problems caused by waves, storm surges, and shoreline erosion (Nicholls et al., Trans R Soc 369:161–181, 2011). The ability to accurately identify low-lying lands is critical for assessing the vulnerability of coastal regions. To do this, coastal managers need elevation data and other coastal zone information, but these data are not always available at resolutions appropriate for making state and regional governance decisions on climate change and adaptation. Coastal Resilience (Ferdaña et al., Adapting to climate change: building interactive decision support to meet management objectives for coastal conservation and hazard mitigation on long island, New York, USA. In: Andrade Pérez A, Herrera Fernandez B, Cazzolla Gatti R (eds) Building resilience to climate change: ecosystem-based adaptation and lessons from the field. IUCN, Gland, 164 pp, 2010) is an ecosystem-based planning framework and web mapping application that visually displays ecological, socio-economic, and coastal hazards information to examine different adaptation solutions. This technical study highlights the limitations and opportunities of mapping sea level rise in Southern New England, USA, in order to evaluate coastal vulnerability and therefore appropriate adaptation strategies. We compared the accuracy of digital elevation data between a nationwide data set with a seamless, multi-state data set that incorporated local high-resolution data. Based on an independent accuracy assessment, the integrated elevation data approach using local- and regional-scale data was 55% (or 1.25 ft) more accurate than the national elevation data set alone. Results of this work indicate that regional elevation data sets are less accurate in determining different sea level rise scenarios than when integrating best-available local elevation data sets with regional data sets. With this approach, we can better assess the impacts of climate change to vulnerable low-lying

B. Gilmer (✉) • Z. Ferdaña
The Nature Conservancy, 1917 1st Ave, Seattle, WA 98101, USA
e-mail: bgilmer@tnc.org; zferdana@tnc.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_4,

lands and help communities identify adaptation plans that protect vulnerable coastal communities and ecosystems, allow for natural resource migration, and reduce socio-economic risk to coastal hazards.

Keywords Adaptation • Digital elevation model • Resilience • Sea level rise • Vulnerability • Climate change • Ecosystem-based adaptation

1 Introduction

Coastal environments contain some of the most dynamic ecosystems in the world, and obtaining and integrating the most up-to-date and accurate digital elevation data continue to be a fundamental challenge for coastal resource managers. As sea level rise (SLR) is predicted to intensify problems caused by waves, storm surge, shoreline erosion, wetland loss, and saltwater intrusion, the ability to accurately identify low-lying lands is a critical factor for assessing the vulnerability of coastal regions (Gesch et al. 2009). Projections of sea level rise over the course of the twenty-first century vary depending on factors such as the type of model used, future emissions scenarios, polar ice sheet melting, and local effects such as land subsidence (Nicholls et al. 2011). The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment projected a rise of 0.2–0.6 m by the year 2100 unless greenhouse gas emissions are reduced substantially (IPCC 2008), though more recent studies have projected sea levels to rise by 1 m by 2100 (Pfeffer et al. 2008; Vermeer and Rahmstorf 2009). Other studies (Hu et al. 2009; Yin et al. 2009) modelling ocean currents in response to climate change predict that the Northwest Atlantic will experience even higher sea levels than the global average because of anticipated slowdowns of ocean currents in response to global warming.

Coastal Resilience (TNC 2011) is an ecosystem-based planning framework and web mapping application that visually displays ecological, socio-economic, and coastal hazards information to examine different adaptation solutions. Specifically, the Coastal Resilience project is designed to inform local communities about climate change and how ecosystem-based adaptation (EBA) can help mitigate coastal hazards. EBA includes a range of actions for the management, conservation, and restoration of ecosystems that will help reduce the vulnerability and increase the resilience of coastal communities. Starting on the shores of Long Island in New York, The Nature Conservancy (TNC) has worked with communities to map sea level rise and other coastal hazards alongside natural resources and human communities at risk (Ferdaña et al. 2010). While communities are able to utilize this information to identify potential impacts and adaptation options at a local level, larger-scale assessments on vulnerability are also critical in influencing regional governance processes. Southern New England, extending from Cape Cod, Massachusetts, to Long Island, New York (Fig. 1), faces a number of impacts resulting from SLR, including habitat fragmentation, habitat conversion, complete loss of certain coastal ecosystems and species, and threats to human communities (Weiss et al. in press; Titus et al. 2009). Assessing the vulnerability of natural and human communities

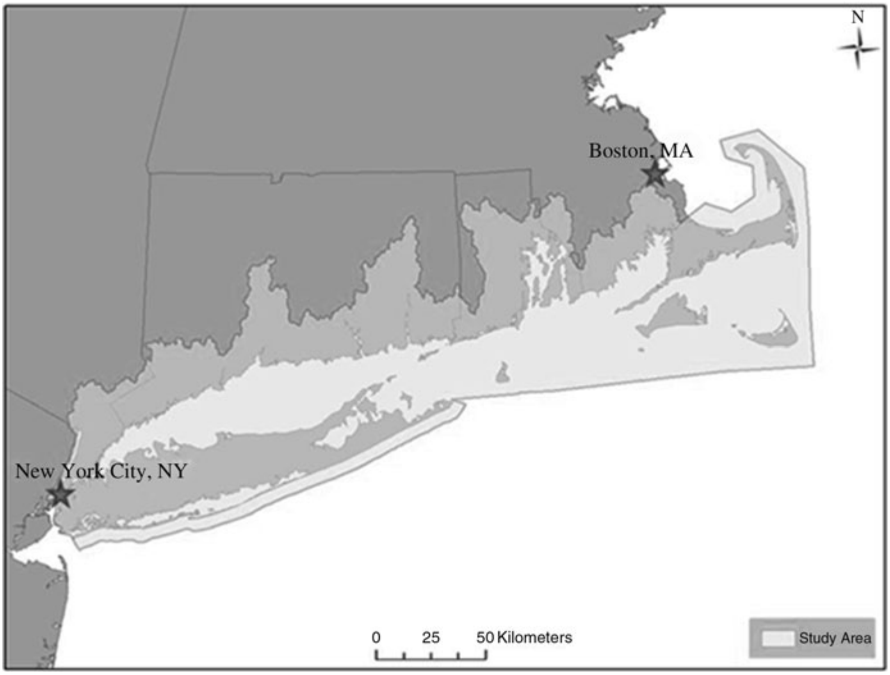


Fig. 1 Study area

from SLR is critical in planning for and adapting to the effects of climate change. To accomplish this, a critical first step is obtaining comprehensive elevation and other coastal zone information. These data, however, are often not available at the resolutions needed to make state and regional governance decisions about climate issues. In the absence of such information, coastal managers may struggle when making required adaptation planning decisions to protect communities and to provide solutions that incorporate both developed and natural infrastructure.

Coastal elevation data have been widely used to quantify the potential effects of SLR; however, the accuracy of the elevation data directly affects the quality and utility of SLR impact assessments (Gesch 2009; Poulter and Halpin 2008; Titus and Wang 2008; Najjar et al. 2000; Kleinosky et al. 2007). Broad-scale (regional and national) delineation of lands vulnerable to SLR using the best-available elevation data often requires integration of state and local data, since the best-available national data set, the National Elevation Dataset (NED; Gesch et al. 2002), does not always include the most up-to-date information. It is especially important to incorporate the most recent elevation data because of the dynamic nature of coastal processes and the rapid pace of development along coastal regions. This is particularly critical in the Southern New England study area, since it contains some of the most highly urbanized estuaries in the USA, such as Long Island Sound, with approximately eight million people living within the watershed (EPA Long Island Sound Study 2007).

The vertical accuracy of the NED has also been found to be inadequate for mapping local, low-level inundation estimates and thus has been deemed unsuitable for local and even regional decision-making (Titus and Wang 2008; Gesch 2009). In the USA, local and state agencies typically collect and maintain the most up-to-date and accurate elevation data, but coastal managers often have trouble effectively integrating these data with federal data due to inconsistent geospatial frameworks such as varying projections, data, and data formats (Gesch and Wilson 2002). Nonetheless, many regional and national studies of coastal environments require seamless topographic data, since hydrologic, demographic, and ecological processes often go beyond the limits of municipal or state boundaries. If forced to choose, many coastal managers have also noted that they favour data consistency over data accuracy for many of their applications (Gesch and Wilson 2002).

The primary purpose of this study is to highlight both the limitations and opportunities of mapping SLR at regional scales across varying elevation data sets to determine whether this information can accurately assess coastal vulnerability to SLR. Previous studies have analysed elevation data in the context of mapping vulnerable coastal areas in the conterminous USA (see review by Gesch et al. 2009), but this study is unique in that it focuses on the challenges and prospects of assessing SLR vulnerability from the perspective of a coastal manager; it is these managers that must make the critical decisions regarding adaptation solutions to climate change. We examined available topographic information consisting of both national- and regional-scale data and assessed the accuracy of disparate elevation data sets. The methodology used in this study was based on previous studies by Gesch (2009) and Gesch and Wilson (2002). Based on our results, we recommend best practices for coastal managers attempting to conduct regional SLR vulnerability assessments in support of climate change adaptation planning efforts. The main objectives of this study were to (1) evaluate potential improvement of a seamless regional elevation data set that was currently available (i.e. the National Elevation Dataset, or NED, from USGS) and compare the mapping of inundation zones using two different approaches to integrating elevation data, and (2) determine achievable SLR projections at which we could accurately and realistically map zones of inundation while spatially illustrating uncertainty. Having the most accurate information possible while accounting for uncertainty gives coastal managers the necessary information to augment their adaptation planning processes with data on climate change.

2 Methods and Results

The process to construct a regional elevation framework to examine coastal vulnerability and adaptation to sea level rise was twofold. First, we evaluated two different integrated elevation data approaches to be used for regional, multi-state SLR inundation mapping. Second, we determined the SLR value to map that was appropriate, based on the elevation data accuracy.

Dataset	Format upon acquisition	Vertical accuracy (RMSE)	Horizontal resolution
National Elevation Dataset(NED)	Grid DEM (multiple sources)	244 cm	10 m
CT LiDAR	Grid DEM (LiDAR derived)	68 cm	3 m
MA DEM	Grid DEM (photogrammetrically derived)	150 cm	5 m
NY Suffolk County DEM	Grid DEM (LiDAR derived)	13 cm	1.5 m
NY Westchester County contours	Contour lines (photogrammetrically derived)	60 cm	5 m
RI Contours	Contour lines (photogrammetrically derived)	20 cm	3 m
RI City DEM	Grid DEM (LiDAR derived)	9 cm	1 m

Fig. 2 Elevation data used in study

We gathered existing digital elevation data that included LiDAR (Light Detection and Ranging) and other data sets, such as the NED, where high-resolution LiDAR data were not available, from a range of federal, state, and local government agencies. We integrated multi-scale, multi-source elevation data sets for the purposes of SLR inundation mapping using an innovative method developed by Gesch and Wilson (2002) (Fig. 2).

This method was employed in an attempt to improve the best-available regional seamless elevation data set by integrating the most up-to-date high-resolution local elevation data, where applicable.

Many types of elevation data sets have been used in previous studies to quantify the potential inundation from SLR (see Gesch et al. 2009). Poulter and Halpin (2008) detail the various approaches used to model sea level rise, ranging from the "bathtub fill" approach to inundating lands that are hydrologically connected to the ocean. The bathtub fill approach simply fills low-lying elevation points. Often this method can create erroneous inundated areas that are not connected to the ocean as all areas equal to or below the given SLR interval become inundated, therefore creating "islands" of inundation. The hydrologically connected approach forces coastal inundation to occur only where low-lying elevation is hydrologically connected to the ocean. It is worth noting that Gesch (2009) stated as follows, "[the] development of large-scale spatially explicit maps presents a new set of challenges. At scales useful for local decision-making, the hydrological connectivity of the ocean to vulnerable lands must be mapped and considered". Though we are in full agreement with this assertion, the time required to adequately condition the DEM to allow for accurate hydrological connectivity was beyond the scope of this project.

We used the bathtub fill approach to identify the most vulnerable lands for a 1-m SLR. It was determined that 1 m was the appropriate SLR interval to map based on the accuracy of the elevation data. In other words, mapping levels smaller than 1 m could not be supported by the data, given the data's vertical accuracy. Expanding on recent work by Gesch (2009), we mapped a 1-m SLR scenario using new methods to spatially illustrate the uncertainty of SLR inundation maps as determined by the input elevation data's vertical accuracy.

2.1 Data Integration

We incorporated attainable local and state, high-resolution elevation data into the best currently available seamless multi-state elevation data set, the National Elevation Dataset (NED). Based on an independent accuracy assessment using US Geological Survey benchmarks, the multi-state seamless elevation data approach from multiple sources was 55% (or 1.25 ft) more accurate than the NED alone (Fig. 3).

Although this integrated approach proved to be successful throughout most of the study area, several areas failed to integrate adjacent data sets of contrasting sources and accuracies. Errors were discovered in cases where two data sets of vastly differing accuracies were brought together (Fig. 3). In these areas, we found that although the reported accuracy of the LiDAR data set in question was very high, several errors in the data set had likely occurred during the LiDAR point classification process. Since we acquired this data set from the end user in raster format, and not from the source of the data, we were unable to correct these errors. We therefore suspect that this LiDAR data set compounded the errors when combining it with the much coarser NED. Thorough examination of LiDAR is important here, and one cannot assume that LiDAR is free of errors because it is of high spatial resolution. Careful examination of high-resolution data is also critical to mapping SLR accurately. The blending procedure can create more errors in the integrated DEM than might be found in the NED without integration.

Even with the above-mentioned erroneous area included in the integrated data set, the overall root mean square error (RMSE) of the integrated data set proved to be 55% more accurate than the seamless NED. It is important to note, however, that because data integration errors can be masked by accuracy assessments derived from point benchmark data, as we found in our study, we recommend the use of additional accuracy assessment metrics in combination with the benchmark data.

Specifically, additional metrics should be able to assess the quality of the overall integrated elevation data set and especially the quality of the blending procedure. For example, cross-sectional transects could be placed along the seams of data sets that are to be blended together. The cross-sectional profiles of the topography would allow comparisons to be made between the most accurate data set (i.e. LiDAR) and the integrated DEM (e.g. a mosaic of the LiDAR and the NED). This additional accuracy assessment metric would also be an effective and rule-based way to determine an appropriate transition zone width for the blending procedure.

Following Gesch and Wilson (2002), blending two disparate elevation data sets requires the identification of a "blending zone" width within which data from each of the two elevation data sets are extracted and interpolated into a new transition zone DEM. The transition zone DEM is composed of elevation values from each of the original disparate DEMs and overlaps both DEMs within the blending zone. The overlapping transition zone DEM is combined with the original DEMs using a blending procedure that forces the output cell values of overlapping areas to be a blend of values. Since the identification of a blending zone width can be somewhat

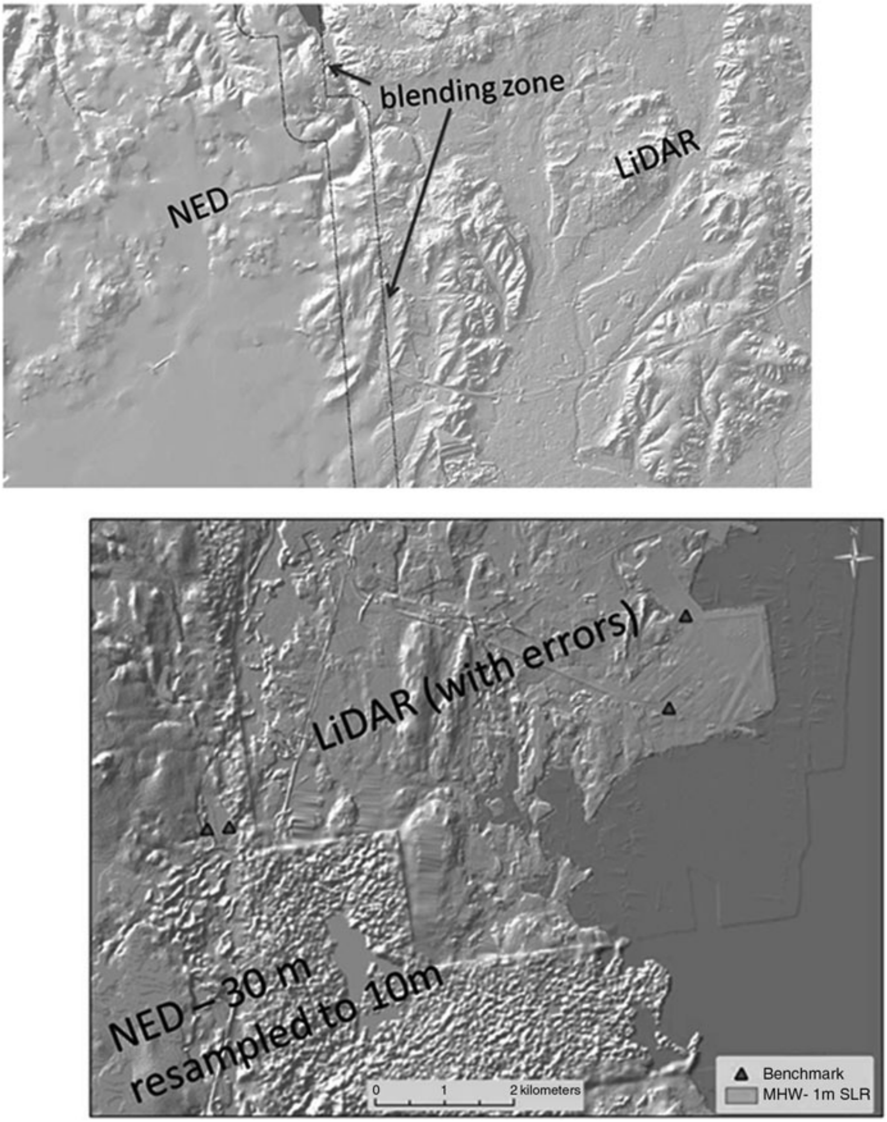


Fig. 3 Successful (*top*) and unsuccessful (*bottom*) integration of elevation data

arbitrary, transects could also be used as a method to test various zone widths to identify the best-fitting zone width via a coefficient of determination (R^2). This would, similar to above, compare the integrated DEM against the most accurate DEM (e.g. LiDAR). This approach would allow users to identify varying transition zone widths, depending on the resolution and accuracies of the input DEMs (Fig. 4).

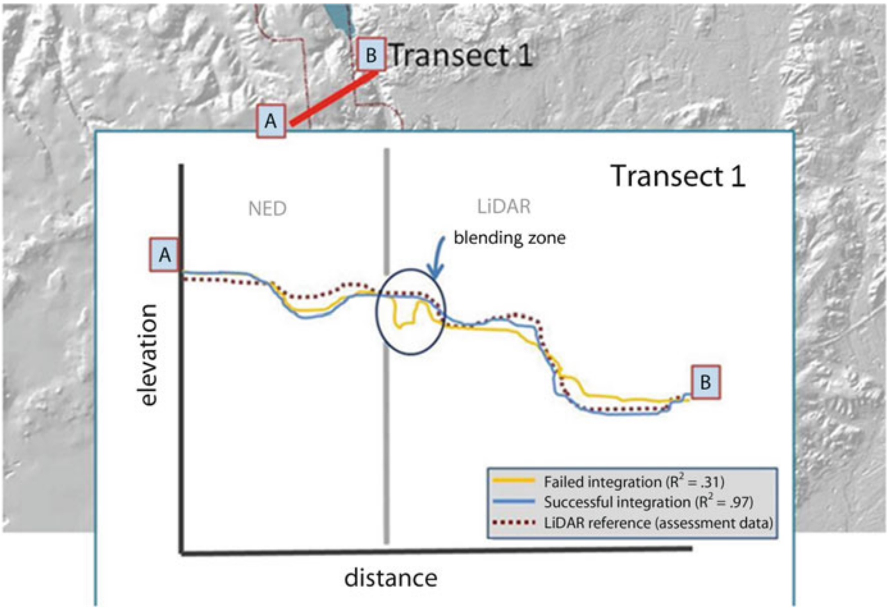


Fig. 4 Transition zone transect accuracy assessment

This study showed that the methods can be used to improve the best currently available multi-state DEM (e.g. NED). Using this methodology, users can update regional DEMs by integrating the most up-to-date and accurate DEMs as they become available. Though this study was tested over a large geographic area, similar methods could also be used for smaller areas where data sets of varying resolutions need to be integrated.

2.2 Sea Level Rise Mapping

Topography data sets such as those used in this study are usually collected for land-based applications and are therefore rarely referenced to tidal data. As we had mapped SLR, transforming the DEMs' datum from NAVD88 to mean high water (MHW) was also necessary. Several tools and techniques have been developed to assist with datum transformations, with the most popular being NOAA's VDATUM. Due to incomplete VDATUM coverage (represented as a point database in coastal waters), a single datum conversion value to go from NAVD88 to mean high water (MHW) was calculated by averaging the difference between both NAVD88 DEMs and MHW in the study area where VDATUM coverage existed. Though this likely introduced errors where local tidal ranges vary from the averaged conversion unit, using alternative methods to adjust for local tidal ranges was beyond the scope of this study (for more information on datum conversions, see NOAA 2009).

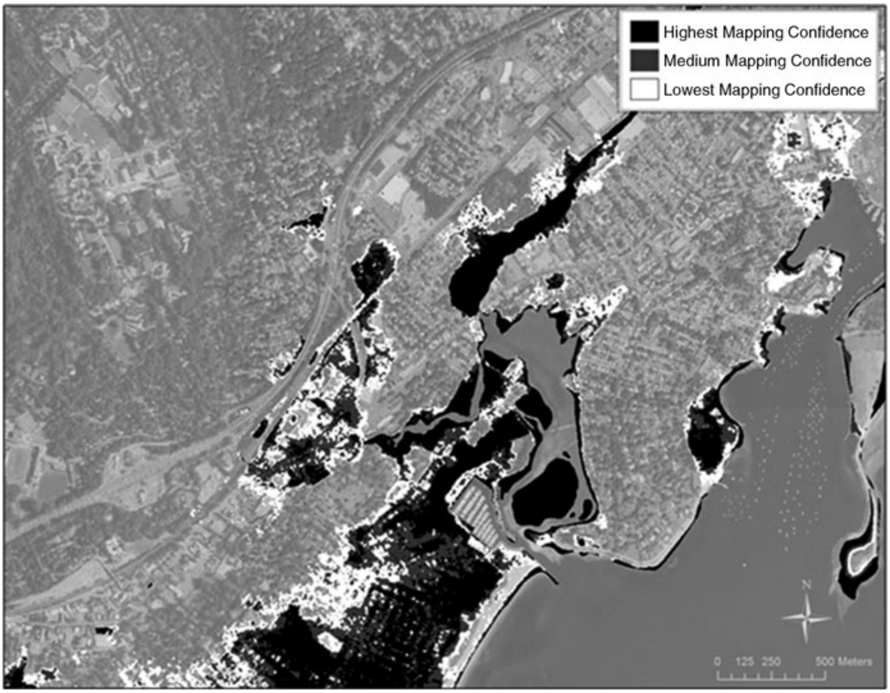


Fig. 5 Sea level rise uncertainty mapping example

Additionally, it was difficult to accurately model hydrologic connectivity while mapping SLR across our study region due to the abundance of bridges and the time required to appropriately condition the DEM (i.e. connecting stream segments through bridges picked up as barriers on the LiDAR). We were therefore constrained to using the "bathtub" SLR mapping approach, leaving low-lying areas upstream of bridges hydrologically unconnected. Given this constraint, we found that the integrated DEM had 7% less inundation than the NED. In other words, since the integrated DEM was more vertically accurate, mapping SLR produced less area of inundation. These findings were expected, since other studies have shown lower-quality elevation data sets to experience higher levels of inundation (Titus and Wang 2008; Gesch 2009). Overall, SLR mapping was more accurate with the integrated DEM, although mapping present-day mean high water (mapping the "0 m" DEM value) was not possible without additional effort because of interpolation errors that occurred during the blending process.

To spatially illustrate the uncertainty associated with mapping a 1-m SLR, we mapped three inundation zones—high, medium, and low—while incorporating the vertical root mean square error (RMSE) of the elevation data in an effort to give users a transparent picture of the variability associated with these elevation data sets (Fig. 5).

RMSE is a measure of precision that calculates the differences between values predicted by a model and the values actually occurring in the data set being modelled. The RMSE is the same accuracy metric used for the assessment of the entire conterminous US NED (Gesch 2007) and is described by Maune et al. (2007).

Gesch (2009) recommends that two inundation zones be mapped as determined by the linear error at the 95% confidence interval in order to spatially illustrate uncertainty. The linear error (LE) is the metric used by the National Standard for Spatial Data Accuracy (see FGDC 1998 for more information). For the 1-m SLR scenario, the zones are as follows:

– High = 1-m SLR + 1.96 × RMSE
– Low = 1-m SLR − 1.96 × RMSE

Although their approach is certainly more cautious, we decided to calculate a third interval using the actual mapped value (e.g. medium = elevation ≤1 m), in addition to using the high and low extents noted above. This was done to provide a "middle ground" SLR estimate. It should also be noted that error can be introduced during the datum conversion process going from NAVD88 to MHW, and where possible, this should be considered here. We modified Gesch's approach and used the following rules to determine the SLR inundation zones:

– High (1 m) = elevation ≤1 m + (1 × RMSE)
– Medium (1 m) = elevation ≤1 m
– Low (1 m) = elevation ≤1 m – (1 × RMSE)

3 Discussion

We should note that if users intend to view or analyse inundation for a specific area, we recommend that they use the single most accurate DEM for modelling SLR and not conduct data integration. This approach would provide the most accurate SLR projection map for that area as it would utilize the most up-to-date elevation data without scaling up high-resolution data to match coarser data. This would also allow the illustration of varying inundation uncertainty zones as determined by the underlying elevation data accuracy. For example, there would be smaller uncertainty inundation zones for more accurate data sets and larger uncertainty zones for less accurate data sets. Additionally, as users moved from one data set to the next, they would be able to visualize the varying uncertainty contained within the underlying elevation data. Following our rule-based SLR mapping method detailed above, low, medium, and high zones would be calculated based on the RMSE for each individual DEM. This approach would create a transparent and accurate representation of potential inundation for decision makers viewing or analysing SLR inundation in a specific geography. However, if a seamless data set is required, we highly recommend the methods outlined above and urge that multiple accuracy assessment metrics be undertaken to ensure accuracy of the DEM blending procedures.

4 Conclusion

The costs to human and natural communities are increasing as coastal development continues and natural buffers, such as coastal wetlands and dunes, are lost. Critical information shortfalls limit the options for coastal managers to address climate change-related risks. Identifying low-lying lands that are likely to be impacted by sea level rise is a paramount first step for coastal climate change adaptation planning. This study provides useful methods for accounting for the accuracy and uncertainty associated with sea level rise (SLR) mapping. The products generated from analyses such as this allow communities to visualize and understand their exposure and vulnerability to climate change impacts and better plan for current and future conditions while considering a range of adaptation solutions. While adaptation to coastal hazards has traditionally focused on using shoreline hardening and engineered defences, ecosystem-based adaptation (EBA) as an alternative and sometimes complimentary approach to built infrastructure is critical to creating human and natural community resilience in the face of climate change. The Coastal Resilience project is designed to facilitate easy access to this information and provide a decision support platform to better inform decision-making and the implementation of EBA approaches. With better information, planners and managers can make climate change adaptation decisions that better protect both human and natural communities.

References

EPA Long Island Sound Study. (2007). *Public perception survey of Long Island Sound watershed residents*. New York: Stony Brook University.

Federal Geographic Data Committee. (1998). *Geospatial positioning accuracy standards part 3: National standard for spatial data accuracy*. Subcommittee for Base Cartographic Data. http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3

Ferdaña, Z. A., Newkirk, S., Whelchel, A., Gilmer, B., & Beck, M. W. (2010). Adapting to climate change: Building interactive decision support to meet management objectives for coastal conservation and hazard mitigation on Long Island, New York, USA. In A. Andrade Pérez, B. Herrera Fernandez, & R. Cazzolla Gatti (Eds.), *Building resilience to climate change: Ecosystem-based adaptation and lessons from the field* (164 pp). Gland: IUCN. http://data.iucn.org/dbtw-wpd/edocs/2010050.pdf

Gesch, D. B. (2007). The National Elevation Dataset. In D. Maune (Ed.), *Digital elevation model technologies and applications: The DEM users manual* (2nd ed., pp. 99–118). Bethesda: American Society for Photogrammetry and Remote Sensing.

Gesch, D. B. (2009). Analysis of Lidar elevation data for improved identification and delineation of lands vulnerable to sea-level rise. *Journal of Coastal Research, 53*, 49–58.

Gesch, D. B., & Wilson, R. (2002). Development of a seamless multisource topographic/bathymetric elevation model of Tampa Bay. *Marine Technology Society Journal, 35*, 58–64.

Gesch, D. B., Oimoen, M., Greenlee, S., Nelson, C., Steuck, M., & Tyler, D. (2002). The National Elevation Dataset. *Photogrammetric Engineering and Remote Sensing, 68*, 5–11.

Gesch, D. B., Gutierrez, B. T., & Gill, S. K. (2009). Coastal elevations. In *Coastal sensitivity to sea-level rise: A focus on the Mid-Atlantic region*. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [Titus, J. G. (coordinating lead author), Anderson, K. E, Cahoon, D. R., Gesch, D. B., Gill, S. K., Gutierrez, B. T., Thieler, E. R., Williams, S. J.(lead authors)]. Washington DC: U.S. Environmental Protection Agency, pp. 25–42.

Hu, A., Meehl, G. A., Han, W., & Yin, J. (2009). Transient response of the MOC and climate to potential melting of the Greenland Ice Sheet in the 21st century. *Geophysical Research Letters, 36*, L10707. 6 p.

IPCC [Intergovernmental Panel on Climate Change]. (2008). *Climate change 2007: Synthesis report*. Geneva: Intergovernmental Panel on Climate Change.

Kleinosky, L. R., Yarnal, B., & Fisher, A. (2007). Vulnerability of Hampton Roads, Virginia to storm-surge flooding and sea-level rise. *Natural Hazards, 40*, 43–70.

Maune, D. F., Maitra, J. B., & McKay, E. J. (2007). Accuracy standards and guidelines. In D. F. Maune (Ed.), *Digital elevation model technologies and applications: The DEM users manual* (2nd ed., pp. 65–97). Bethesda: American Society for Photogrammetry and Remote Sensing.

Najjar, R. G., Walker, H. A., Anderson, P. J., Barron, E. J., Bord, R. J., Gibson, J. R., Kennedy, V. S., Knight, C. G., Megonigal, J. P., O'Connor, R. E., Polsky, C. D., Psuty, N. P., Richards, B. A., Sorenson, L. G., Steele, E. M., & Swanson, R. S. (2000). The potential impacts of climate change on the mid-Atlantic coastal region. *Climate Research, 14*, 219–233.

National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center. (2009). *Coastal inundation mapping guidebook*. Charleston, SC, USA. http://www.csc.noaa.gov/digitalcoast/inundation/_pdf/guidebook.pdf

Nicholls, R. J., Marinova, N., Lowe, J. A., Brown, S., Vellinga, P., de Gusmão, D., Hinkel, J., & Tol, R. S. J. (2011). Sea-level rise and its possible impacts given a 'beyond 4°C world' in the twenty-first century. *Transactions of the Royal Society, 369*, 161–181.

Pfeffer, W. T., Harper, J. T., & O'Neel, S. (2008). Kinematic constraints on Glacier contributions to 21st century sea-level rise. *Science, 321*, 1340–1343.

Poulter, B., & Halpin, P. N. (2008). Raster modeling of coastal flooding from sea-level rise. *International Journal of Geographical Information Science, 22*(2), 167–182.

The Nature Conservancy (TNC). (2011). *Coastal resilience: Adapting natural and human communities to sea level rise and coastal hazards*. www.coastalresilience.org

Titus, J.G., & Wang, J. (2008). Maps of lands close to sea level along the Middle Atlantic Coast of the United States: An elevation data set to use while waiting for LiDAR. Section 1.1. In J. G. Titus & E. M. Strange (Eds.), *Background documents supporting climate change science program synthesis and assessment product 4.1*, EPA 430R07004. Washington, DC: U.S. EPA.

Titus, J. G., Hudgens, D. E., Trescott, D. L., Craghan, M., Nuckols, W. H., Herschner, C. H., Kassakian, J. M., Linn, C. J., Merritt, P. G., McCue, T. M., O'Connell, J. F., Tanski, J., & Wang, J. (2009). State and local governments plan for development of most land vulnerable to rising sea level along the U.S. Atlantic coast. *Environmental Research Letters, 4*, 1–7.

Vermeer, M., & Rahmstorf, S. (2009). Global sea level linked to global temperature. *Proceedings of the National Academy of Sciences of the United States of America, 106*, 21527–21532.

Weiss, J. L., Overpeck, J. T., & Strauss, B. (2011). Implications of recent sea level rise science for low-elevation areas in coastal cities of the conterminous U.S.A. *Climatic Change, 105*, 635–645.

Yin, J., Schlesinger, M. E., & Stouffer, R. J. (2009). Model projections of rapid sea-level rise on the Northeast Coast of the United States. *Nature Geoscience*. doi:10:10.1038/NGEO462.

Quantifying Impacts of Potential Sea-Level Rise Scenarios on Irish Coastal Cities

Stephen Flood and John Sweeney

Abstract This chapter explores the potential economic impacts of sea-level rise (SLR) on the Irish coast, with a special focus on coastal cities. A first pass estimate of potential economic impacts is developed through the use of an Irish digital terrain model (DTM) in conjunction with a geocoded directory of Irish property addresses and historical Irish flood insurance claims data. Potential land inundation impacts and land class vulnerabilities are also presented. The headline results indicate that approximately 350 km^2 of land is vulnerable under a 1-m SLR jumping to 600 km^2 at 3 m. Potential economic costs relating to property insurance claims are in the region of €1.1 billion under a 1 m scenario increasing to over €2.1 billion with a 3 m scenario. These modelled outputs could be used by Irish local government authorities as inputs when developing their local adaptation plans. They also highlight the importance of fully implementing an Integrated Coastal Zone Management (ICZM) approach to foster Irish coastal resilience.

Keywords Economic impacts • Geographical information systems (GIS) modelling • Sea-level rise • Storm surge • Vulnerability assessment

1 Introduction: Sea-Level Rise in the Global Context

This chapter opens by outlining the physical science basis for global SLR projections followed by a review of the economic impacts associated with these potential SLR scenarios. Section 2 positions global SLR in an Irish context. Section 3 presents the results of Irish SLR modelling carried out for this study including potential land inundation as well as disaggregated land class impacts, grid

S. Flood (✉) • J. Sweeney
Irish Climate Analysis and Research UnitS (ICARUS), National University of Ireland, St. Annes, North Campus, Maynooth, County Kildare, Ireland
e-mail: Stephen.flood.2009@nuim.ie; john.sweeney@nuim.ie

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_5,

referenced property mapping and potential claims costs. This chapter concludes with some headline results and recommendations for policy makers and further work.

When examining climate change impacts at a global scale, SLR emerges as an issue of significant concern. It currently contributes (and has the potential to increasingly contribute) to infrastructural damages resulting from coastal flooding, losses of coastal wetlands and mangroves, along with the impacts of coastal erosion and deposition (IPCC 2007a). Global sea level rose at an average rate of 1.8 mm per year over 1961–2003 and at an average rate of 3.1 mm per year from 1993 to 2003 (IPCC 2007b). It is unclear whether the faster rate for 1993–2003 reflects decadal variation or an increase in the long-term trend. Since 1993, 57% of the sea-level rise has been attributed to thermal expansion of the oceans, 28% to decreases in glaciers and ice caps, with polar ice sheet loss from Greenland and Antarctica contributing the remainder (IPCC 2007b). The IPCC Fourth Assessment Report states that due to the limited understanding of some of the important effects driving sea-level rise, a best estimate or future upper bound for sea-level rise cannot be provided. Rahmstorf, in his SLR modelling work, also concedes that the scientific community does not yet hold a full physical understanding of sea-level rise. Moreover, he argues that the uncertainty in future sea-level rise is probably larger than previously estimated. His projections suggest that a rise of over 1 m by 2100 for strong warming scenarios cannot be ruled out as long as the relationship between the rate of sea-level rise and temperature remains consistent in the twenty-first century (Rahmstorf 2007). Work by Overpeck et al. (2006) exploring potential SLR from melting polar ice sheets suggests that polar warming may reach levels similar to those of 130,000–127,000 years ago by 2100. This could result in SLR between 4 and 6 m above present levels.

A number of studies explore SLR impacts in conjunction with storm surges on coastal cities at a global level. Results indicate that there is a significant concentration of highly vulnerable large cities in regions with some of the lowest global income distributions; that is, low income populations are likely to suffer the worst (Dasgupta et al. 2009).[1] GDP losses (above the current 1 in 100 year reference standard) totalled €63 billion in East Asia and the Pacific region, €9 billion for the Middle East and North Africa, €6.2 billion in South Asia, €11 billion in Latin America and the Caribbean and €1.3 billion in Sub-Saharan Africa (Dasgupta et al. 2009).

In a 2007 study of coastal exposure (Nicholls et al. 2007), it is estimated that about 40 million people worldwide[2] are exposed to a 1-in-100-year coastal flood event. By the 2070s, this figure could triple to 150 million people. This increase takes the combined effects of climate change (SLR and increased storminess), population growth, subsidence and urbanization into consideration (Nicholls et al. 2007).

---

[1] A homogenous future increase in extreme water levels during storms of 10% and a sea-level rise of 1 m were used to derive the results. The paper employed the methodology set out by Nicholls et al. (2007) for exploring a 1-in-100-year combined storm surge and sea-level rise impact. Potential GDP losses refer to the population and assets that are threatened, taking no account of any defences.

[2] The study focuses on 136 port cities around the world that had more than one million inhabitants in 2005.

Total assets exposed by the 2070s could reach a total of around €25,900 billion, more than ten times the current level of exposure. However, the key distinction between exposure and impact should be noted. Two cities with equal exposure may experience very different impacts depending on the protection measures in each; developed economy cities normally have higher levels of protection than those in the developing world. While population growth and increased urbanization are the most significant factors in driving the overall increase in exposure, climate change and subsidence can significantly intensify the effect depending on the location (Nicholls et al. 2007).

2 Sea-Level Rise in the Irish Context

The Irish coastline is 4,577 km in length. More than 50% of the population lives within 15 km of the coast, and most of the population is concentrated in the major coastal cities of Dublin, Cork, Limerick and Galway.[3] Coastal exposure is the cumulative result of a number of significant factors including: climate-induced SLR, tidal variation, wave climate, currents and non-periodic water movement such as storm surges. In Ireland, post-glacial isostatic rebound (resulting in SLR of a lesser magnitude in the northern half of Ireland compared to the south) and coastal geomorphological composition are additional factors to consider (Carter et al. 1989).

There is a strong topographical variation between the coasts of the Atlantic Ocean and the Irish Sea. The Atlantic coastline is defined by a high relief of approximately 500 m and rocky cliffs interspersed with bays (European Commission 2009). This rock-dominated coastline characterizes the south-western, western and northern coastal regions of Ireland (Devoy 2008). By contrast, the Irish Sea (east) coast is mainly low lying with non-consolidated sediment and glacial tills. Approximately 20% of Ireland's entire coast is at risk of erosion (European Commission 2009), with sea-level rise already having a significant impact on the soft boulder clay coasts of the east in the form of erosion. Currently, coastal defences protect only about 4% of the Irish coastline (Devoy 2008). Counties Dublin, Down, Louth, Wexford and Wicklow (all situated on the softer Irish Sea east coast) are where retreat is occurring fastest, with coastal erosion rates exceeding 3 m per year in extreme cases. The west and south display increased vulnerability to sea-level rise primarily at low-lying bays and estuaries, such as Cork Harbour (on the south coast), Clew Bay, Tralee Bay and especially the Shannon Estuary (all on the west coast) (Devoy 2008; Sweeney et al. 2008).

[3]Dublin is situated on the east coast of Ireland at the mouth of the Liffey River with a population of 1.5 million including the suburban areas. Cork is situated on the south-west coast at the mouth of the Lee River with a population of 120,000. Limerick is on the west coast at the mouth of the Shannon River with a population of 100,000. Galway, also on the west coast, lies at the mouth of the Corrib River with a population of just over 70,000.

The wave climate[4] is dominated by the Atlantic Ocean input via St. George's Channel and to a limited extent via the North Channel. Atlantic depressions generate significant local westerly storm waves as well as the significant Atlantic swell input into the Irish Sea (Orford 1989). Sea surges can be defined as the difference between predicted and observed still water levels usually measured at high tide. Spring tides (high tides) occur every 14 days around the time of the new and full moons when the gravitational pull of the sun and moon are aligned (Farrell 2007). Irish Sea surges are associated with the movement of major Atlantic depressions over the Irish Sea basin (Orford 1989; Robinson 1979). The extreme 50-year surge heights are approximately 1–2 m on the west coast of the United Kingdom and 1–1.5 m on the Irish coast (Orford 1989; Lennon 1963a, b). Sea surge events will increase on Irish coastal areas over the next decades with ocean modelling results indicating an increase in both the frequency and height of extreme storm surges (in excess of 1 m) (Orford 1989). As a result of tropical sea surface temperatures, there is a strong probability that tropical cyclones will intensify (Arndt et al. 2010). The tails of these storms can rejuvenate while they cross the Atlantic, as they pass over the warmer surface temperatures in the Gulf Stream, and lead to significant increase in wave heights on Irish waters. The most extreme surges will occur over the winter periods and on the west coast. The height of extreme waves (e.g. the 10-year return values) also show up to a 10% increase on the northwest coast. Modelled data suggests that 1-in-100-year coastal flood events are likely to become 1-in-10-year events (McGrath and Lynch 2008).

3 Irish Sea-Level Rise Modelling and Results

Figure 1 presents the output of SLR modelling carried out for this study on the Irish coast. The modelling is based on a digital terrain model (DTM) of the Irish Republic produced by the Irish Environmental Protection Agency at a 20-m scale resolution. The resolution of the DTM is not sufficient for modelling sea-level change in a detailed manner at a very local level as there are significant errors in the vertical projections of the model (Coveney et al. 2010; Gornitz et al. 2002). Despite this, a number of studies have been carried out using such medium resolution DTMs for regional or national assessments (Dobosiewicz 2001; European Environment Agency 2006; Li et al. 2009). The modelled output does not account for existing Irish coastal defences. However, this qualification is not especially limiting as currently less than 4% of Ireland's coast is protected by built shore structures (Devoy 2008). This study is thus framed as a first national estimate exploring some of the potential economic impacts of sea-level rise and storm surges on the Irish coastline.

[4]A wave climate is composed of four items: characteristic wave height and characteristic wave period distributions, direction of wave approach and duration of wave conditions.

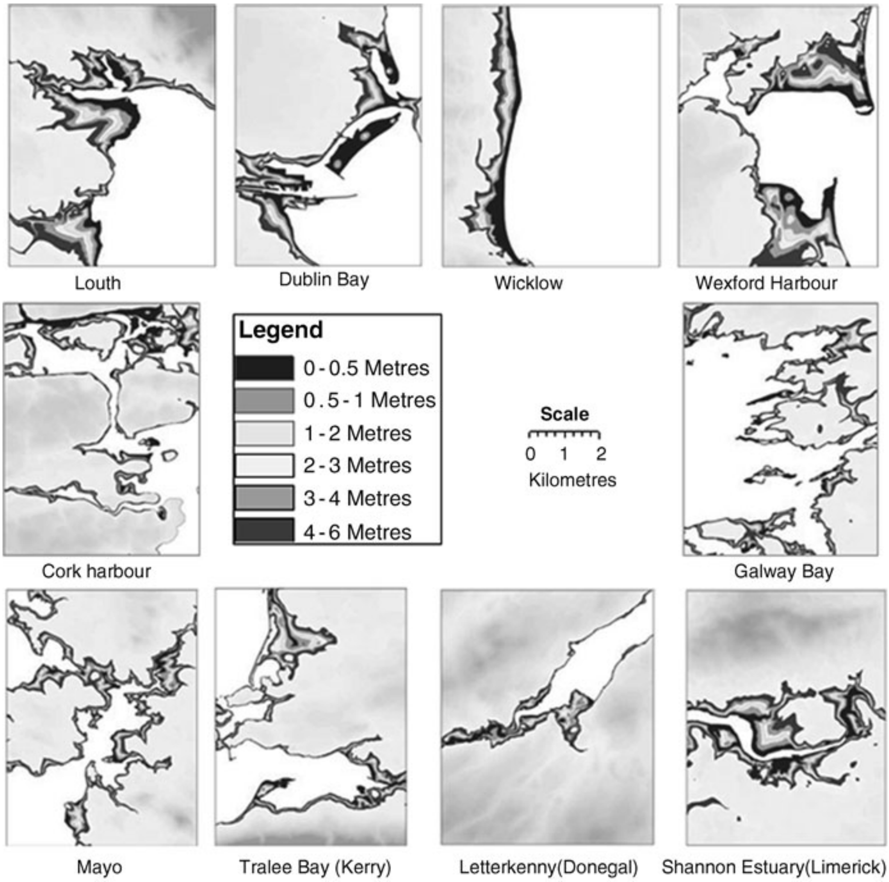


Fig. 1 Sea-level rise scenarios on the Irish coast employing a digital terrain model

The modelling uses six projected scenarios from 0.5 to 6 m (0.5, 1, 2, 3, 4 and 6 m) drawn from the envelope of possible SLR and storm surge scenarios in the literature (Rahmstorf 2007; IPCC 2007a, b; Church and White 2006; Overpeck et al. 2006; Hoozemans et al. 1993). Every century, there is a surge elevation on the eastern Irish coast in the region of 1–1.5 m (Orford 1989). Initially, the area of potential vulnerability to SLR was calculated from the DTM projections. Figure 2 displays the total area vulnerable to SLR/storm surges in the 15 coastal countries under the six scenarios. It ranges from 200 km^2 to close to 1,200 km^2 under the sixth (6 m) scenario. Figures 3 and 4 display the vulnerable land in the counties of Leinster and Munster.

The values should not be considered exact but rather display the relative magnitude of potential impacts. Counties Wexford, Dublin and Louth face the greatest potential losses in the province (or region of) Leinster with counties Kerry,

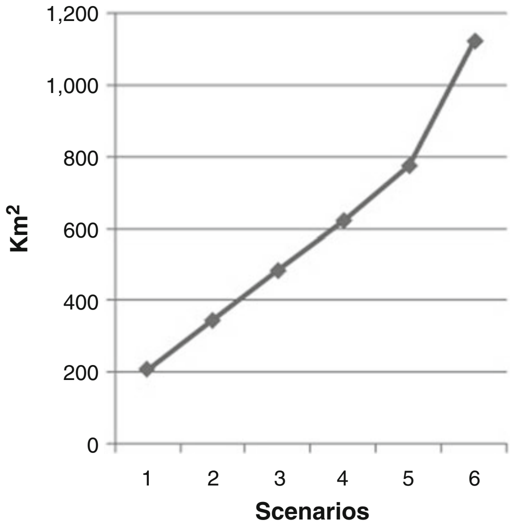


Fig. 2 Total vulnerable area under six scenarios

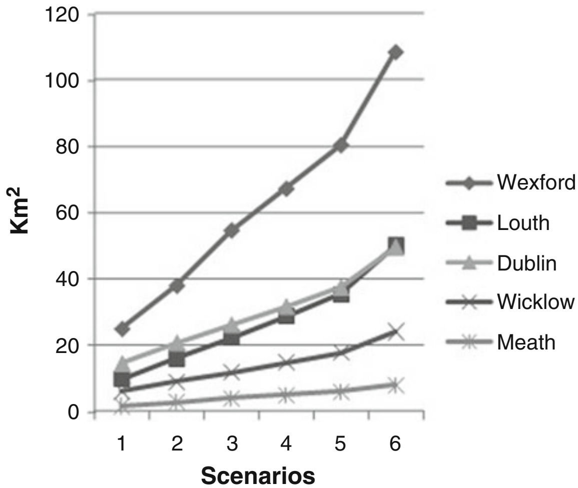


Fig. 3 Vulnerable area of counties in Leinster under six scenarios

Cork and Clare facing the greatest losses in the region of Munster. Figure 5 displays vulnerable land for the Connaught region along with county Donegal. Here one can see that counties Donegal, Galway and Mayo are the most vulnerable. Table 1 displays the vulnerable percentage of land in each coastal county. Louth, Dublin and Wexford are the counties facing the greatest percentage losses ranging from over 1% in the first scenario to over 6% in the sixth.

Building on the initial modelling of vulnerable land areas, the An Post GeoDirectory (a database listing all postal addresses in the Irish republic along with associated x, y coordinates) was then used in conjunction with the projected sea-level scenarios to estimate the number of addresses that would be potentially impacted under a

Fig. 4 Vulnerable area of counties in Munster under six scenarios

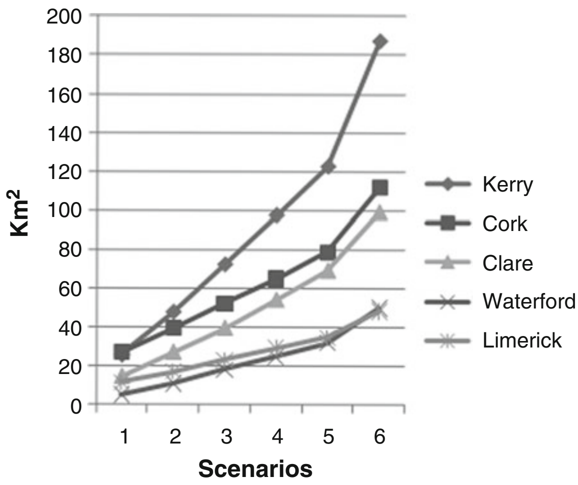
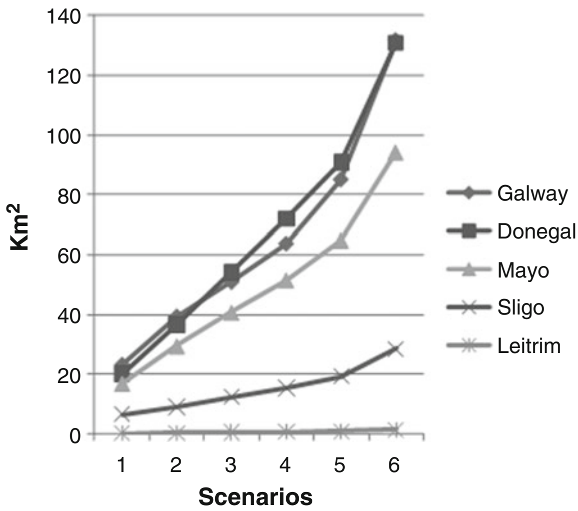


Fig. 5 Vulnerable land in Connaught region under six scenarios along with Donegal



SLR/storm surge event. Address points were first screened to remove vacant and derelict addresses before being considered in the analysis. Addresses were classified as residential, commercial and joint use premises. Figure 6 presents a representation of the Dublin Bay area displaying residential and commercial addresses overlaid on the six sea-level rise scenarios. Figure 7 displays the number of addresses and their composition in each coastal county. Figure 8 displays all vulnerable addresses in all coastal counties. Dublin, Cork and Galway have the most vulnerable addresses ranging from 500 addresses in Galway, 5,000 in Dublin and over 6,000 in Cork under the first scenario. Using the information on vulnerable addresses, determined from the modelling results and in conjunction with the flood claim costs, a generalized damage cost estimate of SLR and storm surge events was calculated. Figures released by the Irish Insurance Federation (Irish Insurance Federation 2010)

Table 1 Vulnerable percentage of land in each county under the six scenarios

Sea level rise scenarios						
	0.5 m	1 m	2 m	3 m	4 m	6 m
Provinces/counties						
Leinster	Vulnerable percentage of land per county					
Louth	1.2	2	2.7	3.5	4.3	6.1
Meath	0.1	0.1	0.2	0.2	0.3	0.3
Dublin	1.6	2.2	2.8	3.4	4	5.4
Wicklow	0.3	0.4	0.6	0.7	0.9	1.2
Wexford	1.1	1.6	2.3	2.8	3.4	4.6
Munster						
Waterford	0.3	0.6	1	1.3	1.7	2.7
Cork	0.4	0.5	0.7	0.9	1.1	1.5
Kerry	0.5	1	1.5	2.1	2.6	4
Limerick	0.4	0.6	0.9	1.1	1.3	1.8
Clare	0.5	0.8	1.2	1.7	2.1	3.1
Connaught						
Galway	0.4	0.6	0.8	1	1.4	2.2
Mayo	0.3	0.5	0.7	0.9	1.2	1.7
Sligo	0.4	0.5	0.7	0.8	1.1	1.6
Leitrim	0	0	0	0	0.1	0.1
Ulster						
Donegal	0.4	0.8	1.1	1.5	1.9	2.7

in 2010 uncovered the insurance costs relating to flood damages from the 2009 substantial November flood events (see Table 2). The majority of the November flood costs were realized in Munster, the West and the Midlands. The three counties that were hit the worst were Cork, Galway and Clare.

Using the figures as a guideline, an approximate average estimate of costs per claim was calculated for residential and commercial properties. Residential was approximated at €16,500 and commercial at €100,000. Joint use properties were estimated at €50,000. Table 3 displays the potential claim cost for all claims under each of the scenarios. However, it must be noted that the nature and time frame of any SLR or storm surge event will reflect on the typical insurance claim costs. These costs should therefore be considered as the potential costs that would occur if any one of these scenarios transpired in the medium term without significant adaptation measures put in place. It must also be noted that the figures from Table 3 relate to damage and repair costs associated with inland flooding events. They do not refer to total replacement costs or account for damage from potential sea water inundation. Under the first scenario, one can see that Cork and Dublin would be impacted to the greatest extent with projected costs of €321 million and €170 million respectively. Using the 2006 Central Statistics Office POWCAR dataset,[5] the economic sectors

[5]The 2006 Census, Place of Work—Census of Anonymised Records (POWCAR) compiled by the Central Statistics Office, Ireland.

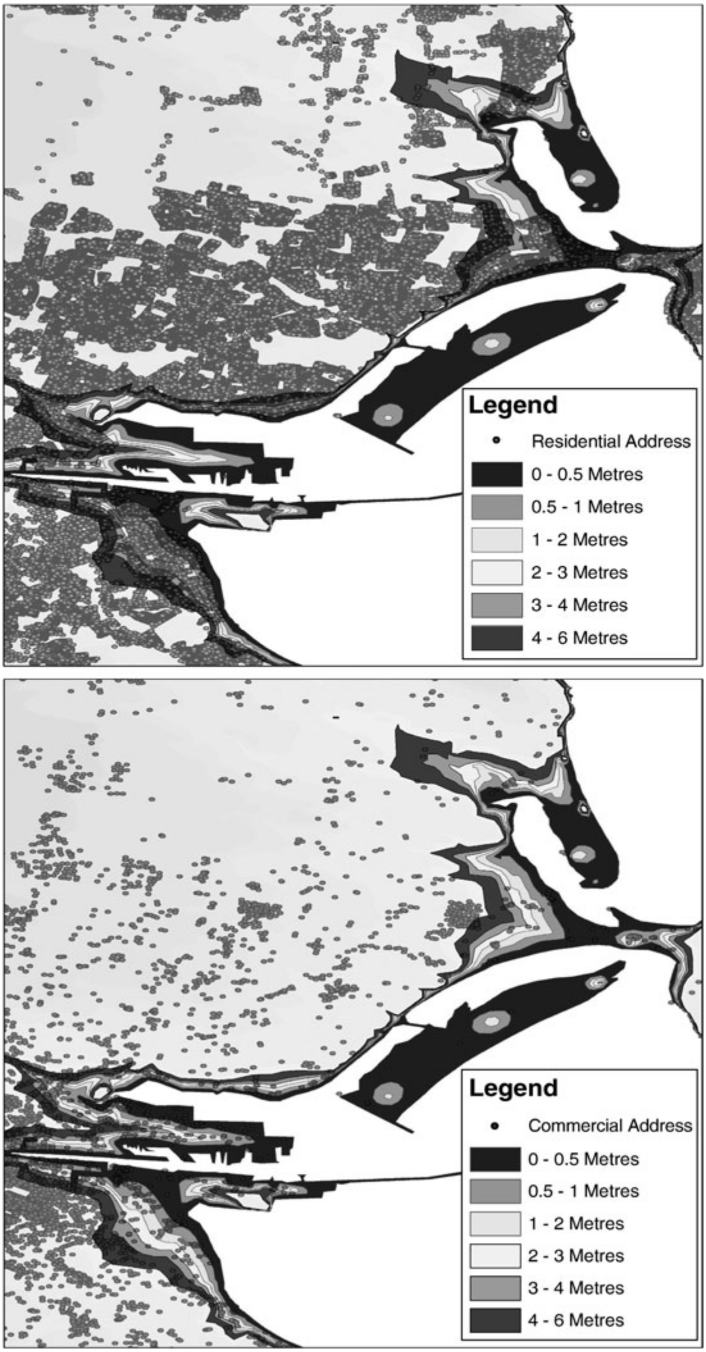


Fig. 6 Residential and commercial addresses displayed over sea-level scenarios in Dublin bay area

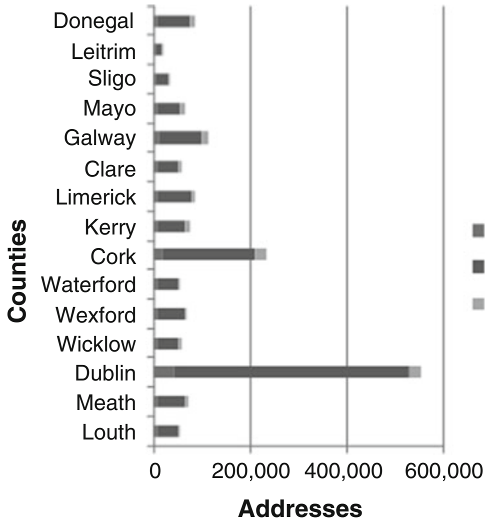


Fig. 7 Total addresses in each coastal county

potentially impacted in each county from potential SLR or storm surge events were calculated. The economic sector that provided the greatest level of employment in each of the coastal electoral divisions[6] was determined, and results are presented in Table 4.

Utilizing the 2006 Corine Land Class[7] (CLC) map, potentially vulnerable land was disaggregated into four land classes: urban fabric, agriculture, industrial or commercial and forest. Urban fabric is made up of both continuous and discontinuous urban areas. Agriculture is composed of non-irrigated arable land, pastures, complex cultivation as well as land principally occupied by agriculture with areas of natural vegetation. Industrial or commercial land is not disaggregated any further. Forest is broken down into broad leaved forest, coniferous forest and mixed forest. Figure 9 presents the areas taken up by these four land classes for each of the coastal counties in the Irish Republic.

Figure 10 displays the vulnerable area of land for each of the four mapped land classes with a log scale ($\log_{10}$). Agriculture potentially faces the greatest vulnerabilities in terms of km^2 land area ranging from approximately 120 km^2 under scenario 1 up to 796 km^2 under scenario 6. Urban fabric is next in terms of vulnerable land. Potential impacts here range from 15 km^2 under the first scenario

---

[6]Electoral divisions (formally known as District Electoral Division pre 1994) are low-level territorial divisions in Ireland. There are 3,440 electoral divisions in the Irish Republic.

[7]CORINE (**Coor**dination of **In**formation on the **E**nvironment) Land Cover (CLC) is a geographic land cover/land use database encompassing most of the countries of the European community.

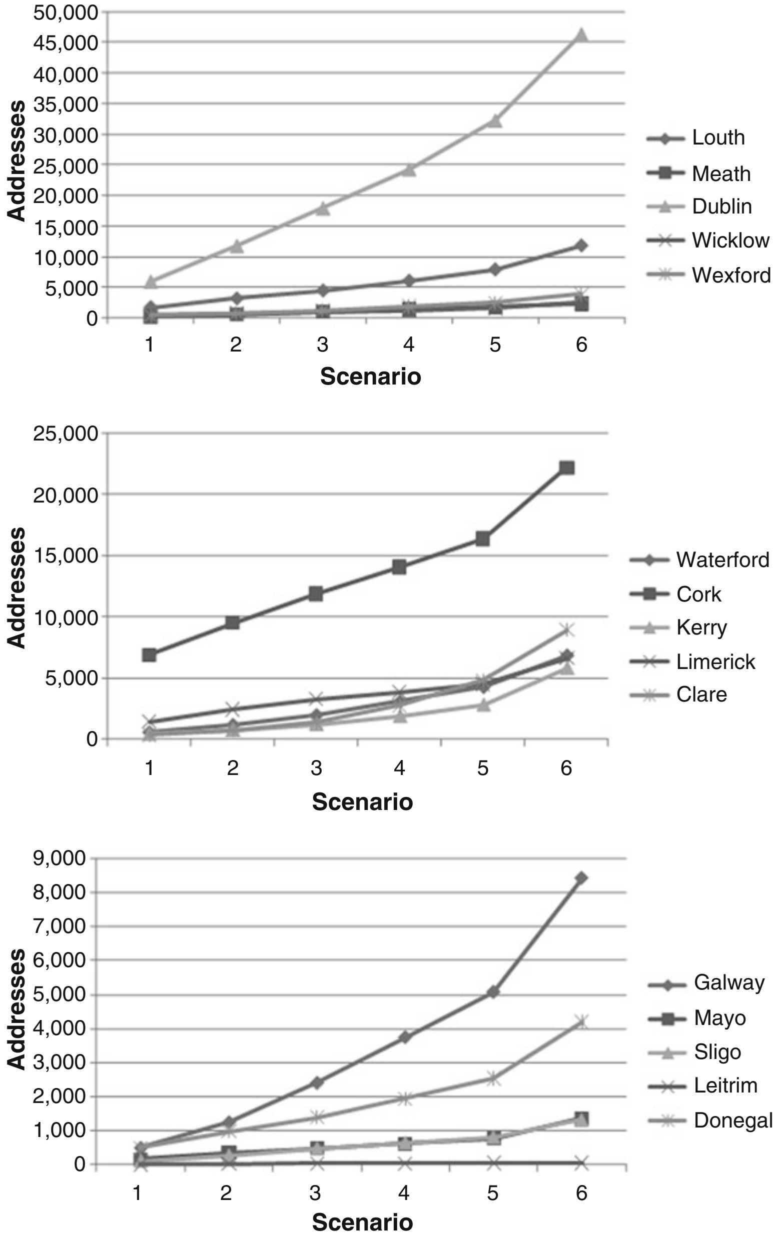


Fig. 8 Total vulnerable addresses in each coastal county under the six scenarios

up to 75 under the sixth. Industrial and commercial along with forestry face the lowest potential km^2 land area impacts ranging from over 3 km^2 for both under scenario 1 and up to 18 km^2 for industrial and or commercial and 20 km^2 for forest under scenario six.

Table 2 Cost of November 2009 flooding by claim type

Claim type	No of claims	Cost of claims
Household	4,629	€76.8 m
Commercial property	1,541	€158.9 m
Motor	2,344	€8.2 m
Total	8,514	€243.9 m

Table 3 Potential insurance claims for all coastal counties under six scenarios

Sea level rise scenarios						
	0.5 m	1 m	2 m	3 m	4 m	6 m
Provinces/counties						
Leinster	€ (millions) for all claims					
Louth	48	90	125	172	221	331
Meath	6	13	23	31	39	49
Dublin	170	339	513	678	898	1343
Wicklow	19	26	33	45	58	90
Wexford	13	25	40	62	83	131
Munster						
Waterford	21	42	74	109	149	231
Cork	321	432	525	608	692	865
Kerry	13	21	34	51	76	166
Limerick	58	86	112	129	150	210
Clare	10	21	39	73	133	255
Connaught						
Galway	14	37	63	98	138	265
Mayo	6	12	15	19	23	41
Sligo	5	13	20	28	35	56
Leitrim	0	0	0	0	0	1
Ulster						
Donegal	21	42	57	79	97	154
Total	725	1,199	1,673	2,182	2,792	4,188

4 Conclusion

This work demonstrates that the phenomena of SLR and storm surges are tangible drivers of coastal vulnerabilities in the form of potential land loss and capital loss in the Irish Republic. The headline results indicate that approximately 350 km^2 of land is vulnerable under a 1-m SLR jumping to 600 km^2 at 3 m. Potential economic costs relating to property insurance claims are in the region of €1.1 billion under a 1-m scenario increasing to over €2.1 billion with a 3-m scenario.

These coastal vulnerability impact results could be used by Irish local government authorities as inputs when developing their local adaptation plans. Currently, without a national adaptation plan, there are limited planned adaptation actions at a local level in Ireland. However, some pioneering local authorities, and city managers, have made limited headway in relation to climate change and adaptation

Table 4 Number one ranked economic sector in each coastal ED by county from 2006 POWCAR

Number one ranked economic sector in each coastal ED by county		
Provinces/counties	Economic sectors	Jobs
Leinster		
Louth	Retail trade	2,214
Meath	Food products beverages	431
Dublin	Real estate, renting and business activities	22,472
Wicklow	Health and social work	2,117
Wexford	Retail Trade	2,093
Munster		
Kilkenny	Wood and wood products	135
Waterford	Health and social work	2,413
Cork	Chemicals and chemical products	3,847
Kerry	Health and social work	2,174
Limerick	Electrical and optical equipment	5,813
Clare	Hotels and restaurants	671
Connaught		
Galway	Hotels and restaurants	3,396
Mayo	Hotels and restaurants	1,146
Sligo	Health and social work	3,588
Leitrim	Agriculture and forestry	8
Ulster		
Donegal	Hotels and restaurants	2,246

planning. A select few have included a number of climate-change-related measures in their local development plans in the absence of any specific state requirements to do so (Flood and NiChiardubhain 2008). Measures include the development of sustainable urban drainage systems (SUDS) and specific planning restrictions in vulnerable coastal zones. It is clear that to implement more widespread measures, a more coordinated approach is needed. The County and City Managers Association (CCMA), the representative body for senior managers in Irish local government, has direct links with central government through its environmental committee. This body may be a useful vehicle for sharing best practice adaptation actions within Irish local governments and for coordinating with central government in furthering adaption planning at a local level (McGloughlin 2011).

These impact results also highlight the importance of the full implementation of Integrated Coastal Zone Management (ICZM) in Ireland, which incorporates the development of a coastal flood early warning system.[8] In addition, significant resources and structures should be made available, going into the future, so that

[8]Integrated Coastal Zone Management (ICZM) or Integrated Coastal Management (ICM) is a process for the management of the coast using an integrated approach, regarding all aspects of the coastal zone, including geographical and political boundaries, in an attempt to achieve sustainability. This concept was born in 1992 during the Earth Summit of Rio de Janeiro.

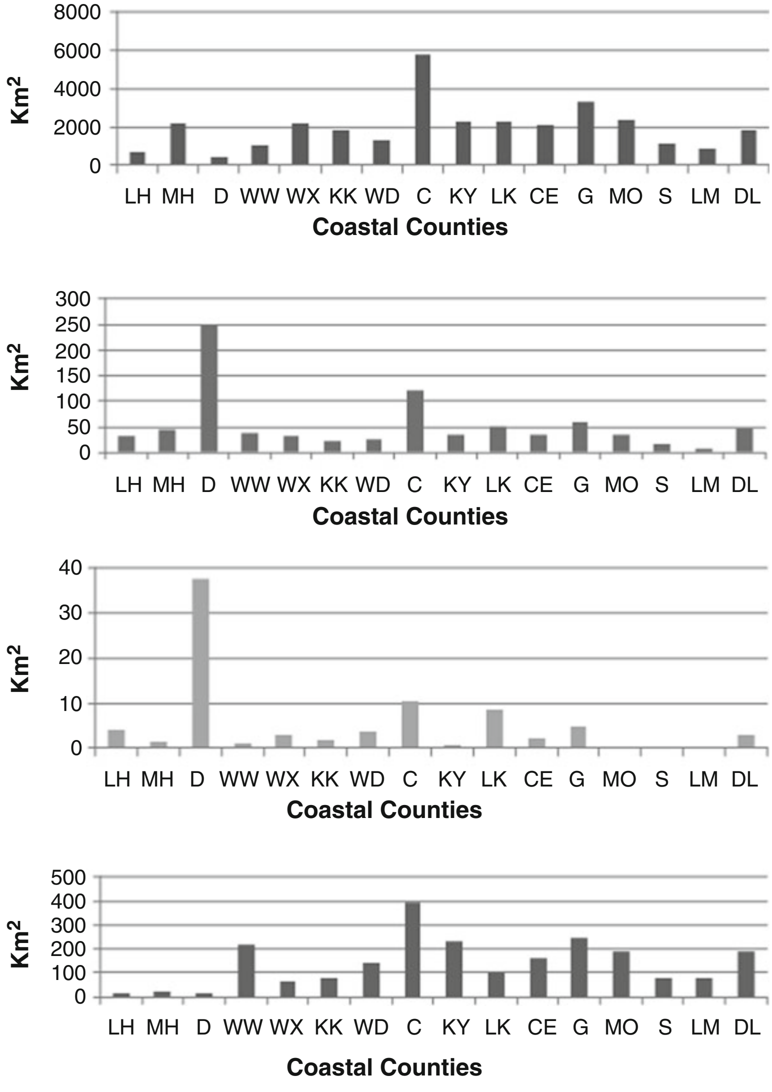


Fig. 9 Land areas in each coastal county for agriculture, urban fabric, industrial or commercial land and forest

increasingly higher quality data relating to Irish coastal zones can be generated. The resulting outputs can then be used to facilitate decision makers and planners in reaching the most appropriate evidence-based decisions and policies in relation to coastal zone management. Erosion and flooding data needs to be integrated into the Planning and Development and National Spatial Strategy Systems. Particularly vulnerable counties and cities along the Irish coast, as highlighted through this study, should be flagged, and planning and adaptive approaches to foster resilience devel-

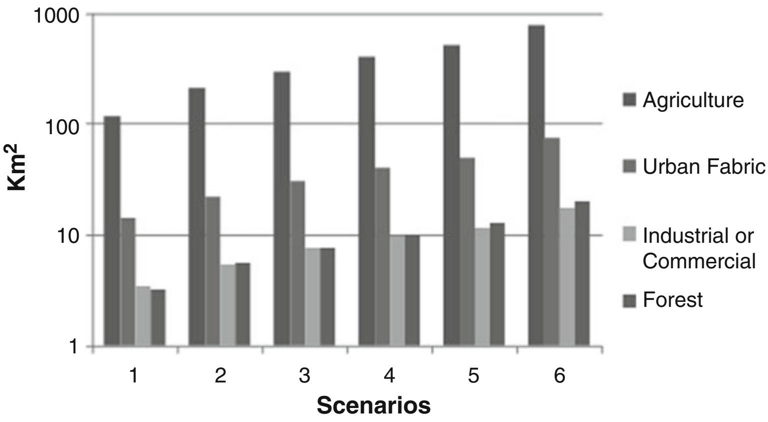


Fig. 10 Area of vulnerable land in square kilometre under six SLR scenarios for agriculture, urban fabric, industrial or commercial and forest

oped. Strategies should be developed to respond to threats in developed urban areas with a focus on soft defences over hard. The portfolio of responses should include beach nourishment and wetland restoration, coastal realignment, rock revetments and flood proofing buildings. This work should be carried out by an island-wide coastal authority structure crossing political divides and implementing approaches on a place by place basis in collaboration with the relevant local authorities.

References

Arndt, D. S., Baringer, M. O., & Johnson, M. R. (Eds.). (2010). State of the climate in 2009. *Bulletin of the American Meteorological Society, 91*(7), 1–224.

Carter, R. W. G., Devoy, R. J. N., & Shaw, J. (1989). Late Holocene sea levels in Ireland. *Journal of Quaternary Science, 4*, 7–24.

Church, J. A., & White, N. J. (2006). A 20th century acceleration in global sea-level rise. *Geophysical Research Letters, 33*, L01602.

Coveney, S., Fotheringham, S., Charlton, M., & Mccarthy, T. (2010). Dual-scale validation of a medium-resolution coastal DEM with Terrestrial LiDAR DSM and GPS. *Computers and Geosciences, 36*, 489–499.

Dasgupta, S., Laplante, B., Murray, S., & Wheeler, D. (2009). *Sea-level rise and storm surges: A comparative analysis of impacts in developing countries* (Research Working Paper 4901). Washington, DC: World Bank Development Research Group.

Devoy, R. (2008). Coastal vulnerability and the implications of sea-level rise for Ireland. *Journal of Coastal Research, 24*(2), 325–341.

Dobosiewicz, J. (2001). Applications of digital elevation models and geographic information systems to coastal flood studies along the shoreline of Raritan Bay, New Jersey. *Environmental Geosciences, 8*(1), 11–20.

European Commission. (2009). *Marine affairs and climate change: Irish overview*. Available from: http://ec.europa.eu/maritimeaffairs/climate_change/ireland_en.pdf. Accessed 25 Nov 2010.

European Environment Agency. (2006). *The changing faces of Europe's coastal areas* (European Environment Agency Report 6/2006). Luxembourg: EEA.

Farrell, G. (2007). *Ireland at risk: Climate change: Impacts on coastal areas*. Dublin: Department of Communications, Marine and natural Resources.

Flood, S., & NiChiardubhain, N. (2008). *Adapting to climate change: The challenge ahead for local government*. Comhar: Sustainable Development Council of Ireland.

Gornitz, V., Couch, S., & Harting, E. K. (2002). Impacts of sea level rise in the New York City metropolitan area. *Global and Planetary Changes, 32*, 61–88.

Hoozemans, F. M. J., Marchand, M., & Pennekamp, H. A. (1993). *A global vulnerability assessment: Vulnerability assessment for population, coastal wetlands and rice production on a global scale* (2nd ed.). Delft: Delft Hydraulics.

IPCC. (2007a). *Climate change 2007: Impacts, adaptation and vulnerability.* Summary for policymakers. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary approved at the 8th Session of working Group II of the IPCC, Brussels.

IPCC. (2007b). *Climate change 2007: The physical science basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, & H. L. Miller (Eds.), Cambridge/New York: Cambridge University Press.

Irish Insurance Federation. (2010). *Bill for November floods estimated at €244 million* (Press release). http://www.iif.ie/MediaPublications/PressRelease/tabid/119/language/en-GB/Default.aspx. Accessed 14 Jan 2010.

Lennon, G. W. (1963a). The identification of weather conditions associated with the generation of major storm surges along the west coast of the British Isles. *Quarterly Journal of the Royal Meteorological Society, 89*, 381–394.

Lennon, G. W. (1963b). A frequency investigation of abnormally high tidal levels at certain west coast ports. *Proceedings of the Institution of Civil Engineers, 25*, 451–484.

Li, X., Rowley, R. J., Kostelnick, J. C., Braaten, D., Meisel, J., & Hulbutta, K. (2009). GIS analysis of global impacts from sea level rise. *Photogrammetric Engineering and Remote Sensing, 75*(7), 807–818.

McGloughlin, J. S. (2011). *Governance and climate change: Making the transition to an adapted Ireland*. Dublin: Environmental Protection Agency.

McGrath, R., & Lynch, P. (Eds.). (2008). *Ireland in a warmer world: Scientific predictions of the Irish climate in the twenty-first century*. Dublin: Met Éireann. C4I.

Nicholls, R. J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., Chateau, J., & Muir-Wood, R. (2007). *Ranking port cities with high exposure and vulnerability to climate extremes: Exposure estimates* (OECD Environment Working Papers, No. 1). Paris: OECD Publishing.

Orford, J. (1989). A review of tides, currents and waves in the Irish Sea. In J. Sweeney (Ed.), *The Irish Sea: A resource at risk* (pp. 18–47). Dublin: Special publication no. 3 of the Geographical Society of Ireland.

Overpeck, J. T., Otto-Bliesner, B. L., Miller, G. H., Muhs, D. R., Alley, R. B., & Kiehl, J. T. (2006). Paleoclimatic evidence for future ice-sheet instability and rapid sea-level rise. *Science, 311*, 1747–1750.

Rahmstorf, S. (2007). A semi-empirical approach to projecting future sea-level rise. *Science, 315*, 368–370.

Robinson, I. S. (1979). The tidal dynamics of the Irish and Celtic seas. *Geophysical Journal of Royal Astronomical Society, 56*, 159–197.

Sweeney, J., et al. (2008). *Climate change: Refining the impacts for Ireland.* Dublin: Published as part of the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme 2007–2013 by the Environmental Protection Agency.

Mapping Risk and Vulnerability in São Paulo Metropolitan Region

Andrea Ferraz Young and Carlos Afonso Nobre

Abstract Current climate change projections indicate that heavy rainfall is an increasing problem in many areas around the world, including the São Paulo Metropolitan Region, Brazil. This will result in severe flooding and landslides in the upcoming years. Therefore, the geography of climate change vulnerability is vital to adaptation planning. Using Geographic Information System (GIS) and mapping tools such as digital elevation models (DEM), this chapter identifies the main areas affected by floods and landslides. We characterize such areas by their biophysical dimensions and socio-economic status. In turn, we not only focus on the physical environment but examine the geography of socio-political determinants of vulnerability. Overall, this chapter will highlight which areas are vulnerable to climate change and what we can expect in 2030.

Keywords Climate change • Urbanization • Megacities • Risk assessment • Vulnerability • Disasters

1 Introduction

Projections indicate that if the São Paulo Metropolitan Region (SPMR) continues to expand at its current rate, there will be an approximate increase of 38% of the urban area by 2030. Effects of this include increased flooding and landslide risks, affecting a larger proportion of the population and in particular the poorest.

A.F. Young (✉)
CEPAGRI, State University of Campinas, Saulo de Carvalho Luz, 111 apto 84B, 13033-195 Campinas, Brazil
e-mail: andfyoung@hotmail.com; andrea@cpa.unicamp.br

C.A. Nobre
CCST – Center for Earth System Science, INPE (National Institute for Space Research), Avenida dos Astronautas, 1758, 12227-010 São José dos Campos, Brazil
e-mail: carlos@inpe.br

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_6,

The risks will be further exacerbated by the increase of temperatures and frequency of heavy rainfall events, especially in the summer. Preliminary studies indicate that between 2070 and 2100, an average rise from 2°C to 3°C of the regional temperature can double the number of days with heavy rainfall in São Paulo (Marengo et al. 2009).

This paper introduces analyses from which projections for 2030 can be concluded. Through the application of a model projection of urban expansion in accordance with HAND (height above the nearest drainage), the present and future impacts and vulnerabilities are presented in the aforementioned risk scenarios. This landscape study identifies possible areas for future occupation and the potential risks if current patterns of land use and occupation are maintained.

The SPMR has a population of approximately 20 million inhabitants, in a territory the size of 8,051 km^2. The highest population density is in São Paulo city, which shelters nearly 11 million inhabitants making up 61% of citizens in an area of 1,051 km^2 (SEADE Foundation 2009). In addition, the municipalities of Guarulhos, Osasco, Santo Andre and São Bernardo do Campo each have more than 500,000 inhabitants. In the region, approximately 40,000 companies and 5.7 million passenger cars (21% of the national total) are registered. The 12 million public transportation journeys, in addition to the 8.1 million independent trips, contribute to the total of 30.5 million made per day. Around three million vehicles circulate the streets of the capital per day (PMSP 1999).

Industries and vehicles are responsible for the release of 6,575 t of air pollutants daily. This equates to 2,400,000 t/year. Currently, vehicles are responsible for 40% of particulate emissions and 31% of sulphur dioxide (SO_2), while other industries are responsible for 10% of particulate matter and 67% of SO_2 emissions. Dense urbanization is an important source of heat. The densest parts of the metropolitan area tend to be the warmest; the temperature decreases as the urban density decreases. The pollutants also affect the radiation and energy balance,[1] especially because particulates are composed of carbon, ozone (O_3), carbon dioxide (CO_2), etc.[2]

Furthermore, regional temperature changes indicate an increase in the number of hot days and nights and a decrease of cold days and nights respectively (Marengo et al. 2009). These data indicate that the intensification of heat islands prevents the dispersion of pollutants, leading to a gradually increasing concentration. Findings show that residual pollutants, which are unable to disperse, are multiplied due to atmospheric photochemical processes. Within this perspective, to understand the impacts and vulnerabilities to climate change is essential to propose adjustment measures to make cities more resilient to the problems they already face.

---

[1]Energy from exchanges of heat between the Earth and the atmosphere above.

[2]This paragraph refers to a communication made by Maria de Fatima Andrade in 2010 (professor at the Astronomy and Geophysics Institute – IAG/USP).

2 Methodological Considerations Regarding the Analysis Process

The study provides data and analysis that illustrate the impacts and projections for 2030, through the identification of possible areas which may be occupied in the future. Potential risks, if the usage pattern and current land use are maintained without any changes, are identified and analysed.

The HAND model identifies the risk areas susceptible to floods and landslides. The algorithm HAND (or vertical distance to the nearest drainage) proposes an approach based on measures that could enable a more accurate representation of the terrain (Rennó et al. 2008; Nobre et al. 2011).

The HAND model is a descriptor algorithm that uses the terrain topographic information to extract hydrological information from an area. This information is obtained by estimating the relative height difference between each grid point and the closest point of drainage associated with a stream (Rennó et al. 2008; Nobre et al. 2011).

The first task was to build a database, gathering public information on land use, urban expansion, conservation areas and river basins from the various agencies. These data form the basis for working on the 'HAND' and 'Urban Expansion Model'. Through the 'Urban Expansion Model', a visualization of the areas of expansion in 2030 was constructed.

3 What Is Changing?

The Metropolitan Region of São Paulo, which already suffers from floods every summer, may have increased number of days with heavy rainfall until the end of the twenty-first century. Total rainfall over 30 mm/day has the potential to cause severe flooding. Total rainfall above 50 mm/day, virtually non-existent before the 1950s (Fig. 1), usually occurs two to five times a year in São Paulo.

Increasing urbanization in combination with global warming events predicts that extreme rainfall will occur more frequently in the future, increasingly affecting wider areas of the SPMR.

4 Where and How Vulnerable Is the SPMR?

According to Brooks (2003), the vulnerability to climate change is primarily defined as a function of the character of the perturbation. The focus is directed towards the physical manifestations of climate change (temperature, rainfall, etc.), the likelihood and frequency of its occurrence and the effects on human systems. In order to understand and reduce human vulnerability, it is necessary to know where and how the

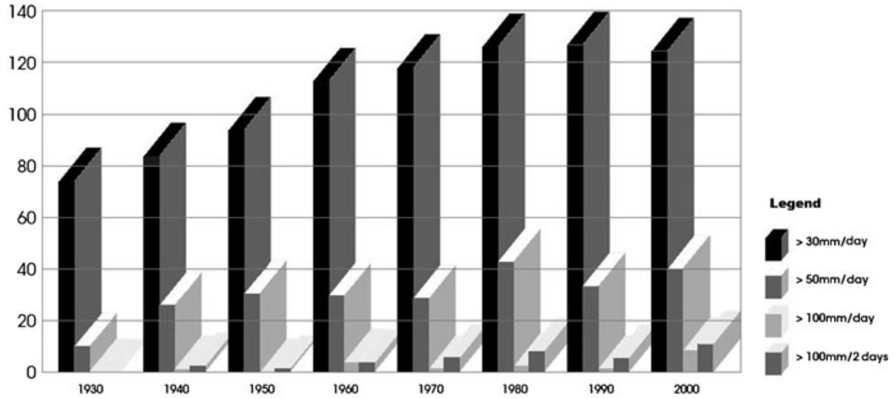


Fig. 1 Events of heavy rainfall in Sao Paulo for decade (mm/day from 1933 to 2009) (Source: CSST/INPE and Meteorological Station of the Astronomy and Geophysics Institute (IAG/USP))

climate will affect these systems (Liverman 2001). From this perspective, the most vulnerable people to climate change are those living in exposed areas. The nature of social vulnerability will depend on the nature of the hazard to which the human system in question is exposed: although social vulnerability is not a function of hazard severity or probability of occurrence, certain properties of a system will make it more vulnerable to certain types of hazard than to others. Therefore, vulnerability is not only a function of the physical characteristics of climate events but more importantly an inherent property of a society determined by factors such as poverty, inequality, gender patterns, access to health care and housing, etc. (Brooks 2003).

For the majority of cities, the level of vulnerability depends on the scale of risk to extreme weather events, which is also influenced by the quality of buildings and infrastructure in the urban areas. The reduction of vulnerability could be achieved by urban planning and land use management that ensures risk reduction within urban construction and expansion through preparedness of citizens and key emergency services (Blaikie et al. 1994).

In the case of SPMR, the drainage system plays an important role due to the various problems which have been observed: the dimensions of drainage channels are inadequate to permit free flow of water bodies; waste materials in different proportions have been found blocking the drainage channels; in general, the problems of drainage channels range from the occurrence of streets flooding to environmental deterioration.[3] Essentially, the worsening of the drainage problems has always been tied to the occupation of the fluvial plain and poor environmental quality of the urban spaces, agonized by the elimination of vegetation, soil sealing,

[3]From the Avenues Plan of Prestes Maia, in 1930, taking advantage of the lowlands for the construction of the road system has been integrated as a routine solution, aiming to expand the road infrastructure. Thus, gradually the water system of the city of São Paulo was transformed into its road system. The situation was getting worse as more streams have been channelized, and, despite all the interventions, the floods have increased over the years in frequency and intensity.

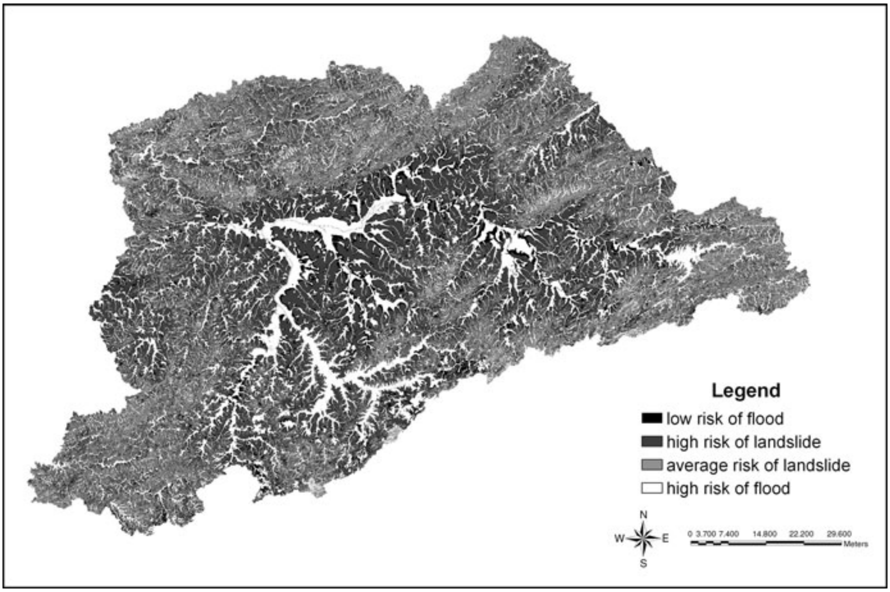


Fig. 2 HAND model applied in SPMR (Source: Nobre et al. 2011)

slum-lying land discarded by property market speculation, illegal settlements in areas of protection with the increasing of risk areas along the watersheds, etc.

To analyse the risks of flooding in the SPMR and to identify the most vulnerable areas, the HAND model was developed from a Digital Terrain Model. Through the HAND model, it is possible to consider (assume) all streams (small rivers) at the zero level of slope and remap all the other points of the topography according to the relative vertical distance (Nobre et al. 2011). All confluences of drainage lines on the field are captured by this model, and from the meeting of two or more rivers, it is possible to know where the water will accumulate and which areas are susceptible to flooding and flood risk.

The areas most susceptible to inundation refer primarily to fluvial plains which do not exceed slopes over 5 m. The model HAND (Fig. 2) also shows that there are smooth plains located in the hills of the SPMR, demonstrating that even in places of high altitude terrain can be flat and therefore susceptible to inundation.

Geomorphic properties of a stream channel depend upon the hydrologic conditions controlled by the attributes of the watershed. Flooding is a natural phenomenon and has a specific probability of occurring in any given year, which reflects the attributes of the watershed and the driving force of climate. As flooding is a natural part of a stream's hydrologic regime, stream systems have been adjusted to the occurrence of overbank flows over geologic time. Human-induced land use changes cause various hydrologic and geomorphic adjustments, including alterations in the size and timing of flood peaks and in the magnitude and type of soil erosion. Changes in land use and land cover affect the magnitude-frequency relationship of runoff by reducing the infiltration capacity of the soils in the watershed. Watershed scale changes such as urbanization change the natural rainfall-runoff regime in such a way that large floods begin to occur more frequently and a stream's hydrologic regime becomes 'faster than normal range' – peak discharges get larger. The urbanization creates impervious surfaces within a watershed. The infiltration capacity of the land surface decreases, and water is able to run off more quickly, which alters the hydrologic regime.

A correlation between the areas most affected by sewage pollution to the main roads, slums, buildings and deforested areas was also carried out. We found that one of the most polluted areas of the basin corresponds exactly to the fluvial plain at the Tiete, Tamanduatei, Pinheiros and Aricanduva basins, among others around the central area of SPMR. Therefore, flooding would increase the risk of diseases caused by polluted water.

For the risk analysis on landslides, the HAND model was used because it also records slopes above 27%. The slope data were analysed in relation to rainfall distribution equal to or greater than 100 mm/day. The classes of land use were also considered and assessed in terms of risk characteristics (with help from the six experts from the Technological Research Institute).

Therefore, in this case, the parameters considered were categories above the 30° slope. The instability of hills is related to episodes of extreme rainfall, in terms of intensity and volume, usually triggered by rainfall events above 100 mm in the unstable terrain. The risk of landslide has been generated from an algorithm defined as a function of the slope, rainfall distribution and land use categories.[4]

4.1 *The Main Risk Scenarios*

4.1.1 Flooding

Apart from the damage and inconvenience suffered by the people directly affected, flooding in the Alto Tiete basin will produce wider effects, stretching beyond regional boundaries, with devastating effects on the state and country's economy.

The metropolitan areas have come under intense pressure to respond to federal mandates to link land use planning, transportation and environmental quality, and from citizen concerns about managing the side effects of growth such as urban expansion, congestion, housing affordability and loss of open space. The planning models used by São Paulo Planning Organizations were generally not designed to

[4]Urban areas always present some risk of flooding and landslides when rainfall occurs. Buildings, roads, infrastructure and other paved areas prevent (hinder) rainfall from infiltrating into the soil. Heavy or prolonged rainfall produces very large volumes of water surface, which can easily overwhelm drainage systems. In well-governed cities, this is rarely a problem because appropriated drainage systems are built into the urban area, with complementary measures to protect against flooding – for instance the use of parks and other areas of open space to accommodate floodwaters safely from unusually serious storms. Most residential areas in SPMR have no drainage system installed and rely on natural drainage channels.

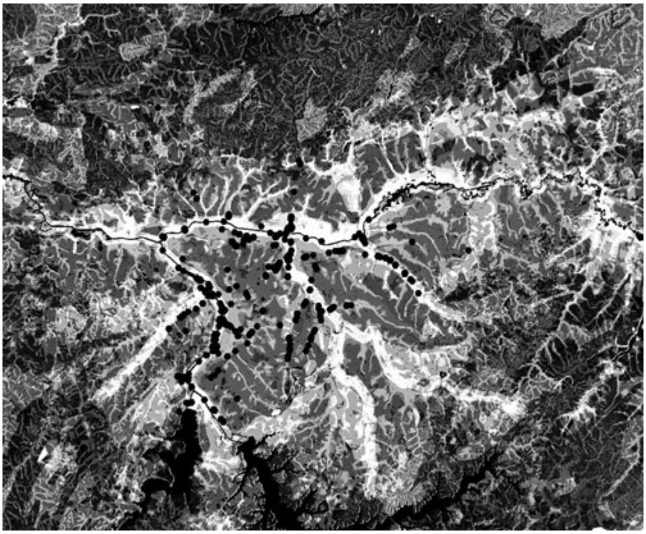


Fig. 3 Susceptible areas to flood in the fluvial plain of Tiete River Basin (Source: HAND model and flash flood points provided by CGE (Center of Emergency Management 2010))

address these questions, creating a gap in the ability of planners to systematically assess and respond to these issues. Land use planning and control measures were not executed in an integrated manner, perpetuating the emergence of new risk scenarios.

The purpose of this study was to develop a map (Fig. 3), using determined basin characteristics including basin area, percentage of basin area covered with impervious surfaces and length of primary water course through basin and basin slope.

The impacts of flooding affect dwellings, industrial activities, commercial business, public and private services, urban transport and road systems. To attend to these issues, there is a tendency to increase the fleet of vehicles in the SPMR and the expansion of roads in the fluvial plain areas. Such measures not only increase the level of vehicles but put more people at risk to flooding.

4.1.2 Landslide

Landslide risk areas, caused by the occupation of hillsides,[5] are mainly concentrated in areas of recent urban expansion. This has mainly been observed in the last three decades and is attributed to the geotechnical occupation of land that is more susceptible to landslides in remote areas of SPMR.

---

[5]The landslide risk areas are mainly located on lands in geomorphological compartments of crystalline rock in the Embu Ridge, surrounding the sedimentary basin of São Paulo, in west, south and east, and in the northern into the São Roque Ridge, where the relief is mountainous and dynamics of surface processes is intense (high energy).

The city of Sao Paulo has about 30% of its population (2.7 million people) living in shanty towns, slums and precarious housing, which are generally illegally occupied. Slums alone are estimated to house 1.6 million people. The majority of slums are concentrated in hazardous areas (Ross 2004).

Over 50% of the slums in São Paulo City are concentrated in the Southern Zone (Jardim Angela, Capão Redondo and Campo Limpo), and many are at risk to landslides. In other districts of São Paulo, the areas of risk are distributed in the West Zone (Butantã and Jaguaré), Northern Zone (Perus, Jaraguá and Brasilândia) and in the Eastern Zone (Sapopemba, São Mateus and Itaquera). To get an idea, the Northern Zone contains 327 slums, majority of which are located in areas of high slope that was once occupied by the typical vegetation of the Serra da Cantareira. In the Eastern Zone, there is also a significant concentration of slums (around 344) facing the same situation. Other municipalities of the SPMR that are vulnerable to landslides in the Upper Tietê Basin are Northern Region: Guarulhos, Mairiporã, Caieiras, Francisco Morato, Franco da Rocha; Eastern Region: Ferraz de Vasconcelos and Guararema; Southern Region: Maua, São Bernardo do Campo, Santo André, Diadema, Ribeirão Pires, Rio Grande da Serra, Embu Guaçu and Juquitiba; and Western Region: Santana do Parnaíba, Osasco, Carapicuíba, Barueri, Itapevi, Jandira, Taboão da Serra, Embu, Itapecerica da Serra and Cotia.

5 Urbanization and the Spread of Risk Areas in 2030

To display the future risks, it was necessary to analyse the pattern of urban expansion through remote sensing techniques by comparing the data from Landsat satellite images between 2001 and 2008. In turn, we calculated the areas and identified the rate of growth. Subsequently, we generated a model of urban expansion for 2030 by interpolation techniques. This model of urban expansion (Fig. 4) was integrated with the slope classifications of HAND model to identify risk areas in the future.

The analysis of expected urban expansion estimated to occur by 2030 indicates that the risk scenarios, and their vulnerabilities to surface dynamic processes triggered by severe weather events such as floods at fluvial plains and landslides on hillsides, will get worse. Such estimates are based on the expectation of an increasing number of irregular settlements in risk areas.

6 Conclusions

The Urban Expansion Model (for 2030) was based on urban economic theory, which states that the value of location is capitalized into the price of land. The model was based on historical data using Landsat satellite images (2001–2008) which allowed to visualize the effect of site, neighbourhood, accessibility and policy impacts on the metropolitan territory. The trend is that the current urban area of São Paulo suffers

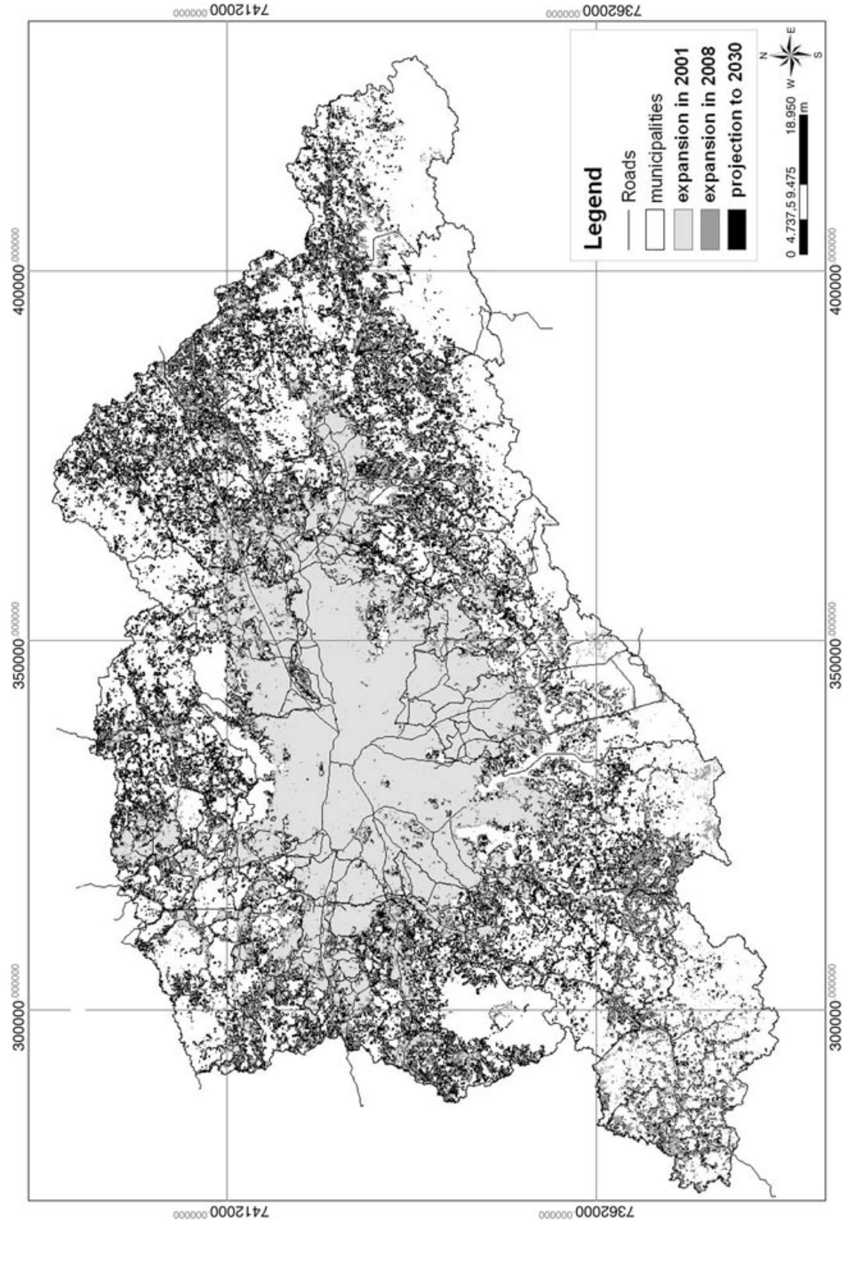


Fig. 4 Urban expansion model applied in SPMR

few changes, but in contrast, the surrounding areas will be occupied which will put strong pressure on natural resources.

If this process actually takes place, there will be new areas of risk, and vulnerability will intensify both in relation to flooding and landslides. Assuming that the area projected for 2030 will undergo an expansion of approximately 38.7% (i.e. will have a total length of 3,254.23 km^2), the risks of flooding will increase significantly. In this case, over 20% of the total area of expansion would be susceptible and could possibly be affected.

Considering the slope at an angle to a horizontal surface greater than 15º and 30º (obtained through the HAND and Urban Expansion Model integration), the risk of landslides was estimated for 2030. Approximately 4.27% of the areas of expansion in 2030 may constitute new areas of risk to landslides.

We agree with Waddell (2000), broadly speaking, government agencies influence the land development process through a combination of land use regulations and infrastructure provision. These are frequently combined into packages that attempt to foster a development pattern in ways that promote planning objectives, for example, by pursuing one or a combination of the following community visions:

- Containing development within an urban growth boundary
- Focusing development along primary transportation corridors
- Focusing development within centres connected by multimodal transportation
- Encouraging development in parts of the region with underutilized infrastructure
- Allowing the development of impoverished areas

The use of 'HAND model' and 'Urban Expansion Model' in the SPMR context can describe different 'scenarios' with hazards assumptions that can be input to the model to examine their potential consequences on outcomes such as urban form, environmental risk, density and land use patterns.

In other words, the models allow the visualization of a hypothesized future. It does not assume that a particular vision can be realized but facilitates exploration of the trade-offs that may be involved in attempting to avoid the disasters, given the range of possibilities in terms of policy demands, their costs and consequences. The models do not attempt to 'optimize' policy inputs, but they intend to facilitate interactive use to support an integrated and participatory planning.

Interpreting the comprehensive metropolitan territory is a key part of constructing a climate policy in SPMR. Each land use plan designation (Land Use Plan, Drainage System Plan, and Climate Alert Plan) may be described as a set of restrictions on development options based on climate change and adaptation.

References

Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (1994). *At risk: Natural hazards, people's vulnerability, and disasters* (pp. 333–352). London: Routledge.

Brooks, N. (2003). *Vulnerability, risk and adaptation: A conceptual framework* (Tyndall Centre Working Paper No. 38). Norwich: Tyndall Centre for Climate Change Research.

Liverman, D. M. (2001). Vulnerability to global environmental change. In J. X. Kasperson & R. E. Kaspersen (Eds.), *Global environmental risk*. Tokyo/New York/Paris: United Nations University Press.

Marengo, J. A., Jones, R., Alves, L. M., & Valverde, M. C. (2009). Future change of temperature and precipitation extremes in South America as derived from the PRECIS regional climate modeling system. *International Journal of Climatology, 15*, 2241–2255.

Nobre, A. D., Cuartas, L. A., Hodnett, M., Rennó, C. D., Rodrigues, G., Silveira, A., Waterloo, M., & Saleska, S. (2011). Height above the nearest drainage: A hydrologically relevant new terrain model. *Journal of Hydrology, 404*, 13–29.

PMSP – Prefeitura do Municipio de São Paulo. (1999). Atlas Ambiental da Cidade de São Paulo. Secretaria Municipal do Verde e do Meio Ambiente.

Rennó, C. D., Nobre, A. D., Cuartas, L. A., Soares, J. V., Hodnett, M. G., Tomasella, J., & Waterloo, M. J. (2008). HAND, a new terrain descriptor using SRTM-DEM: Mapping terra-firme rainforest environments in Amazonia. *Remote Sensing of Environment, 112*(9), 339–358.

Ross, J. L. (2004). São Paulo: a cidade e as águas. Geografia de São Paulo 2. A metrópole do séc. XXI. Org. Carlos, F.; Oliveira, A. U. de. Ed. Contexto.

SEADE Foundation. (2009). Perfil regional desenvolvido pela Assessoria de Gestão Estratégica da Secretaria de Economia e Planejamento, a partir de trabalho sobre a economia regional paulista, elaborado pela Unidade de Assessoria Econômica, com a colaboração dos Escritórios Regionais de Planejamento, da Coordenadoria de Planejamento e Avaliação e do Instituto Geográfico e Cartográfico.

Waddell, P. (2000). A behavioral simulation model for metropolitan policy analysis and planning: Residential location and housing market components of UrbanSim. *Environment and Planning B: Planning and Design, 27*(2), 247–263.

Water Crisis: Public Management of a Critical Situation

Dafne Mazo and Ana Alcantud

Abstract The Mediterranean climate, the major climate type of southern European countries, is characterized by hot and dry summers, with periodic drought periods. In this general context, in 2005 and 2007, two important drought episodes took place in Catalonia, Spain.

Within these critical periods, the Catalan Government approved several regulatory measures in order to maintain available water resources, regulate the use of water and preserve the household water supply for as long as possible.

In this regard, one of the public bodies' main concerns was to guarantee the water supply to the city of Barcelona and the Greater Barcelona area, where 3.5 million people live. This required strong coordination among the Catalan Regional Government, the Metropolitan Entity of Hydraulic Services and Waste Treatment (EMSHTR), together with local governments such as Barcelona City Council.

With the aim of achieving the stated goals, the regulatory measures focused on the application of progressive water restrictions on urban supplies. This was assessed according to the different drought status scenarios as well as on numerous communicative actions and some other measures to preserve the supply and to involve citizens in the fight against water depletion. One of the communicative activities was the "Install me!: Every drop counts" campaign, which involved the free distribution of water-saving devices for taps. This campaign played a crucial role in regards to water savings and behavioural changes.

Keywords Coordination • Communicative • Campaigns • Drought • Public bodies • Water crisis management

D. Mazo (✉) • A. Alcantud
Ecoinstitut Barcelona, Torre dels Pardals, 69 entl. 4a, 08032 Barcelona, Spain
e-mail: dafnemu01@gmail.com; alcantudan@gmail.com

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_7,

1 Introduction

In Spain, the rainfall pattern is generally irregular and varies greatly from year to year as a result of the Mediterranean climate, making the Mediterranean area especially vulnerable to drought episodes (ACA 2008a, b).

In fact, Catalonia has endured various episodes of moderate and severe droughts throughout recent history. During the last drought episode in 2007, the Catalan reservoirs' water level dropped to 32% of their capacity by the end of the year, in comparison to 58% in 2006. The situation became even more critical in April 2008 (Bauzà 2007) when the water level reached 19.9% of the Catalan reservoirs' capacity which is almost one-fourth of the capacity of 2006 (Efe Agency 2008).

This water scarcity situation implied that public bodies, with competences concerning water storage and supply, had to coordinate their efforts to guarantee the water supply to households and production sectors for as long as possible. During the last drought episode, a hydrological plan was adopted in order to respond to the situation and make Catalonia more resilient to change.

Climate change is expected to reduce precipitation and increase the frequency of droughts (Iglesias et al. 2010). According to Barceló (2008), the observed decline in natural water availability is coherent with climate change projections. These projections point out that rainfall will decrease in the Mediterranean region and especially in Spain. Therefore, it is of utmost importance to take into account water crisis management examples such as this in order to assist other Mediterranean cities and regions that will be faced with more frequent drought episodes.

2 Public Regulatory Measures Developed During Drought Episodes

2.1 Decree of Drought

In 2005 and 2007, two important drought episodes took place in Catalonia. In order to regulate the use of water and to preserve the availability of domestic supply, the Government of Catalonia approved the Decree of Drought 93/2005 in the year 2005. Similarly, the Decree of Drought 84/2007 was passed in 2007, which improved the foreseen communicative aspects and implemented some other measures to preserve the available domestic and industrial supply.

The core of the Decree of Drought consisted of the so-called hydrological status scenarios (Pre-alert, Exceptional Status 1, Exceptional Status 2 and Emergency). The Decree fixes the water availability thresholds that define the status scenarios and the management measures to be applied in each of these scenarios (Table 1).

The measures foresaw a progressive and sequential application of different restrictions to preserve water resources. The aim was to delay, for as long as possible, the worst case scenario, which implies that the reserves continue to be

Table 1 Drought decree status scenarios

[Pre-alert]	Intensified monitoring of the evolution of reserves
	Information and awareness-raising measures
[Exceptional status 1]	15% reduction in the supply for irrigation in regulated systems
	Cancellation of spillovers for purely hydroelectric uses
	Intensified user controls
	Intensified water-saving measures in the supply networks
	Restrictions on discharges and non run-of-river systems
	Supply restrictions to municipalities (270 l/inhabitant/day)
[Exceptional status 2]	A 45% reduction in the supply for irrigation in regulated systems
	Greater intensification of water-saving measures in the supply networks
	Restrictions on non-basic uses
	Supply restrictions to municipalities (230 l/inhabitant/day)
[Emergency]	Restrictions to the supply

Source: Decret 84/2007 (Drought Decree 84/2007)

depleted (because of the lack of rainfalls) and therefore it is necessary to activate the Emergency Status Scenario that proposes to cut off households' water supply (ACA 2008a, b).

2.2 *Parliamentary Motion*

The Parliamentary Motion 21/VIII, together with the Decree of Drought 84/2007, was one of the basic regulatory governance mechanisms. It contributed to structuring the appropriate measures needed to manage the scarce water resources during the drought episodes. The motion gave support to the Catalan Government in the deployment of appropriate institutional campaigns in order to encourage water savings, particularly in urban households.

According to the deployment of the Parliamentary Motion, the Catalan Water Agency (ACA) carried out nine different institutional communicative activities. All these activities pursued the same general goal: to encourage water savings in urban households. The activities were aimed at involving the consumers, being themselves part of the drought problem and its solution (Table 2).

3 Communicative Measures Foreseen by the Catalan Government

3.1 *"Install Me!: Every Drop Counts" Campaign*

The "Install me!: Every drop counts" campaign was an institutional communicative instrument designed by the Catalan Government (Presidency Department, Environment Department and ACA) in collaboration with Ecologistes en Acció

Table 2 Deployment of the Parliamentary Motion 21/VIII: communicative activities

Year	Communicative activity	Mass media – dissemination
February 2007	Awareness raising campaign regarding drought and water saving: "If you want water, close the tap"	TV and radio spots Press releases
July 2007	Reinforcement of the awareness raising campaign on drought and water saving: "If you want water, close the tap"	Radio Ads on public means of transport (metro, bus, train)
December 2007	Advertisement: "There's not much left" on the measures carried out during the drought	Press releases
January 2008	"Install me!" campaign	Press
March 2008	X Water Festival: All the activities were conceptualized by ACA and oriented to awareness raising on the water scarcity and the need for saving water. There were:	25,000 leaflets distributed to schools
	Joint manifesto of all public bodies, companies and non-profit organizations	6,000 posters for shops
	Pedagogical workshops on water	Public means of transport (buses)
	Child games on water saving	TV and radio spots
	...	Press releases
March–April 2008	"Together we can tackle the drought" campaign	TV and radio spots Press releases
April–May 2008	Advertisement: "We are working to guarantee the water for everybody"	Press releases
June 2008	Exhibition: "We give solutions to guarantee the future water"	Exhibition held in Robert Palace
July 2008	Reissue of the "Together we can tackle the drought" campaign	TV and radio spot Press releases

Source: Moció Número: 390-00021/08 (Parliamentary Motion 21/VII)

(Environmental Association) and various ironmonger associations and distribution chains.[1] Taking place from the 19th to 20th of January 2008, the campaign consisted of free distribution with the main daily newspapers of 1,300,000 water-saving devices for taps (in boxes containing two devices) together with leaflets explaining the severity of the water problem, the actions developed by the public bodies as well as instructions on how to install the devices and how to identify the logo of the ironmonger shops participating in the campaign.

The goal of the "Install me!: Every drop counts" campaign was to contribute to the population's awareness that water is a scarce resource that needs to be preserved. At the same time, during the crisis, the water-saving campaign aimed to reduce the water consumption as much as possible in order to extend the availability of water until the next rainfall event.

[1]Catalan Association of Ironmongers and the following ironmonger chains: Ferca, Cafer, Cadena 88, Cofac and Cifec.

Fig. 1 Water-saving "kit" provided during the "Install me!: Every drop counts" campaign (Source: ACA website (http://aca-web.gencat.cat/aca/sequera/en/que-es-sequera.jsp))

Fig. 2 Water-saving devices provided during the "Install me!: Every drop counts" campaign (Source: ACA website (http://aca-web.gencat.cat/aca/sequera/en/que-es-sequera.jsp))

The campaign targeted the entire population of Catalonia through different channels, through newspapers and also city councils and schools. There were municipalities, for instance, Barcelona, where the water-saving devices were distributed door-to-door among the citizens.

The campaign reinforced the feeling of lack of water resources but, at the same time, gave to the population a "free solution" that contributed to reduce the household water consumption without involving big modifications in their everyday life. The only real effort that was required from the users was to install the device in order to conserve the household water supply (Figs. 1 and 2).

3.2 Potential Impact of the Campaign

The installation of the two water-saving devices on taps implies around a 12–15%[2] reduction of household water consumption.

In 2008, the average household water consumption in Catalonia was 148.3 l/person/day. The consumption was even smaller in the Greater Barcelona area: 109.9 l/person/day (AMB 2011). If the potential savings of the installation of the two water-saving devices are applied to Catalonia, it will result in saving 17–22 l/person/day.

4 Context Factors

There were three key factors within the drought context that promoted the high degree of concern regarding water scarcity among the population.

4.1 The Influence of Mass Media

There were phases during the drought period in which every day in the regional television news, the headlines covered the drought and the water level in the reservoirs. Moreover, there was a high coverage of the drought situation in the newspapers (Fig. 3).

4.2 The Closure of Public Fountains

One of the most visible actions that impacted the population was the closure of the public ornamental fountains during the Exceptional Status 2 (EMSHTR 2008). At this time, city officials placed banners informing citizens why the fountains were closed. Although this measure was not relevant in terms of urban water savings, it visually reinforced that water was scarce. It also allowed public bodies to accelerate the necessary works to install close circuits of non-drinking water in public fountains and other additional water-saving mechanisms (in fountains, public gardens and street cleaning services).

[2]Data obtained by means of expert interviews for the elaboration of the impact assessment paper, *"Install me!" Campaign. Communicative Campaign Within the Drought Context in Catalonia*, within the 7th FP Project EUPOPP "Policies to Promote Sustainable Consumption Patterns".

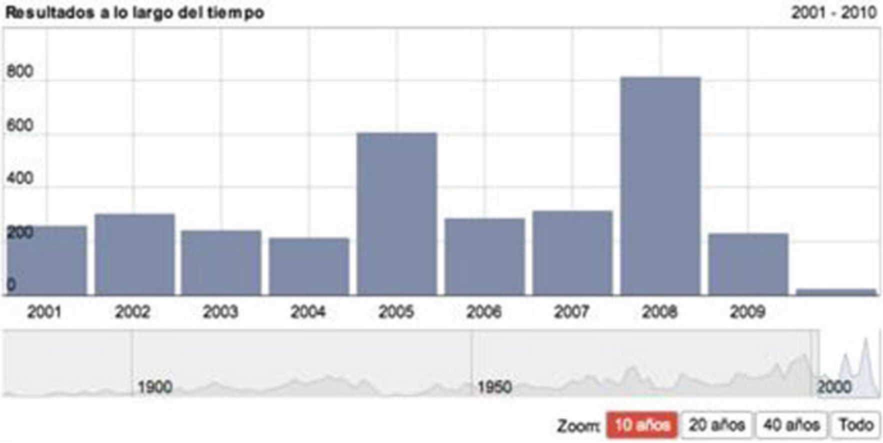


Fig. 3 Number of words containing the word "drought" during 2001–2009 in *La Vanguardia* newspaper (Source: La Vanguardia newspaper library (http://www.lavanguardia.com/hemeroteca/)

4.3 The Arrival of Water Tanks from Marseille

The collaboration between the Catalan Government (Environment Department and Catalan Water Agency-ACA), Aigües de Barcelona (water supply company) and the harbours of Barcelona and Tarragona was crucial for the development of this action.

In order to guarantee the water supply to Barcelona and its metropolitan area, the Catalan Government bought water from France. The water costs were extremely high (5–6 € /m^3 of water), and each tank could only transport drinking water to meet the needs of Barcelona for half a day.

However, the media coverage and the impact on the population were huge: buying and transporting water to Barcelona greatly strengthened the perception that there was no water, and it created feelings of concern and anxiety among the population.

5 Behaviour Change Effects

The main objective of the "Install me!: Every drop counts" campaign was to raise awareness on the scarcity of water resources and the need to preserve it. According to research carried out by ACA (ACA 2008a), 91% of the interviewees agreed that the free distribution of water-saving devices contributed to raise awareness on the need to save water.

The drought made people change their attitudes and their water consumption patterns. During the two drought crisis episodes (2005 and 2007), the household water consumption was reduced and former water consumption levels have since not been reached again. During 2010, water consumption in the Greater Barcelona area was 107.4 l/inhabitant/day, making it one of the areas with the lowest water consumption levels within Europe (AMB 2011). According to AMB Environment Entity (Entitat del Medi Ambient, EMA), in the year 2000, the consumption level was 132.8 l/inhabitant/day, meaning that during the last 11 years, consumption has decreased by 19% (AMB 2010). Current consumption levels in Greater Barcelona area are very low when compared to the usage of 273 l/inhabitant/day from Stockholm, the 289 l/inhabitant/day from Geneva, the 158 l/inhabitant/day from London or the 131 l/person/day from Madrid.

Some experts affirm that it is unknown to what extent the water consumption can be further reduced. In 2008, there were some municipalities within the Metropolitan Area of Greater Barcelona with daily inhabitant consumption below 100 l/inhabitant (AMB 2009), which is the limit set by the World Health Organization as the daily water amount to cover basic needs.

The campaign influenced the amount of water-saving devices installed whereby 61% of interviewees (ACA) installed at least one water-saving device on taps, 47% installed two mechanisms and 7% tried but did not maintain its usage (ACA 2008a).[3] These water devices were perceived as efficient mechanisms to save water and at the same time they contributed to reduce household water expenses.

The water-saving practices developed as a result of this campaign are also worthy of mention. According to the "Households and Environment 2008 Survey", (INE 2008) 94.1% of the Catalan households put in practice water-saving behaviours. Taking a shower instead of a bath is a widespread action in 95.7% of Catalan households, and closing the tap while brushing teeth or lathering is common in 95.1% of the cases.

6 Final Recommendations

Urban areas need to be resilient in order to foresee and overcome the consequences of climate change-related events. This will be of utmost importance in the Mediterranean region where the climate is already subject to periodical drought episodes. As a result of climate change, precipitation is expected to be less frequent and droughts will become more common. In effect, water will be considered a scarce natural resource that needs to be preserved to ensure our basic needs.

In order to achieve this goal, both urban planning and "soft" measures (such as information dissemination or communication campaigns) will need to be undertaken. It will require collective efforts from citizens, public bodies and the private sector. In this sense, during the last drought episode, the Catalan public bodies focused their efforts to ensure adequate domestic supply to the Greater Barcelona area. The use

[3]These are the results of a statistically representative survey. Technical characteristics: sample: 626 individuals; 95% confidence; sampling error: ±3.92%; Catalan households that bought at least one newspaper with a water-saving device on 20 January 2008.

of non-drinking water was extended to actions such as cleaning streets and parks or watering gardens, for which structural investments were necessary. Resilience was also achieved through institutional communicative campaigns that urged citizens towards behaviour changes aimed at saving water.

The analysis of the management strategy adopted by Catalan public bodies in order to cope with the drought brings to light a couple of key aspects that might be considered for the development of future efficient strategies on climate change adaptation in cities:

- *Policy interaction* of complementary measures, such as regulatory, communicative and economic, can effectively facilitate the goal attainment of any kind of strategy.
- *Coordination of different involved public bodies for competence distribution* is essential in order to apply the appropriate measures within the different exceptional status and to avoid campaign overlap.
- *Stakeholders' participation in the design and implementation of the policy instruments* (NGOs, producers or distribution chains, associations, etc.) increases the effectiveness of the campaign.
- *The possibility to promote behaviour changes depends on how much personal sacrifice is required.* Citizens are more willing to change everyday practices that do not involve personal sacrifice or modifications in their living standards. The distribution of free water-saving devices for taps required minimum effort from citizens.
- *The information transparency regarding the applied Sustainable Consumption (SC) policies is of utmost importance.* Involved public bodies need to be clear about the motivations and goals of the SC policies and the actions developed in order to achieve these goals. The communicative efforts implied in the water crisis management were remarkable and made citizens feel informed.
- *Monitoring mechanisms* are crucial for the visibility of the environmental impacts concerning citizen's actions. Citizens are more willing to change their habits when they understand how their actions contribute to reduce the environmental impacts. Thus, the lack of these mechanisms can result in a less efficient management strategy.

References

Agència Catalana de l'Aigua – ACA. (2008a). *Estudi de la notorietat i experiència d'us dels dispositius d'estalvi en aixetes.* Final Report, not published.

Agència Catalana de l'Aigua – ACA. (2008b). Information from the following website: http://aca-web.gencat.cat/aca/sequera/en/que-es-sequera.jsp. Cited 30 May 2011.

Área Metropolitana de Barcelona – AMB. (2009). *Dades Ambientals Metropolitanes 2008,* available at http://www3.amb.cat/ema/docum/dades_ambientals_08.pdf. Cited 9 June 2010.

Área Metropolitana de Barcelona – AMB. (2010). *Dades Ambientals Metropolitanes 2009,* available at http://www.amb.cat/web/emma/publicacions/dades_09. Cited 9 June 2011.

Área Metropolitana de Barcelona – AMB. (2011). *Dades Ambientals Metropolitanes 2010. Dossier de Premsa.* Press Dossier, available at http://www.amb.cat/c/document_library/get_file?p_l_id=6284&folderId=236924&name=DLFE-8118.pdf. Cited 9 June 2011.

Barceló, D. (Coord.). (2008). *Aguas continentales. Gestión de recursos hídricos, tratamiento y calidad del agua*, Consejo Superior de Investigaciones científicas. Madrid: CSIC.

Bauzà, J. (2007). Cataluña vive una de las peores sequías. *ELPAIS.com.* Retrieved November 8, 2007, from http://www.elpais.com/articulo/cataluna/Cataluna/vive/peores/sequias/elpepuespcat/20071108elpcat_20/Tes. Cited 30 May 2011.

Efe. Madrid Agency. (2008). Los embalses catalanes mantienen una situación crítica pese a la ligera subida. *El Confidencial.* Retrieved April 8, 2008, from http://www.elconfidencial.com/cache/2008/04/08/59_embalses_catalanes_mantienen_situacion_critica_ligera_subida.html. Cited 30 May 2011.

Iglesias, A., Moneo, M., Garrote, L., & Flores, F. (2010). Drought and climate risks. In A. Garrido & M. Llamas (Eds.), *Water policy in Spain*. Leiden: CRC Press.

Instituto Nacional de Estadística-INE. (2008). *Encuesta Hogares y Medio Ambiente. 2008*. Available online: http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft25/p500&file=inebase&L=0. Cited 17 Jan 2011.

Regulatory References

Consell Metropolità de la EMSHTR – EMSHTR. (2008). Modificació del reglament general del servei metropolità de subministrament domiciliari d'aigua en l'àmbit metropolit, de 7 de febrer de 2008. *Butlletí Oficial de la Província de Barcelona (BOPB) 36* (11/02/2008).

Decret. (93/2005). de 17 de maig, d'adopció de mesures excepcionals en relació a l'us dels recursos hídrics. *Diari Oficial de la Generalitat de Cataluya 4389* (de 23 de mayo de 2005), 14793–14802.

Decret. (84/2007). de 3 d'abril, d'adopció de mesures excepcionals i d'emergència en relació amb la utilització de recursos hídrics. *Diari Oficial de la Generalitat de Catalunya 4860* (de 12 de abril de 2007), 13109–13125.

Moció Número: 390–00021/08. Informe relatiu al compliment de la Moció 21/VII de la Sessió de Control del Parlament de Catalunya. *Butlletí Oficial del Parlament de Catalunya (BOPC) 278* (de 9 de junio de 2008), 65–68.

Environmental Assessment and Restoration of Typhoon Morakot Disaster: A Case Study in Kaohsiung, Chinese Taipei

C.M. Kao, B.M. Yang, M.S. Lee, and S.F. Liu

Abstract In August 2009, Chinese Taipei experienced its worst floods in 50 years after Typhoon Morakot struck almost the entire southern region. During the 3-day event, Typhoon Morakot brought copious amounts of rainfall, peaking at 2,500 mm, which triggered severe flooding throughout the region. The Kaoping River Basin was one of the most impacted regions in southern Taiwan. In the upper catchment of the Kaoping River Basin, the Shaolin Village was completely destroyed by the floods, and more than 500 villagers were buried by the mud rock flow. After the flooding, researchers and volunteers from local universities, government agencies, and non-governmental organizations (NGOs) jointly initiated an environmental impact assessment, monitoring, and rebuilding project and formed a disaster-area investigation team. The major tasks for the volunteer team were to (1) collect field and environmental data, (2) construct geographical information system (GIS) for disaster areas, (3) delineate environmentally sensitive area, (4) perform victims' counselling and assistance, and (5) develop environmental rebuilding plans. Field investigation results show that there are more than 15 potential hazardous areas inside the basin, which are mainly (1) potential flooding and landslide areas, (2) potential pollution areas (including waste landfills sites and flooded industrial sites), and (3) source water intake area. As the Shaolin Village is located inside a potential flooding and landslide area, a new green and sustainable village (Shaolin Green Village) has been built in a lower catchment area outside of the sloping field.

C.M. Kao (✉) • B.M. Yang
Institute of Environmental Engineering, National Sun Yat-Sen University, No. 70, Lien-Hi Rd., 804 Kaohsiung, Taiwan
e-mail: jkao@mail.nsysu.edu.tw

M.S. Lee
Environmental Protection Bureau, Kaohsiung City Government, 802 Kaohsiung, Taiwan

S.F. Liu
Deputy Mayor Office, Kaohsiung City Government, 802 Kaohsiung, Taiwan

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_8,

In the green village, each home has a solar energy system for electricity generation and rainwater catchment system for irrigation. An on-site treatment system and subsurface flow constructed wetland system have been designed for wastewater treatment, and the treated water has been recycled for irrigation purposes. The experiences and findings obtained from this study would be useful in developing strategies to minimize the impacts of flooding on the Kaoping River Basin and other similar watersheds.

Keywords Environmental sensitive area • Flooding • Geographical information system • Green village • Typhoon Morakot

1 Background

The Earth is undergoing a warming process, and humanity faces an increasing possibility that extreme natural disasters are on the rise due to climate change and global warming (Saptomo et al. 2009; Yasuhara et al. 2011). The gradually increased temperature caused by the enhanced greenhouse effects has been found to be an important factor, significantly affecting the Earth's hydrological cycles (Li et al. 2009). Increases in air temperature and changes in rainfall pattern occur around the globe (Saptomo et al. 2009; Wu et al. 2011). Climate change also causes the rise of sea levels, which expands the flooding area and affected population.

Researchers have reported that the frequency of extreme precipitation events in East and Southeast Asia will increase with climate change (Li et al. 2009; Saptomo et al. 2009). In particular, the potential impact of associated storm hazards will cause more damage to densely populated countries in Asia. Temperature rise may not seem significant, but it can affect rice yield and increase evapotranspiration. Temperature rise may also interact with many other influences of climate change and create severe drought (Saptomo et al. 2009). Gao et al. (2002) found an increased temperature in China accompanied with enhanced precipitation of 1.6% and 11.4% in northern and southern China from several scenarios. Webster et al. (2005) observed a substantial increase in the intensity of tropical cyclones in the western Pacific over the past 30 years. Residential areas situated on coastal zones and riversides are considered to be the most likely to be affected by climate change (Yasuhara et al. 2011).

In Taiwan and most of the Eastern Asia countries, rainfall amount from typhoon events accounts for a significant portion of annual rainfall. Thus, typhoons are important sources of water in the region while at the same time they also trigger disasters such as floods, mud and rock flow, debris flows, and landslides. Moreover, high turbidity and elevated concentrations of sediments carried in stream flow during and after typhoon events usually cause significant impact on the water treatment system (Cheng et al. 2009). As for the effects of climate change on typhoons, researchers have reported that events are magnified and typhoon characteristics are affected due to climate change, thereby, causing extreme floods and storms (Cheng et al. 2009; Yasuhara et al. 2011). The low atmospheric pressure that would serve to magnify the impact of typhoons generally brings about local heavy rainfall. Thus, it is very important to understand the impact of climate change on typhoons for the planning of adaptation measures against extreme flooding which are accelerated as a result.

2 Introduction

Taiwan is located in the subtropical zone with high temperatures and rich rainfall. The average annual precipitation is 2,500 mm, and it reaches 3,000–5,000 mm in the mountainous regions. Although the rainfall in Taiwan is plentiful, it is not evenly distributed across the island. Most of the precipitation is concentrated in the summer season (June, July, and August). Additionally, there are typhoons in the summer season, which frequently occur simultaneously with storms. In Taiwan, there are 21 major rivers, 29 secondary rivers, and 79 minor rivers. The drainage areas for most rivers are relatively small, and only nine rivers contain drainage areas of more than 100 km^2. Moreover, most rivers have relatively steep slopes and short lengths. Only six rivers exceed 100 km, and only five rivers have slopes milder than 1/1,000 (WRA 2006). Most watersheds contain unstable components such as sandstone and mudstone, which are prone to collapse, creating mudflow problems after flood events. An unevenly distributed water resource is caused by a combination of the following: concentrated rainfall, short rivers and rapid flows, poor flow conditions, uneven time distribution of flows, and rapid rise of flow peak (CEPD 2004). Thus, more efficient water resource management and allocation strategies are required.

Having steep terrain and excessive rainfall, the most severe disaster in Taiwan is flooding which is caused by typhoons and storms in the summer season with intensive rainfall and rapid flows. In comparison with rivers around the world, the rivers of Taiwan have the steepest slope, the largest discharge per unit drainage area, and the shortest flood peaking time. With all these unfavourable natural conditions, flood control measures have become an area of steady growth in Taiwan (WRA 2006). In the past 50 years, the Taiwanese government has devoted a lot of money to flood damage reduction by levee construction, dredging, flood diversion, flood detention, watershed management, and drainage improvement. Meanwhile, the government of Taiwan has acted persistently in water resources development for various water demands as well as water allocation to reduce negative environmental impacts due to construction of water resources development projects (TEPA 2002; Lee et al. 2008; Wu et al. 2010). Following the progress of recent research and development, flood reduction and prevention measures have moved towards a new milestone through the establishment of an alert and warning system, a flood damage alert system for the island and flood warning systems for major basins. However, water resource allocation and development still need further efforts because of the expected increase of water demand in the near future. Thus, the shortage of water is an urgent problem to be solved, or it will affect living conditions and the ecosystem in Taiwan. Furthermore, it will cause an adverse impact on economic growth (TEPA 2006). Taiwan must continue to act persistently in water resource development and allocation, in addition to maintenance of natural environment, improvement of living quality, and pursuit of sustainable watershed environment.

3 Kaoping River Basin

The Kaoping River Basin, located in the southeast region of Taiwan, is the largest and the most intensively utilized river basin in Taiwan. It is 171 km in length, drains a catchment of more than 3,625 km^2, and has a mean flow of 239 m^3/s. Figure 1 shows the location of Kaoping River Basin, Kaoping River, its catchment, and three major reaches (Chi-San Creek, I-Liao Creek, and Lao-Non Creek). It serves as a water supply to the Kaohsiung City (the second largest city in Taiwan), several towns, two counties, and a number of large industries (electronic, steel, petrochemical, etc.). The Kaohsiung metropolitan water demand is approximately 1.65 million tons per day, and 88% of this is acquired from Kaoping River. Although the mean annual rainfall in this river basin is close to 3,000 mm, over 90% appears in the wet season. The period of high flow rate in the stream usually occurs in the late spring and summer due to the impacts of monsoon and typhoon (Chen et al. 2008). The supply of raw water from Kaoping River to the advanced water treatment plant is still not stable due to the following evidence: (1) the ratio of wet to dry season in the Kaoping River Basin is nine to one, which causes the difficulty in water resource utilization in this region; (2) uneven seasonal distribution precipitation concentrates in the period from May to October, which accounts for almost 90% of the annual precipitation; (3) extreme rainfall intensity, steep river slope, rapid flow conditions, and high run-off coefficient of the Kaoping River watershed. This causes the lowest

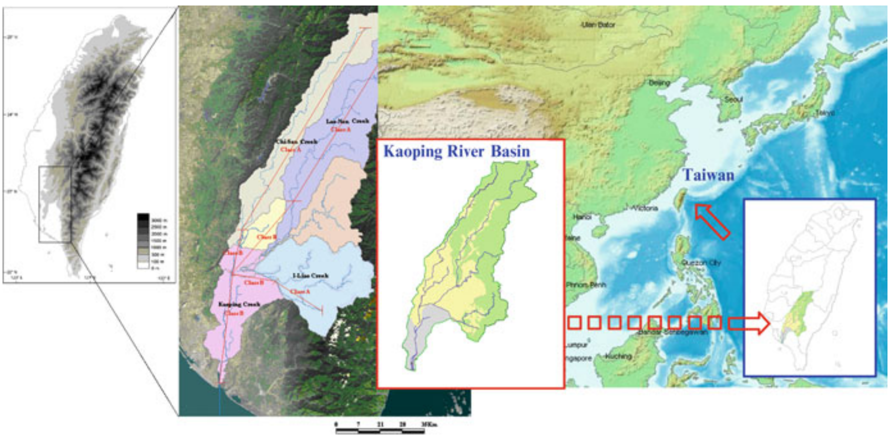


Fig. 1 Location of Kaoping River Basin, Kaoping River, its catchment, and three major reaches (Chi-San Creek, I-Liao Creek, and Lao-Non Creek)

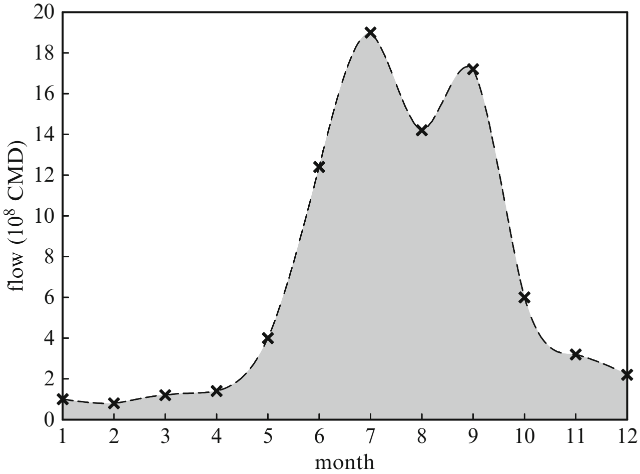


Fig. 2 Variations in quantity of flow versus month in the Kaoping River

utilization of the water resource in this region (Lin et al. 2010; Lai et al. 2010). Moreover, due to the increased water demand of domestic and industrial usage in the basin, current water resource management strategies need to be evaluated. Figure 2 shows the variations in quantity of flow versus month in the Kaoping River.

4 Typhoon Morakot Disaster

4.1 Background

In August 2009, Taiwan experienced its worst floods in 50 years after Typhoon Morakot struck large areas of southern Taiwan. Typhoon Morakot brought 2.5 m of rainfall over the 3-day event. Southern Taiwan suffered serious flooding; the storm destroyed homes, farms, buildings, and roads, causing approximately NT$100 billion (US $3 billion) in damage (TEPA 2010). The Kaoping River Basin was one of the most effected regions in southern Taiwan, and half of the basin was seriously impacted by this natural disaster (TEPA 2010). Figures 3 and 4 show the impacts of the storm on Chi-San Creek and Lao-Non Creek sub-basins (TEPA 2010). In the upper catchment of the Kaoping River Basin, most of the villages including the Shaolin Village were destroyed by the floods and more than 500 villagers were buried by the mud and rock flow. Figure 5 presents aerial photos showing the drastic changes of topography of Shaolin Village before and after the typhoon invasion (TEPA 2010). Figure 6 presents the photos illustrating the changes of landforms of Shaolin Village before and after the typhoon invasion (TEPA 2010). Results reveal that most of the fluvial plain has been buried by the debris, and a 2-m increase in land elevation was observed due to landslide and mud and rock flow.

Fig. 3 Impacts of Typhoon Morakot on Chi-San Creek sub-basin

Fig. 4 Impacts of Typhoon Morakot on Lao-Non Creek sub-basin

Fig. 5 Air photos showing the drastic changes of topography of Shaolin Village before (*left photo*) and after (*right photo*) the typhoon invasion

Fig. 6 Photos showing the drastic changes of landforms of Shaolin Village before (*left photo*) and after (*right photo*) the typhoon invasion

4.2 Environmental Impact Assessment, Monitoring, and Rebuilding

The 3-day flooding triggered by Typhoon Morakot not only caused drastic changes to local terrain and topography but also caused significant variations in the environmental and ecological conditions inside the Kaoping River Basin. To evaluate the impact of flooding on local environment and ecosystem and develop appropriate watershed management and disaster area rebuilding plans of the Kaoping River Basin, detailed environmental impact assessment and monitoring is required. Thus, after the disaster, volunteers from universities, research centres, Taiwan Environmental Protection Administration (EPA), Kaohsiung City Government, local government agencies and communities, and non-governmental organizations (NGO) jointly initiated an environmental impact assessment, monitoring, and rebuilding project and formed a disaster-area investigation team. The major tasks for the volunteer team were to (1) perform detailed environmental sampling for field data collection, (2) construct geographical information system (GIS) for disaster areas and construct a GIS platform for data management and decision making, (3) delineate environmental sensitive and potential hazard areas, (4) perform victims counselling, guidance, and assistance to help victims recover from the disaster, and (5) develop environmental + rebuilding plans and build a green village for the victims.

In the first task, approximately 35 locations were constructed for environmental media sampling and data collection. Figure 7 shows the sampling locations inside the Kaoping River Basin. For each environmental sampling location, air quality, surface water, drinking water, soil, and groundwater samples were collected and analyzed. Results from the environmental sampling and analyses show that the drinking water quality in some victim shelters and disaster areas contained high concentrations of turbidity and *E. coli* numbers, which needed to be improved. Based on the analytical results, the local water treatment company improved the temporary water treatment system so the water quality met the drinking water quality standards. Furthermore, local landfills and waste dumping sites located within the disaster areas were washed away by the floods and caused the contamination of downgradient soil and groundwater environments. Full-scale site investigation is required to delineate the soil and groundwater contamination. Temporary groundwater pumping for domestic use should be banned within the groundwater contaminated areas. Results from this study also indicate that increased format concentration was observed in several temporary shelters in disaster areas. Thus, the local government performed a detailed indoor air investigation so the victims would not expose themselves in possible high-risk shelters.

In the second task, a GIS platform was constructed as a tool for field data management and analysis. The GIS platform was provided for team members for data sharing and decision making. Figure 8 shows the GIS platform developed in this task. In the third task, field investigation and the satellite image analyses show that there are more than 15 potential sensitive and hazardous areas inside the basin, which require further investigation. These potentially sensitive and hazardous areas

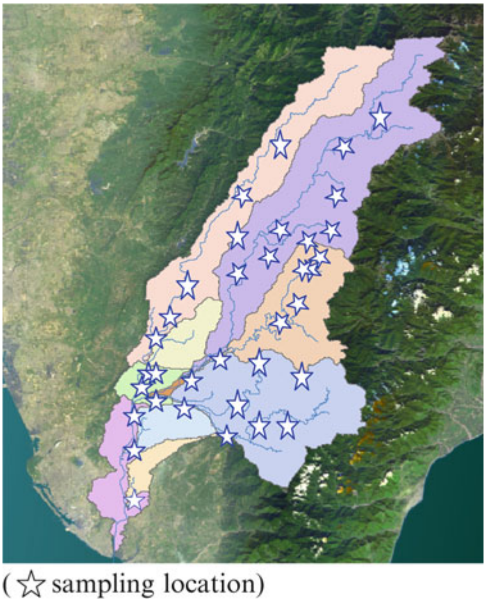


Fig. 7 Environmental sampling locations inside the Kaoping River Basin

Fig. 8 GIS platform developed for data management and decision making

are mainly (1) potential flooding and landslide areas, (2) potential pollution areas (including waste landfill sites and flooded industrial sites), and (3) source water intake area. As the Shaolin Village is located inside the potential flooding and landslide area, a new green and sustainable village (Shaolin Green Village) has been built by the government which can be seen in Fig. 9. In the green village, each home has a solar energy system for electricity generation and rainwater catchment system for irrigation. An on-site treatment system and subsurface flow constructed wetland system have been constructed for wastewater treatment, and the treated water has been recycled for irrigation purposes.

Fig. 9 Photo shows the Shaolin Green Village

5 Development of Watershed Management and Flood Control Strategies for Kaoping River Basin

Despite the heavy damages caused by typhoons in Taiwan, the typhoon rainfalls act as a main source for the water supply of the country. Typhoons in Taiwan are unique as they contribute both to valuable water sources required by communities but also create damages from associated storms. Thus, it is necessary to develop appropriate adaptation measures against extreme flooding resulted from typhoons. To minimize the impact of the flooding on the living environment, the following watershed management strategies have been developed for the Kaoping River Basin: (1) development of integrated, sustainable, and multimedia watershed management plans for the potential hazards and intensively used watersheds; (2) application of natural, sustainable, and green systems (e.g. constructed wetland, porous media infiltration) for water treatment, flood detention, and water storage in the disaster areas; (3) development of effective and practical land use management plans; (4) implementation of strict management of upstream water catchment areas and protection of forests to maintain the quality and quantity of water; and (5) promote the adopt-a-river project. Figure 10 presents the land use patterns of the Kaoping River Basin. Results indicate that the watershed is intensively used for different purposes. Thus, over-developed land uses should be prohibited. Enhanced land use management, forest preservation, soil and water conservation, and pollution prevention and treatment are required to protect the sources and quality of water in catchment areas. Figure 11 shows the proposed locations of artificial lakes for storm

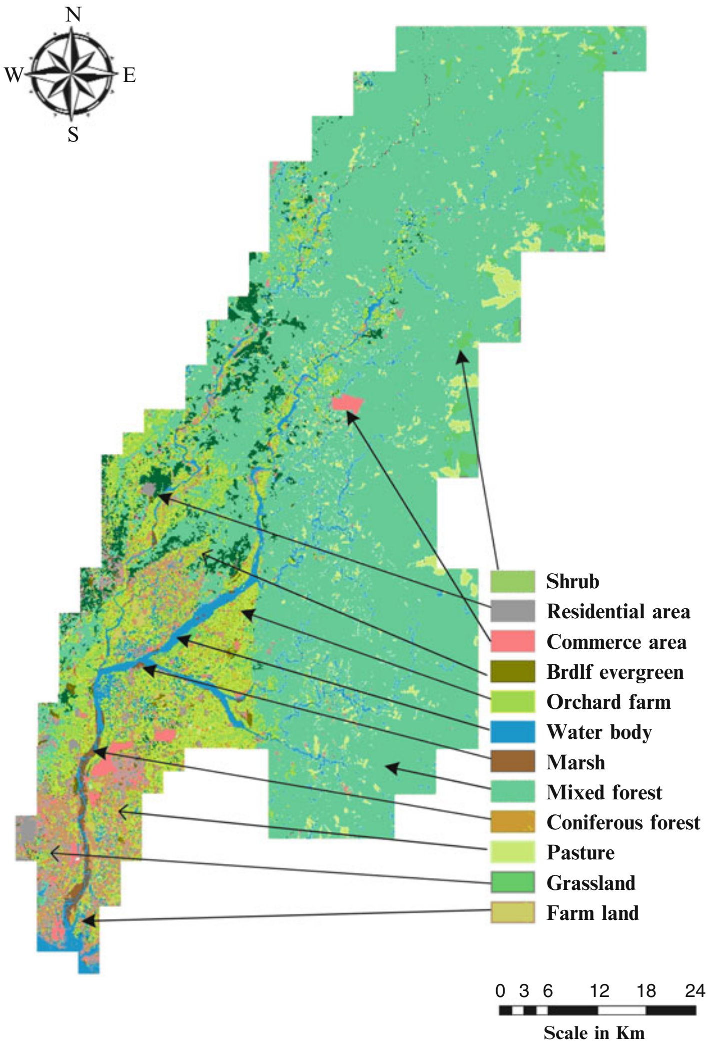


Fig. 10 Land use patterns in the Kaoping River Basin

water detention and groundwater recharge. These measures are more economic, more sustainable, and more environmentally friendly.

Through the adopt-a-river project, Kaohsiung City Government has organized more than 100 volunteer teams. The volunteers are involved in watershed investigation, disaster prevention, and victim rescue. With the support, efforts, and contributions from those unsung heroes, the Kaoping River Basin can be effectively managed. Thus, the damages caused by flooding can be reduced. The experience and findings obtained from this study would be beneficial for developing strategies to minimize the impact of the flooding on the Kaoping River Basin.

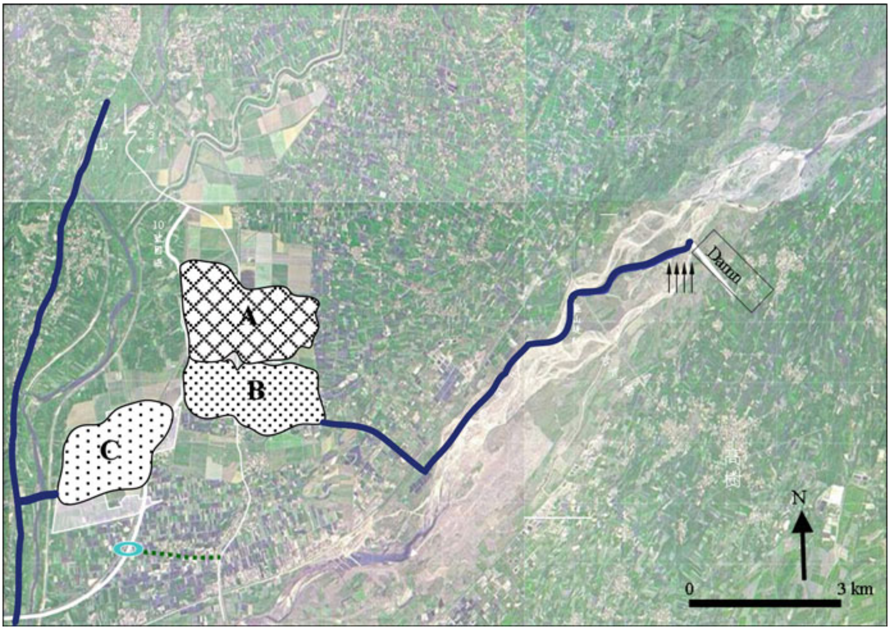


Fig. 11 Proposed locations of the artificial lakes for storm water detention and groundwater recharge

References

CEPD (Council for Economic Planning and Development). (2004). Agenda 21: Vision and strategies for national sustainable development, Taipei, Taiwan.

Chen, C. F., Chen, Y. C., & Lin, J. Y. (2008). Determination of the optimal water resource management through a fuzzy multi-objective programming and genetic algorithm: A case study in Kinman. *Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management, 12*, 86–95.

Cheng, K. S., Hou, J. C., Wu, Y. C., & Liou, J. J. (2009). Assessing the impact of climate change on annual typhoon rainfall—A stochastic simulation approach. *Paddy and Water Environment, 7*, 333–340.

Gao, S. L., Wang, J. X., Ying, A. W., & Li, D. F. (2002). A macro-scale and semidistributed monthly water balance model to predict climate change impacts in China. *Journal of Hydrology, 268*, 1–15.

Lai, Y. C., Kao, C. M., & Surampalli, R. Y. (2010). Developing NPS suspended solids control strategies using multimedia watershed management modeling. *Water Environment Research, 82*, 2205–2210.

Lee, M. S., Kao, C. M., Chen, T. Y., & Hong, J. N. (2008). Development of watershed management strategies for the Chiang-Chun River Basin, Taiwan. *Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management, 12*, 47–51.

Li, M. H., Tien, W., & Tung, C. P. (2009). Assessing the impact of climate change on the land hydrology in Taiwan. *Paddy and Water Environment, 7*, 283–292.

Lin, C. E., Kao, C. M., Surampalli, R. Y., Lai, Y. C., & Lee, M. S. (2010). Integrated water resource management for Kaoping River Basin. *Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management, 14*, 151–156.

Saptomo, S. K., Setiawan, B. I., & Yuge, K. (2009). Climate change effects on paddy field thermal environment and evapotranspiration. *Paddy and Water Environment, 7*, 341–347.

TEPA (Taiwan Environmental Protection Administration). (2002). Development of non-point source pollutant remedial strategy, Taipei, Taiwan.

TEPA (Taiwan Environmental Protection Administration). (2006). Evaluation of soil erosion and development of sediment control strategies for Kaoping River Basin, Taipei, Taiwan.

TEPA (Taiwan Environmental Protection Administration). (2010). Environmental impact assessment, monitoring, and rebuilding of the Typhoon Morakot disaster, Taipei, Taiwan.

Webster, P. J., Holland, G. J., Curry, J. A., & Chang, H. R. (2005). Changes in tropical cyclone number, duration and intensity in a warm environment. *Science, 309*, 1844–1846.

WRA (2006) Water Resource Agency, Ministry of Economic Affairs, Annual report, Taipei, Taiwan.

Wu, C. Y., Kao, C. M., & Lin, C. E. (2010). Using a constructed wetland for non-point source pollution control and river water quality purification: A case study in Taiwan. *Water Science & Technology, 61*, 2549–2555.

Wu, Y. C., Hou, J. C., Liou, J. J., Su, Y. F., & Cheng, K. S. (2011). Assessing the impact of climate change on basin-average annual typhoon rainfalls with consideration of multisite correlation. *Paddy and Water Environment, 13*, 1–10 (Published online).

Yasuhara, K., Komine, H., Yokoki, H., Suzuki, T., Mimura, N., Tamura, M., & Chen, G. (2011). Effects of climate change on coastal disasters: New methodologies and recent results. *Sustainability Science, 6*, 219–232.

Flood Risk Protection Concept for the Urban Region Geising/Altenberg in the Flood Formation Area of the Eastern Ore Mountains, Germany

Petra Schneider, Ralf Löser, and Frank Gössel

Abstract Due to the results of the climate change prognosis for Saxony County, and especially the Ore Mountains, the number of heavy rain events will have a higher recurrence interval in the near future. There were more prognosticated heavy rain events with destructive capacity for the urban areas. The urban areas are densely located especially in the valleys of the East Ore Mountains, which form natural run-off channels for heavy rain events in flood generation areas. Straightforward climate change measures must be taken into account such as sustainable land use technologies. Additionally, in flood generation areas appropriate flood protection concepts, for example, engineered protection methods, should be implemented. The key activities in terms of flood protection in the Geising/Altenberg area include a potential analysis of retention effects as well as the discussion on the effectivity of compensation measures on agricultural lands, settlements and forestry areas. The main scope was an assessment of the efficiency of possible compensatory measures to support the effect of the natural water infiltration and water retention in the flood generation areas. The required flood protection measures in the flood generation area of Geising and Altenberg must not affect the natural character of the area. The inclusion of mining facilities for flood retention or discharge was evaluated to be critical.

Keywords Flood protection concept • Flood risk in mining areas • Climate change adaption for heavy rain events

---

P. Schneider (✉) • R. Löser
Environmental Remediation Concepts, C&E Consulting und Engineering GmbH,
Jagdschänkenstr. 52, D-09117 Chemnitz, Germany
e-mail: p.schneider@cue-chemnitz.de; r.loeser@cue-chemnitz.de

F. Gössel
Mayor Office at Geising town, Hauptstraße 25, D-01778 Geising, Germany

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_9,

1 Introduction

The Central German Uplands are often affected by heavy rainfall with short-term extreme water run-off. In Saxony, the establishment of flood generation areas was first implemented by law after the “Millennium Flood” in 2002. Floods are natural events which are aggravated as a result of anthropogenic influences. Due to climate change and rapid urbanization processes, the risks of floods and the related damage potential are increasing.

In August 2002, Saxony was affected by a severe flood affecting more than two-thirds of the counties’ territory (Socher and Böhme-Korn 2008). This flood event, due to the volume of its impact, was named the “Millennium Flood” and gave rise to the reconsideration and redirection of flood protection and related disaster management in Saxony. A strategic approach was developed, which contained as a first step the preparation of the flood protection concepts. In this framework, a new methodology was developed for the risk assessment and the cost-benefit analysis, and all measures were prioritized, to create the basis for a Flood Protection Investment Program (Socher and Böhme-Korn 2008). This methodology formed the groundwork for the preparation of the flood protection concepts for all water bodies of the first order.

Flood protection improvements are especially needed in urban areas, where they pose a unique challenge due to the risk to humans and sensitive infrastructure (LAWA 2010). As central mountain areas are often affected by heavy rainfall with short-term extreme water run-off, they are characterized as “flood generation areas”. Despite downstream catchments benefiting from technical measures for flood risk protection which contribute to flood risk reduction, there is no absolute protection. In Saxony, the establishment of flood generation areas was firstly established by the Saxonian Water Law after the “Millennium Flood” in 2002.

The development of flood protection concepts for rivers of the second order, according to the Saxonian Water Law § 99, is usually in the responsibility of the communes. Geising and Altenberg are both located in the flood generation area in the catchment of the Rotes Wasser River Basin. The flood protection concept for Rotes Wasser River Basin was decided by the Environmental Ministry of Saxony to be developed as a model and pilot project for flood generation areas. C&E Consulting und Engineering was involved in the preparation of the flood protection concepts for Geising/Altenberg as project supervisor and manager.

2 “Rotes Wasser” Catchment Characteristics

The Eastern Ore Mountains form a natural region that covers the eastern part of the Saxon Ore Mountains in the south-east of Germany with an average altitude of 700 m above sea level. Several protected areas are located in the Eastern Ore Mountains including the fauna-flora-habitat areas as well as the protected mountain meadows with their unique linear cairns.

The cross-border catchment of Rotes Wasser covers 39 km², out of which 4.5 km² are located in the Czech Republic (due to the EU Water Framework Directive, a cross-border water body). The river length to be considered is 51.8 km and includes both first- and second-order rivers. The area has about 20,000 inhabitants, and Geising and Altenberg are the main municipalities. Due to the provisions of the Saxonian Water Law § 100b, the flood generation area "Geising–Altenberg" is registered as a protected area with a surface of about 9,300 ha since 2006 and includes the catchment of "Rotes Wasser". Relevant engineered systems for flood protection did not exist in the study area before the "Millennium Flood". The existing level of protection is defined by recurrence intervals of HQ2[1] to HQ20 for Geising town as well as HQ5 for the town of Altenberg.

Abandoned mines, mine dumps and a tailings pond, as well as artificial water bodies (ditches, reservoirs), are characteristics of the catchment area. From the Middle Ages onwards, the culture of the Ore Mountains has been heavily influenced by mining. The former mines of Altenberg and Geising are now principal attractions in the Eastern Ore Mountains area, especially the Altenberg Sinkhole above a collapsed tin mine (Pinge) and the basalt hill Geisingberg (824 m). The Altenberg Sinkhole has a depth of 150 m and a diameter of 450 m, on which the mining of tin began around 1440.

3 Methodology and Approach

3.1 General Approach

When elaborating on the plans of action for flood reduction in a river basin, the establishment of an integrated modelling approach and a compilation of basin-related information are required. This should be realized by means of an open system software and standardized catchment and time series data (Krahe et al. 2004). This approach was also followed in the Geising/Altenberg flood generation area. The methodology comprised the following working steps:

- Description of the characteristics of the catchment area
- Determination of hydrological base data
- Analysis of historical flood events
- Hydraulic calculations with current precipitation data and evaluation of protection scopes (recurrence intervals)

[1]The recurrence interval (sometimes called the return period) is based on the probability that the given event will be equalled or exceeded in any given year. The given number indicates the recurrence interval of flood. The situation in Altenberg, for example, showed a protection level against floods with a recurrence interval of 5 years.

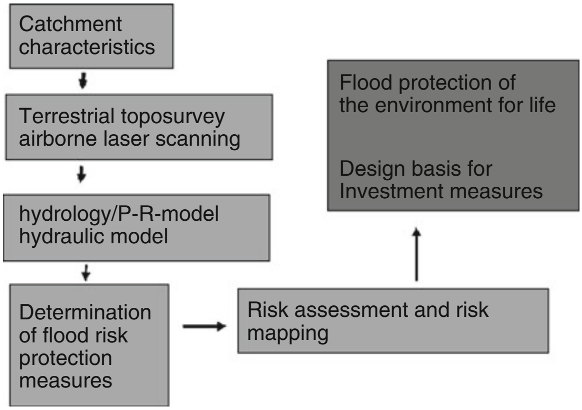


Fig. 1 Scheme of the processing of hydrological data in the flood formation area Geising/Altenberg

- Analysis of the current protection status and of the risk and damage potential, risk analysis and assessment and development of risk maps
- Evaluation of potential flood protection measures
- Cost-benefit analysis of the flood protection measures
- Prioritization of the flood protection measures

The evaluation techniques used for identifying the potential of flood reduction measures included a detailed knowledge of the discharge formation in a catchment area and a survey of the retention possibilities along the river in the whole river basin (Krahe et al. 2004). In the present study, we applied terrestrial topo survey to the whole catchment as well as airborne laser scanning for the development of a Digital Terrain Model (see Fig. 1). The river basin model was based on results of a precipitation-run-off model. For hydraulic modelling, the free software Hydrologic Engineering Centers River Analysis System HEC-RAS (Brunner 2008) was used.

The methodology comprised the definition of scenarios for decentralized flood protection in terms of their technical, socio-economic and ecological feasibility and taking into account the environmental potential of the river basin. All data were processed based on GIS.

3.2 *Considerations of the Mining Situation*

Like most of the towns in the area, Geising and Altenberg were founded as mining towns in the fifteenth century. The mining activities left some significant landmarks in the flood formation area of Geising/Altenberg such as the abandoned mines and shafts, mine dumps and the Bielatal tin mill tailings pond (Daus et al. 2000). The famous landmark of the mining town Altenberg is the Pinge, a result of a tin mining collapse in 1620, which formed a crater with a depth of 150 m and a diameter of 450 m. Figure 2 gives an impression of the main mining objects in the flood formation area of Geising/Altenberg. In the south is located the Zinnwald mining area.

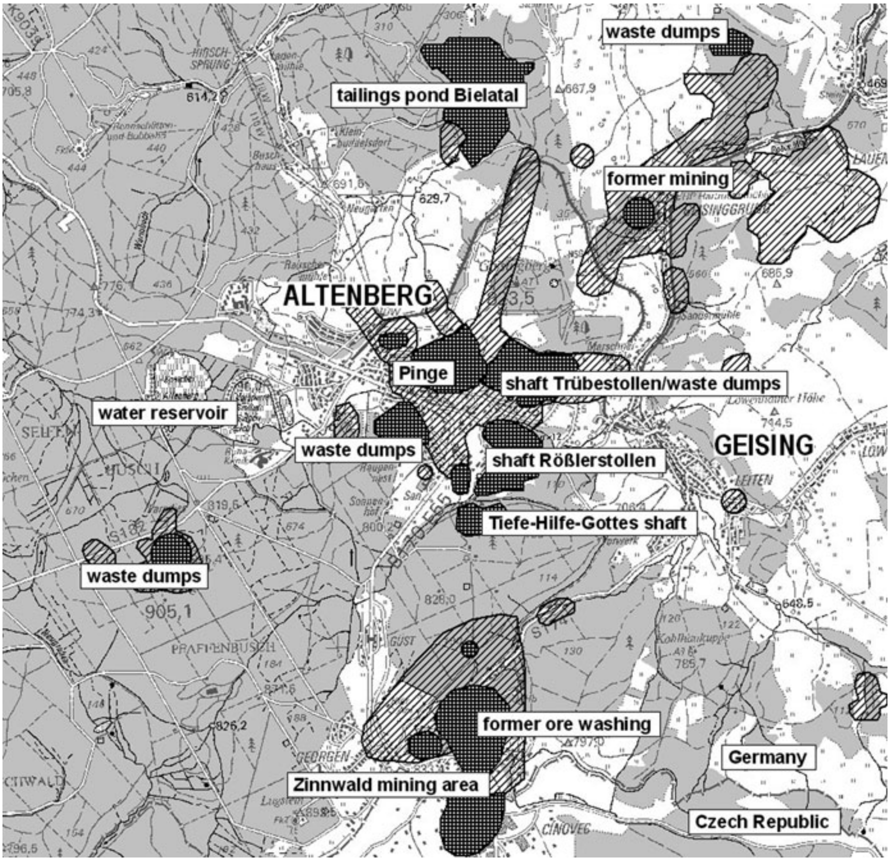


Fig. 2 Mining sites in the catchment area

4 Results

4.1 Hazard and Risk Assessment

The identification and assessment of compensatory measures are one of the basic principles of hydrological planning in flood generation areas. The location and the type of flood protection structure create possibilities for the integration of urban functions. The result is a multifunctional structure in which urban activities are embraced by flood protection. The project components comprised the following subjects.

In the case of Geising/Altenberg, the existing surface and subsurface buildings construction of the former mining required special attention within the development of the flood protection system due to a higher risk of breakdown during flooding. However, the mining residues and in particular the shafts could serve as retention

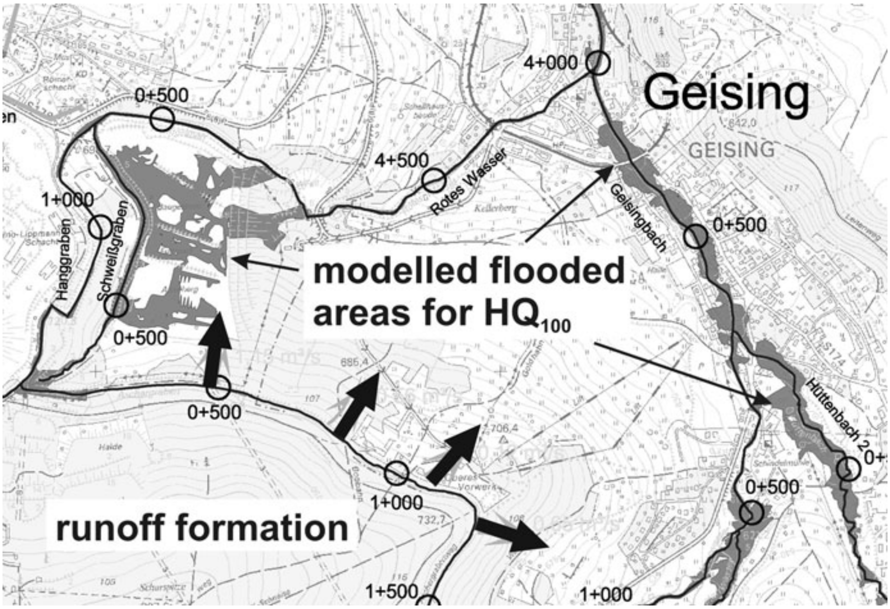


Fig. 3 Results of the hydraulic calculations (example) – flooded areas HQ100. (The *small arrows* indicate the flooded areas, here in case of HQ100 recurrence interval. *Big arrows* indicate the flow direction in case of immediately formed surface water run-off after heavy rains in areas with steeper slopes where retention is not possible due to the morphology)

space for flooding water. The existing level of protection of the settlements along the rivers was evaluated on the basis of the full board run-off water.

Within the frame of the hydrological assessment, the influence of the mine drainage system was evaluated. It was estimated that within the mine drainage system, a retention time of 2 days was expected for heavy rainfall.

4.2 Protection Scopes and Results of Risk Assessment

Key activities in terms of flood protection are a potential analysis of the retention effects as well as the discussion on the effectiveness of compensation measures on agricultural land, settlement and forestry area. The main scope was the assessment of the effectiveness of possible compensatory measures to offset the effect of the natural water infiltration and water retention in the flood generation areas.

The future risk analysis considered the following scenarios as protection scopes: Altenberg town HQ100 (means the town shall be protected against big floods with a recurrence interval of 100 years), Geising town HQ50 (due to dense urbanization) and tailings pond of Bielatal due to high risk potential of dam failure HQ1000. Figure 3 shows an example of the visualization of the hydraulic modelling results for the flooding scenario of HQ100.

The visualization in Fig. 3 shows the main problem of flood forming in a flood formation area: due to the hilly morphology, there is no relevant retention capacity. Heavy rains immediately form powerful run-off discharges, which run downhill with highly damaging energy. Furthermore, due to the morphology there is not much space for flood protection measures.

The results of the assessment of the flood risk potential were used as a basis for the evaluation of appropriate protection measures. The approach for the evaluation of the flood risk protection measures comprised the following steps:

- Evaluation of protection scopes (recurrence intervals for floods) considering the land use
- Assessment of the damage potential as result of the hydraulic calculations for HQ100 and HQ200
- Evaluation of flood protection measures (engineering measures, change of land use, rain water retention/rain water management) by re-evaluation of the designed measures by the hydraulic model and modelling of the protection effect
- Evaluation of measures of precaution

Based on a cost-benefit analysis and the prioritization, an action plan was developed. The action plan considered three types of measures:

1. Large-scale measures (scale larger than one catchment, e.g. land use change)
2. Measures on catchment and tributary scale (e.g. dams)
3. Measures on the river (e.g. enlarge diameter of bridges)

Three main categories of catchment-related measures are often described as decentralized flood reduction measures (FRM, Krahe et al. 2004):

1. Enhancement of the storage potential of the catchment area by activating and improving the natural storage capacity of soils, e.g. take off sealing, conservation tillage, rainwater infiltration and local storage (depressions, rain retention ponds, small reservoirs). This concerns the process of run-off generation.

    - Due to the hilly morphology, these kinds of measures have only a small implementation potential in the Geising/Altenberg flood formation area. An upstream flood control reservoir was taken into account to optimize the flood protection. Due to the presence of nature protection areas as well as the morphological situation, there can be detected only a few locations suitable for a rain water retention basin.

2. Protection and reactivation of flood zones along the tributaries (e.g. re-naturalization, relocation of dikes, protection of flood zones against further sealing).

    - This approach is, due to the non-applicability of other methods, the most favourable in the river basin of Rotes Wasser.

3. Technical flood protection (e.g. by installing reservoirs and setting up controllable retention areas in the foreshore of the tributaries). This concerns the processes of runoff concentration and runoff dispensation.
   - This kind of measures is also of major importance in the catchment, as can be seen from the examples given below.

Examples for the developed flood risk measures in Altenberg town, which entered into the prioritization process, for each tributary river are given below.

Measures for the Tiefenbach/Tiefenbachgewölbe/Rößler shaft/Trübe shaft

- Trübe shaft will be used for the dewatering in case >HQ100
- Decrease of the run-off in case HQ100 by redirection of the water into Galgenteich pond
- Establishment of a sediment trap at the entrance to the Tiefenbach tubes
- Re-design of Upper Walkteich to become a rainwater retention basin
- Re-design Mühlenstraßen dam/flood dewatering via Trübe shaft

Measures for the Heerwasser River

- Enlargement of the dewatering diameter for the road S 174 in Zinnwald
- Construction of Tiroler Weir at the border to Czech Republic
- Replacement of the triple tube with a "rough glide"
- Construction of a rain water retention basin downstream the border to Czech Republic

Measures for the Bielatal Tailings Pond

- Use of Trübe shaft for flood dewatering to protect Altenberg town in case of >HQ100
- Construction of slope trenches for dewatering of the run-off via Trübe shaft
- Remediation of the sedimentation pond and upgrade of the dewatering system on the dumps as well as long-term stable remediation of the Bielatal Tailings Pond including surface sealing
- Construction of a dewatering system for the tailings ponds due to DIN 19700 for HQ1000

The inclusion of mining facilities within the measures of flood protection and flood discharge as well as water retention has to be evaluated critically. In general, they are not suitable to fulfil those functions without being damaged. It requires high costs to strengthen them for such functions. The complex hydrological processes in mining areas are another problem. For that reason, it is difficult to capture any damage caused for rehabilitation. Some mining tunnels, which had been reinforced after the 2002 flood, are appropriate to be used for water retention only. The flood protection concepts considered those tunnels to be feasible for the flood protection of Altenberg and Geising towns.

5 Conclusions

The results of the risk assessment pointed out three types of risks in the flood formation area of Geising and Altenberg:

- Risk of flooding (mainly in the area of Altenberg town)
- Risk caused by old mining (relevant for the whole catchment)
- Risk caused by surface run-off (mainly in the area of Geising town)

The potential analysis in terms of retention effects included an evaluation of the efficiency of compensatory measures on agricultural land or settlements and forestry areas. The main scope was the assessment of the hydrological efficiency of possible compensatory measures to support the effect of the natural water infiltration and water retention in the flood generation areas. The required flood protection measures in the flood generation area of Geising and Altenberg must not affect the natural character of the area. While taking into account the nature conservation interests and the local morphology, a location for an upstream flood control reservoir could be concluded close to the Czech border only. Taking into account the prognosticated climate change impacts, especially the expected increase of floods in the area, the long-term protection concept for humans and properties needs to be improved.

The results of the climate change prognosis for Saxony County, especially the Ore Mountains, indicate that the number of heavy rain events will have a higher recurrence interval in the near future. It is forecast that the frequency of heavy rain events with destructive capacity for the urban areas will increase. The urban areas are densely located especially in the valleys of the East Ore Mountains, which form the natural run-off channels for heavy rain events in flood generation areas. "Smooth" climate change adaption measures, like sustainable land use technologies, have to be taken into account together with engineered flood protection measures as an appropriate flood protection concept in that area.

References

Brunner, G. (2008). HEC-RAS rivers analysis system. Hydraulic reference manual. Version 4.0, 2008, US Army Corps of Engineers, Hydraulic Engineering Centre, USA.

Daus, B., Mattusch, J., Paschke, A., Wennrich, R., & Weiss, H. (2000, May). Kinetics of the arsenite oxidation in seepage water from a tin mill tailings pond. *Talanta, 51*(6), 1087–1095.

Krahe, P., Herpertz, D., Ebele, M., Busch, N., Buiteveld, H., Naef, F., Helbig, A., & Beersma, J. (2004). Development of methodologies for the analysis of the efficiency of flood reduction measures in the Rhine Basin on the basis of reference floods, CHR report I-21, ISBN 90–36956–75–7.

LAWA (German Working Group on Water Issues of the Federal States and the Federal Government). (2010). Recommendations for the establishment of flood risk management plans. Adopted at the 139th LAWA General Meeting in Dresden on 25/26, March 2010.

Socher, M., & Böhme-Korn, G. (2008, August). Central European floods 2002: Lessons learned in Saxony. *Journal of Flood Risk Management, 1*(2), 123–129.

Part III
Toward the Resilient City

Introduction: Toward the Resilient City

Kristina Yuzva and Monika Zimmermann

Crisis and disasters impose significant threats to sustainability and have the power to affect society, the environment, and economy. The capacity of a city to respond 'creatively, preventively and proactively to change or extreme events, thus mitigating crisis or disaster', is to be resilient (ICLEI-Local Governments for Sustainability 2002).

While resilience is not a recent concept—with roots in child psychology and ecology studies (Baud and Hordijk 2009)—the focus on resilient cities only entered the local government agenda in the past 10 years. During the United Nations Johannesburg Summit in 2002—the World Summit on Sustainable Development (WSSD)—the international community came to realize that a sustainable city must be a resilient city. In effect, ICLEI's Resilient Communities and Cities Initiative was launched at the Local Government Session of the WSSD in 2002 to help local actors develop and implement local resilience agendas.

The initial definition of resilience was applied most frequently to the literature on disasters, whereby local governments and disaster management communities recognized that building resilience to disasters was a crucial element in creating sustainable cities. Recent attempts to define and apply resilience have occurred against a build-up of ongoing debate on the readiness of our cities to effectively cope with the impacts of climate change. As such, there grew a common understanding among experts that cities need to improve their resilience to climate change impacts (e.g. ICLEI's Climate Resilience Communities Program). In turn, local governments are currently searching for tools to help protect their communities from the impacts and costs associated with climate change.

K. Yuzva (✉) • M. Zimmermann
ICLEI – Local Governments for Sustainability, World Secretariat, Kaiser-Friedrich-Str. 7, 53113 Bonn, Germany
(Now United Nations University)

United Nations University, Bonn, Germany
e-mail: resilient.cities@iclei.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_10,

Hence, resilience goes beyond disaster risk reduction to emphasize the preparedness to extreme events, reduced vulnerability, and enhanced adaptive capacity.

More recently, the term 'resilience' is being offered 'as an economic and performance model shifting risk to opportunity' (ICLEI's White Paper: Financing the Resilient City 2011). In particular, the international community is beginning to define urban resilience in economic terms, focusing on the efficiency and reliability of urban performance in response to climate change by focusing on the benefits and utility to residents and users and predictable returns to investors.

As demonstrated above, resilience has been defined in many ways and used in a variety of contexts. A number of presentations and panel sessions held at the Resilient Cities 2011 Congress offered a further exploration of that ground, drawing on lessons about approaches, methods, and the practice of urban resilience. Delineating their experiences from different sectors and areas of expertise—ranging from urban agriculture, water, food and energy security, urban planning, water management, green infrastructure, and adaptation planning—the following chapters allow for more complex questions to be raised about the resilience of a city within a wider spatial, organizational, and societal context in which it exists.

Despite the wide perspectives on the meaning of resilient cities—its span of coverage, how to implement it, and who plays what roles—the following chapters demonstrate that several common elements have emerged that contribute to making our cities more resilient. These have been identified as the following:

- Systems thinking approach: There is a growing consensus that urban systems must be approached as one integrated system as vulnerability of any one system element affects the system as a whole.
- Collaboration: Transition towards more resilient cities requires intense interdisciplinary and cross-institutional co-operation. Each discipline and sector has something to contribute, and new synergies can be created as a result.
- Decentralization: Decentralized systems are more resilient as failure of a partial system would only affect a small part of the urban area. Some examples include multiple and local water resources and local energy production.
- Incentives: In order to implement resilience policies, we must create win-win scenarios for all the actors involved. For example, robust physical infrastructure is not enough unless it is accompanied by institutional and societal capital.

In these chapters, we have only begun to understand what it means for a city to be truly resilient. There are still gaps that need to be addressed. Most importantly, some authors discuss how social aspects are often ignored in the contemporary understanding of urban resilience. As the risks and impacts of climate change disproportionally affect the most vulnerable in our society (e.g. elderly, urban poor, children, and women), social and economic concerns must be at the forefront of resilience thinking.

Moreover, as the concept evolves, there are still some questions that are left unaddressed such as how independent do cities have to be to achieve resilience, e.g. some authors highlight the benefits of growing food locally as it improves living conditions, creates income, and decreases vulnerability of urban poor. In addition, what role does urban transport play in making our cities more resilient? How can (local) energy systems become more resilient, and how can renewable energy as a key factor for independent and sustainable energy be promoted? While some chapters aim to tackle these questions, we hope to offer a more comprehensive analysis in the upcoming Resilient Cities 2012 Congress.

Taken as a whole, the following chapters help to demonstrate how our recent attempt to define resilient cities recognizes more actors, creates new space for ideas, incorporates more flexible patterns of urban planning, and can lead to more synergies in developing new approaches. Future resilient cities conferences will have to go into much more detail to demonstrate the rich opportunities but also challenges when creating more resilient communities.

References

Baud, I., & Hordijk, M. A. (2009). *Dealing with risks in urban governing: What can we learn from 'resilience thinking'*. In The 4th international conference of the international forum on Urbanism: The New Urban Question-Urbanism beyond Neo-Liberalism. Available at: http://newurbanquestion.ifou.org/proceedings/index.html.

ICLEI. (2011). *Financing the Resilient City: A demand driven approach to development, disaster risk reduction and climate adaptation—An ICLEI White Paper*. Bonn: ICLEI Global Report.

ICLEI-Local Governments for Sustainability. (2002). *ICLEI's Resilient Communities and Cities (RC&C) initiative*. Available at: http://www.iclei.org/fileadmin/user_upload/documents/Global/Progams/RCC/RCC_short_report_Feb9_final3.PDF.

Water, Energy and Food Security in Mexico City

Martha Delgado

Abstract Population growth, climate change and accelerated economic activity will increase the demand for food, water and energy. As these three issues are interlinked and interdependent, securing them is central to alleviating poverty and creating climate-resilient and robust green economies. As engines of economic growth and social development, cities are at the forefront in creating innovative solutions to such challenges. In turn, this paper will first examine how Mexico City is securing its water resources by focusing on the Programme of Sustainable Water Management in Mexico City for 2007–2012. Moreover, the Mexican government is realizing that issues of water security are closely linked to food and energy security as reflected in the various government plans, particularly in the Climate Action Programme in Mexico City 2008–2012 (PACCM). The PACCM proposes both mitigation and adaptation strategies in areas of water management, energy, transport and waste management. Finally, this chapter concludes that as urbanization and planning in cities becomes more complex, Mexico City will have to act under the coordination of planning agencies and will have to work on the creation of appropriate legislation with the strength of civil society.

Keywords Civil society • Institutional coordination • Long-term planning • Urban growth • Water supply and sanitation

1 Introduction

Due to their economic and social importance, cities play a critical role in creating solutions to the impacts of climate change.

M. Delgado (✉)
Ministry of Environment, Mexico City Government, Plaza de la Constitución 1 3er Piso, 06068 Mexico City, Mexico
e-mail: presenci@prodigy.net.mx

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2, DOI 10.1007/978-94-007-4223-9_11,

For historical and political reasons, Mexico is a highly centralized country. Along with the Metropolitan Area of Mexico (MCMA), Mexico City accounts for 45% of the national industrial activity, produces 38% of the gross national product and contains 20% of the total Mexican population. The city is home to almost all government offices, business centres, national and international cultural activities, universities and major research institutes. The rapid growth in the last 50 years has been characterized by both expansion of urban and residential areas and illegal land invasions and informal settlements in peripheral areas.

Mexico City registers a total of 8.8 million inhabitants in an area of 1.484 km^2, 59% of which is conservation land, that is, rural areas. It has 2.54 million homes and 2.9 million vehicles, which in sum make 12 million trips a day. In addition, the Metropolitan Area of Mexico City (MCMA), comprising 16 municipalities of the federal district, 59 municipalities of the state of Mexico and 29 municipalities of the state of Hidalgo, has a population of 21.3 million. The MCMA has a vehicle fleet of 4.5 million vehicles all of which make 21.6 million trips a day.

No doubt that the great challenges that urban areas are facing are access to food, water and energy. These three issues are closely related and, therefore, they require comprehensive solutions in order to make our cities more resilient.

This chapter will focus primarily on the issue of water, looking particularly at the initiatives and process that are already in place to deal with water security in Mexico. Subsequently, we demonstrate how water is intrinsically linked to the issue of energy and food security.

2 Water Security: Mexico City

Throughout the years, government authorities have attempted to address population growth by providing urban services from a supply perspective, that is, always looking for new sources of supply to meet the growing service requirements for the city of Mexico. Water services have not been an exception. It began with the exploitation of the aquifer and subsequently with the development of large hydraulic infrastructure projects to bring water from Valle de Lerma (state of Mexico) and from the Cutzamala System (state of Mexico and Michoacan). Despite such efforts, there are many areas in Mexico City that still lack adequate water services. For example, in the MCMA, water is supplied at 63 m^3/s, while in Mexico it is supplied at 32 m^3/s.

The search for new sources of water, along with the overexploitation of the current sources as the only ways to resolve the water demand of Mexico City, is closely related. According to the Programme of Sustainable Water Management in Mexico City for 2007–2012, there are no records of when the overexploitation of the aquifer began; it is in the 1940s that the effects are manifested in the city by way of subsidence. The latest estimates of the aquifer show a negative 30% water balance, meaning that for each cubic metre that is removed, only 300 l can be recharged.

With regard to the important issue of water, the Federal District Government has identified five main guidelines for its management in the federal district:

1. Aquifer recharge and protection of the conservation land
2. Consumption of potable water
3. Leak detection and suppression
4. Sewage, treatment and reuse of treated wastewater
5. Parks and lake areas of high environmental value

According to figures provided by the United Nations, 884 million people lack access to drinking water sources, while 2.5 billion lack access to sanitation facilities. The root causes of the current crisis in water and sanitation can be traced to poverty, inequality and unequal power relations. This is further exacerbated by social and environmental problems such as rapid urbanization, climate change and increased pollution and depletion of water resources.

Water is and will be a central theme in urban systems as it directly affects people in their private lives. However, people also require reliable and affordable energy as it is essential to generating income and providing basic social services such as good lighting, clean drinking water, health services and agricultural activities. Moreover, without water and energy, our cities could not meet the food requirements of the world's population.

3 Energy Security: Mexico City

Given the increasing risks related to the security of energy supplies and climate change, the long-term energy security scheme should focus not only on renewable energy but also on how to move away from our dependence on oil. It is time to take a step forward and incorporate energy sources and clean technologies to ensure energy supply for future generations. Investment in science and research to develop clean technologies must have an important role in the development of our cities.

In Mexico City, about 88% of greenhouse gas emissions are attributed to the consumption of energy as fossil fuels and electricity used in transport, industry, commerce or services. The challenge is to balance economic and population growth with environmental sustainability through improving and expanding the public transport system; transforming vehicle technology; efficient use of energy in buildings and in industrial plants, on lighting systems, in water pumping systems and households; the use of renewable energy and rational use of water (including savings and water reuse and aquifer recharge).

In order to address these three challenges, local governments need support from citizens. Involving citizens in the governing process will ensure that a joint consensus is reached on the dangers and solutions to water, energy and food security. To achieve this collaboration, it requires that policies, finance and technology get harmonized to achieve synergies.

On 5 December 2006, assuming the responsibility of the head of Federal District Government, a set of public commitments were made to citizens expressing a desire to lead the development of Mexico City's new horizons of equity, welfare and economic growth. The General Programme of Development 2007–2012 of Mexico City offers a planning framework to meet this commitment.

The General Programme of Development 2007–2012 of Mexico City, which is based on a public commitment to society, has seven axes of action:

1. Political reform: full rights to the city and its inhabitants
2. Equity
3. Safety and swift justice
4. Competitive and inclusive economy
5. Intense cultural movement
6. Long-term sustainable development
7. New urban order, efficient services and quality of life for all

Each axe has set objectives, strategies and lines of action. For example, for axe 6 on sustainable development, local governments designed and implemented the Climate Action Program of Mexico City 2008–2012 (PACCM).

4 The Climate Action Program (PACCM) of Mexico City

The implementation of the Climate Action Program aims to integrate, coordinate and promote public action in Mexico City to reduce the environmental, social and economic risks of climate change and promote the welfare of the population by reducing emissions and capturing greenhouse gases (GHGs).

The PACCM has two overarching goals: (1) to reduce seven million tons of carbon dioxide equivalent in the period 2008–2012 and (2) to conduct a comprehensive climate change adaptation plan for Mexico City and have it fully operational by 2012.

The specific objectives are:

- Influence the behaviour patterns, habits and attitudes of Mexico City's population to contribute to climate change mitigation and adaptation
- Attract investment and funding for GHG mitigation projects to overcome barriers to implementation
- Promote technological innovation related to combating climate change
- Position the government and Mexico City as a national and international leader for its efforts to mitigate GHG emissions in the context of the commitments made by Mexico to the United Nations Framework Convention on Climate Change
- Set the example for public policy in mitigating and adapting to climate change in Mexico and generate a multiplier effect on the country and the world

The PACCM has 26 mitigation actions in the categories of water, energy, transport and waste; 12 shares on adaptation and 6 shares on communication and education. In turn, the Government of Mexico City has made significant progress in efficient use of water and energy.

The Climate Action Program represents set actions that the Government of Mexico City has openly decided to take to deal with the impacts of climate change. Since its publication in June 2008, this program has been the definition of priority actions aimed at reducing greenhouse gas emissions and adaptation to climate change.

With the certainty that climate change represents the greatest environmental challenge, Mexico City has made it a priority to implement public policies to mitigate and adapt to climate change with the aim of increasing the city's resilience and minimizing vulnerability. This has lead the Secretariat of Environment/Ministry of Environment of the Federal District Government to create a record of GHG reductions to report the progress made with the Climate Action Program of the city of Mexico in order to promote accountability and transparency.

Today, the goal of reducing GHG emissions has been achieved. From January 2008 to June 2011, there has been a reduction of 5,772,033 tons of carbon dioxide equivalent (CO2e Ton) accumulated, representing 82% improvement over the goal of seven million tons of CO2e accumulated, which was set by the Program of Action Climate 2008–2012 (Secretaría Medio Ambiente del Gobierno del Distrito Federal 2011).

With the creation of the Interagency Commission on Climate Change in the Federal District (CICCDF), which is represented by 36 GDF agencies, the Secretariat of Environment has been able to institutionalize public policies to address climate change and encouraged the active participation of citizens, the academia, NGOs and even the industry.

The commitment to face the climate threats in a more secure way for the population enables to report the following progress:

During the period January 2008 to June 2011, the greatest GHG reduction was in the transport sector, where emissions were reduced to 4,851,783 tons CO2e.

The energy category (covering energy efficiency and renewable energy) reported a reduction of 183.425 tons of cumulative CO2eq. While water management contributed to the reduction of 1.804 tons of CO2e, waste management reports a reduction of 127.175 tons of CO2e and reforestation activities a reduction of 607.846 tons of CO2e.

The main hydrometeorological threats for the city are heavy rainfall that generate flooding, heat waves and cold waves, high winds, hail, snow and atypical frosts or droughts. It is clear that disasters do not come only because of the threat itself but because of a high vulnerability that creates a greater risk.

Consequently, the Programme of Measures for Adaptation to Climate Change promotes a set of short- and long-term actions for climate change risk reduction in Mexico City. It also promotes the generation of adaptive capacities that reduce vulnerability and moderate the potential damages, taking advantage of the opportunities arising from changes in climate in Mexico City and the surrounding areas.

The Programme of Measures for Adaptation to Climate Change includes the following:

1. Identification of the main threats and vulnerability analysis – This includes studies which aim to understand and evaluate the different aspects of Mexico City's climate change vulnerability.
2. Integration of the adaptation perspective to enhance existing capabilities – Various government areas (environment, civil protection, health, rural development and water systems) have functions related to the social adaptive capacity and should make this explicit in their activities. This line of action includes the creation of intra- or interlinkages on the basis of civil protection system and environmental system. It will be necessary to consider both the increase in risk and in vulnerability.
3. Implementation of adaptation actions – This refers to all actions that involve changes to infrastructure (water and roads), to buildings, to urban planning and to crops and biodiversity, in order to lessen the impacts of the manifestations of climate change on the basis of early warning systems and climate modelling.

On the issue of water, the Ministry of Environment has five programmes:

1. Water Conservation Program in Federal District Housing
2. Water Conservation Program in Government Buildings and Offices of the Federal District
3. Energy Improvement Systems Pumping Equipment
4. Environmental Statement which states the obligation to submit Emergency Program Water Savings
5. Wastewater Treatment Program

On the issue of energy, there are four major programmes:

1. Sustainable Housing Program
2. Certification Program for Sustainable Buildings
3. Renewable Energy Program in Mexico
4. Energy Efficiency Program in the Federal District Government

5 Conclusion

As urbanization progresses and planning in cities becomes more complex, Mexico City will have to act under the coordination of planning agencies and will have to work on the creation of appropriate legislations with the strength of civil society.

It is important to note that part of the urban population lives in precarious economic conditions, lacking basic health, water supply, education, housing, employment, etc. This reality requires that the limited resources available to the city are directed to solve the most urgent and basic problems of the population, among which are issues of water quantity and quality, energy supply and food security. Therefore, it is crucial to have the appropriate institutional framework and informed participation of all society members to address the problems and challenges associated with food, water and energy security.

Reference

Secretaría del Medio Ambiente del Gobierno del Distrito Federal. (2011). *Informe de Avances 2011*. http://www.sma.df.gob.mx/sma/index.php?opcion=26&id=531.

Nature at the Heart of Urban Design for Resilience

Julia Marton-Lefèvre

Abstract As hubs of innovation, economic activity and social melting pots, cities can lead the way in testing new approaches to make our increasingly urban planet more resilient (Alberti et al. 2003). Natural infrastructure—ecosystems such as forests or wetlands that provide a steady flow of benefits like clean air and water, flood and drought protection and climate regulation (Council of the EU 2010)—has a key role to play in addressing the three major challenges for urban resilience: water, energy and food security. Investing in nature can help cities save money whilst boosting the local economy, enhancing quality of life, securing livelihoods and generating employment.

Keywords Ecosystems • Environment • Nature • Resilience • Urban

As we all know, we now live on an urban planet—more than half of us are city dwellers. This proportion will keep increasing and is expected to reach 70% by 2050 (UN-DESA 2008).

Cities already consume over three-quarters of the world's resources, many of which become more and more scarce (Smaoun 2011). In short, cities can no longer grow the way they used to and must now adapt to new pressures, which will intensify with climate change.

Cities must now reconsider where they get their food and water supplies, where their electricity comes from and where their waste goes, how close people live to the coast or to polluting industries and ultimately how can they keep growing whilst also remaining safe and attractive places for their populations.

J. Marton-Lefèvre (✉)
IUCN, International Union for Conservation of Nature, Rue Mauverney 28,
1196 Gland, Switzerland
e-mail: mail@iucn.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_12,

Cities will increasingly be forced to cope with floods, air and water pollution, water scarcity, heat stress and new diseases. Cities in developing countries and the urban poor are particularly at risk (IPCC 2007).

Natural infrastructure has the potential to strengthen water, energy and food security by providing increasing resource use efficiency, mitigating risk and widening the range of conditions under which vital ecosystem services will prevail.

1 Water

Coping with the growing water needs of cities is one of the most pressing challenges of this century. The relationship between water and cities is crucial. Cities rely on a steady supply of safe drinking water and in turn have a huge impact on freshwater systems. Moreover, to meet the growing demand, many cities are overexploiting their water resources whilst upstream activities are degrading life-sustaining watersheds.

One in three of the world's largest cities draws a significant proportion of its drinking water from forest protected areas (Dudley and Stolton 2003). As such, many of the world's big cities have understood that protecting natural ecosystems to secure their water supplies makes economic sense. Rather than chopping down forests or draining marshlands, keeping water catchments healthy saves billions of dollars by not having to pay for costly urban infrastructure to store water, clean it or bring it from elsewhere (Smith et al. 2006).

For example, Caracas, the capital of Venezuela, relies on the Guatopo and Macarao rivers for its freshwater provision. Those rivers continue to supply a constant flow of freshwater to the city's five million inhabitants. Kenya's capital Nairobi depends on the water provided by the Mau Forest, which provides a range of services estimated at US $1.5 billion a year (UNEP 2011). The forests of China's Miyun watershed generate water benefits worth US $2 billion a year whilst supplying 70% of Beijing's drinking water (IUCN 2010).

Moreover, healthy wetlands provide natural wastewater treatment services, such as the Nakivubo wetland in Uganda, which saves the capital city Kampala US $2 million a year in terms of sewage and treatment facilities. And, of course, perhaps the best-known example is New York City, which saved US $4–6 billion on water treatment plants (plus annual maintenance costs) by investing just US $1 billion on protecting forests in water catchment areas (TEEB 2010). Well-managed, healthy watersheds also boost cities' resilience by providing buffers against water-related hazards such as floods, landslides and drought (PEDDR 2011).

Yet, many cities are losing precious water resources through leakage or pollution. Some cities are losing up to half of their drinking water because of leaking pipes or other problems in urban distribution systems. The amount of water lost in many megacities is enough to provide an additional 10–20 million people with drinking water, which is both unsustainable and unacceptable. Sanitation is another major cause for concern, whereby the lack of adequate wastewater treatment, sanitation and drainage facilities contaminates drinking water and spreads disease (UNW-DPAC 2011).

To secure water for our thirsty cities, we must urgently invest in natural infrastructure and fix the faults in the human-made infrastructure.

2 Energy

Cities consume 75% of the world's energy (OECD 2008). Many forms of energy are the result of a service provided by species and ecosystems. Ecosystems are also key to helping meet the growing energy demand, that is why we need to enhance their quality and minimize the impacts of energy—even renewable energy options—on ecosystems.

One way to enhance energy security in cities is to consume less energy. Natural infrastructure can help here too. For example, green rooftops can help mitigate the urban heat island effect and reduce the need for air conditioning (Gill et al. 2007). The city of Toronto estimated that citywide greening could achieve direct energy savings in the order of US $22 million and avoid 56,300 tons of carbon emissions (Banting et al. 2005). Parks and green areas can also help save lives. The 1995 heat wave in Chicago killed 600 people—the worst affected areas had the lowest tree coverage. Since then, urban forests came to be regarded as a vital part of Chicago's infrastructure (CABE 2011).

Access to energy remains another major challenge for the urban poor, particularly in sub-Saharan Africa, where the majority of households rely on firewood and charcoal for most energy needs. For example, the ring of deforestation around Khartoum in Sudan extends to almost 200 km; charcoal supplies for the city now come from as far as 400 km away. Deforestation has been acknowledged as a critical factor undermining security and stability in the country (UNEP 2007). In addition, in countries such as Benin, conventional electricity is expensive and difficult to find. As a result, many appliances are run on batteries which are quickly discarded and end up polluting the environment.

To address this interdependent energy and pollution crisis, an IUCN member organization, Nature Tropicale, with financial support from the Netherlands Committee of IUCN, trained 444 young people, of which 107 were women, in the use of solar energy kits. In a matter of 4 months, solar energy production had been distributed in Benin's eight major cities including the capital Cotonou. This project created a huge demand for this environmentally friendly energy alternative.

Other solutions that could help make cities both more self-reliant and more sustainable are waste-to-energy projects. In Pakistan, IUCN collaborated on a pilot project to use dung from a cattle farm some 50 km from Karachi and convert it into biogas and high-grade organic fertilizer. The methane from the waste will produce electricity for local use, or sale, supporting a power plant of 25–30 MW. It is estimated that the top 10 cities of Pakistan produce 50,000 tons of waste, which can be used to produce 6,000 MW of energy.

According to the latest report by the Intergovernmental Panel on Climate Change (IPCC), by 2050 nearly 80% of our energy needs—including rising demand in developing countries—can be met through renewable energy sources.

But not all "clean" energy is necessarily "green". That is why IUCN actively participates in efforts to make global biofuel production more sustainable, to minimize environmental impacts of large dams and to ensure that ocean-based renewable energy, such as offshore wind and tidal power, does not damage marine biodiversity.

3 Food Security

The reasons behind the current food security crisis are many. Some blame market speculation, others declining yields due to climate change. Still others point the finger at biofuels and increasing meat consumption which drive food prices up. What is certain is that the rapid urbanization and population growth have the potential to threaten food security and undermine the resilience of cities.

Growing food in the vicinity of urban areas in the face of change strengthens urban resilience. This is where urban agriculture comes in. Earlier we mentioned green roofs, so how about "edible landscapes"?

Urban agriculture contributes to the greening of cities, curbs air pollution, increases humidity and lowers temperatures. It cuts down on carbon emissions by reducing the number of trucks entering the city to deliver food. It has many other benefits. For example, money spent on produce grown locally and sold in farmers' markets stays in the community, raising incomes and creating jobs. It also helps close the gap between the producers and consumers of food, who are often ignorant about where their food comes from (Kisner 2008). Furthermore, urban agriculture can also help maintain healthy populations of pollinators which are an essential element of biodiversity (Allen-Wardell et al. 1998). The total economic value of insect pollination worldwide is estimated at over US $200 billion dollars (153 billion €) per year, representing nearly 10% of the world's agricultural output for human food (Gallai et al. 2009) via (TEEB 2011).

Already, many cities are taking steps towards becoming "locavores", whilst low-carbon and more sustainable diets are also growing in popularity. In Geneva, close to where IUCN global headquarters are located, many products sold in supermarkets come with the tag "de la région", identifying locally grown produce. Campaigns such as "Pas de fraises en hiver" in France are encouraging consumers to think twice about their choices and how they affect the planet.

The most extensive use of urban agriculture is today found in Cuba, where more than 50% of Havana's fresh produce is grown within the city limits, using organic compost and simple irrigation systems.

4 Nature at the Heart of Urban Design for Resilience

In conclusion, cities play a vital role to making our planet more resilient. Our task today is to move to more compact, resource-efficient living and to embrace nature-based solutions as part of urban design. We must also reconcile urban development with nature conservation to ensure that urban growth does not accelerate the loss of biodiversity.

This can be good for both nature and people. Cities that recognize the importance of biodiversity, and invest in green belts and nature parks around them, consistently rank higher on various “liveable cities” indexes. For example, IUCN works with Parks Victoria based in the Australian city of Melbourne on the “Healthy Parks, Healthy People” initiative that recognizes the vital link between the health of people and the health of our planet.

IUCN was also closely involved in the groundbreaking study on “The Economics of Ecosystems and Biodiversity” (TEEB), which includes a chapter dedicated to local and regional authorities. The findings of the TEEB study are clear: investing in nature can help cities save money whilst boosting the local economy, enhancing quality of life, securing livelihoods and generating employment.

Already, more than 20 cities, including Nagoya, Curitiba, Cape Town and Bonn, are leading the effort to develop urban biodiversity management programmes, recognizing nature’s importance for the well-being of their citizens.

2011–2020 is a decade of action to save life on Earth. Cities can, and must be, a key part of the solution.

References

Alberti, M., Marzluff, J. M., Shulenberger, E., Bradley, G., Ryan, C., & Zumbrunnen, C. (2003). Integrating humans into ecology: Opportunities and challenges for studying urban ecosystems. *BioScience, 53*, 1169–1179.

Allen-Wardell, G., Bernhardt, P., Bitner, R., Burquez, A., Buchmann, S., Cane, J., Cox, P. A., Dalton, V., Feinsinger, P., Ingram, M., Inouye, D., Jones, C. E., Kennedy, K., Kevan, P., Koopowitz, H., Medellin, R., Medellin-Morales, S., Nabhan, G. P., Pavlik, B., Tepedino, V., Torchio, P., & Walker, S. (1998). The potential consequences of pollinator declines in the conservation of biodiversity and stability of food crop fields. *Conservation Biology, 12*, 1–11.

Banting, D., Doshi, H., Li, J., & Missios, P. (2005). *Report on the environmental benefits and costs of green roof technology for the city of Toronto*, Prepared for city of Toronto and Ontario Centres of Excellence—Earth and Environmental Technologies (OCE-ETech). Available from http://www.toronto.ca/greenroofs/pdf/fullreport103105.pdf. Accessed 16 May 2011.

CABE. (2011). *Chicago urban forest*. Available from http://webarchive.nationalarchives.gov.uk/20110118095356/http:/www.cabe.org.uk/case-studies/chicago-urban-forest. Accessed 10 May 2011.

Council of the EU. (2010). *Biodiversity: Post-2010 EU and global vision and targets and international ABS regime—Council Conclusions*. Available at http://register.consilium.europa.eu/pdf/en/10/st07/st07536.en10.pdf. Accessed 10 Feb 2011.

Gill, S., Handley, J., Ennos, R., & Pauleit, S. (2007). Adapting cities for climate change: The role of the green infrastructure. *Journal Built Environment, 33*(1), 115–133.

IPCC. (2007). *Climate change 2007: Impacts, adaptation and vulnerability—summary for policy-makers, intergovernmental panel on climate change*.

IUCN. (2010). *Moving closer to nature. The story of the livelihoods ad landscape strategy in the Miyun Landscape, China*. Beijing: IUCN.

Kisner, C. (2008). *Green roofs for urban food security and environmental sustainability, urban agriculture*. Available from http://www.climate.org/topics/international-action/urban-agriculture.htm. Accessed 16 May 2011.

PEDRR. (2011). Managing watersheds for urban resilience, Policy Brief, Presented at the Global Platform for Disaster Risk Reduction 12 May 2011, Geneva, Switzerland.

Smaoun, S. (2011). Integrating the environment in urban strategic planning, UNEP Urban Environment Programme, 6th Annual Brussels Climate Change Conference 2011. Available from http://www.eu-ems.com/event_images/Downloads/UNEP.pdf. Accessed 16 May 2011.

Smith, M., de Groot, D., Perrot-Maîte, D., & Bergkamp, G. (2006). *Pay—Establishing payments for watershed services*. Gland: IUCN. (Reprint 2008, Gland: IUCN.)

TEEB. (2010). *The economics of ecosystems and biodiversity: Mainstreaming the economics of nature: A synthesis of the approach, conclusions and recommendations of TEEB*. Available from http://www.teebweb.org/LinkClick.aspx?fileticket=bYhDohL_TuM%3d&tabid=1278&mid=2357

TEEB – The Economics of Ecosystems and Biodiversity for Local and Regional Policy Makers. (2010). Available from http://www.teebweb.org/Portals/25/Documents/TEEB%20for%20Local%20and%20Regional%20Policy/TEEB%20Loc%20Pol%20QG%20English.pdf

TEEB in Local Policy. (2011). *The economics of ecosystems and biodiversity in local and regional policy and management*. Edited by Heidi Wittmer and Haripriya Gundimeda. Earthscan, London.

UNEP. (2007). *Sudan post-conflict environmental assessment*. Available from http://www.unep.org/sudan/post-conflict/

UNW-DPAC. (2011). *UN-Water Decade Programme on Advocacy and Communication (UNW-DPAC)*. Available at http://www.un.org/waterforlifedecade/swm_cities_zaragoza_2010/pdf/facts_and_figures_long_final_eng.pdf.

Smart City: Energy Efficiency in a New Scope

A Systemic, Oriented Approach Improving Energy Efficiency on the City Level

Christoph Rat-Fischer, Florian Rapp, Philipp Meidl, and Norbert Lewald

Abstract The challenge of sustainable and energy-efficient cities has been recognized by international organizations as well as local communities. Discussions and actions undertaken in this context indicate the close connections that exist between adaptation and mitigation policies on the one hand and economic development that gives rise to technology development paths on the other hand. Cities' commitments to climate change and adaptation needs are increasing, as well as the necessity of forward thinking techniques. To address these challenges, the EU Commission has recently launched a new initiative to fund implementation projects of Smart Cities.

In this context, the relevance of concepts—in comparison to the multitude of existing approaches—needs to be assessed. The European Institute for Energy Research (EIFER) has started a research project to identify the most important working fields and topics for cities on their way to tackle this question. Energy efficiency measures seem to be the key element in order to exploit the systemic approach.

First results of this project show that most approaches are either too specific or focus on smaller parts of the urban site. New forms of cooperation between research, business and infrastructure providers are needed. For example, the 'smart city' is an emerging concept that aims to tackle energy efficiency and sustainability in cities and tries to bring municipalities, utilities, industry and research together. By addressing some of the remaining gaps in urban knowledge and management, the 'smart city' approach will contribute to more sustainable and resilient cities.

Keywords Energy efficiency • ICT • Smart city • Systemic approach • Urban flows

---

C. Rat-Fischer • F. Rapp (✉) • P. Meidl • N. Lewald
European Institute for Energy Research (EIFER), Emmy-Noether-Str 11,
76137 Karlsruhe, Germany
e-mail: rat-fischer@eifer.org; rapp@eifer.org; meidl@eifer.org; lewald@eifer.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_13,

1 Introduction

1.1 Key Question

How does a systemic-oriented approach improve energy efficiency on the city level and therefore support sustainable quality of life and foster urban resilience?

1.2 Introduction

Cities' commitments to climate change and adaptation needs are growing as well as the need for new ways to handle them as the impacts of climate change become more severe. Extreme heat in the summer, heavier rain storms, growing flood risks, stresses on public health and threats to the cities' economies are some of the common drivers that influence governance and planning herein.

However, most of the communicated approaches tackling sustainability issues and urban planning are either too specific or too focused on smaller parts of the urban site. Too little attention is paid to the interactions and interdependencies within and between cities. To tackle this shortcoming, research is turning towards approaches encompassing the whole city.

The European Institute for Energy Research (EIFER) has started a research project on these kinds of approaches. A promising one seems to be the so-called smart city concept. Until now it has been a concept under development as different stakeholders from mainly IT industry, research and municipalities have been trying to shape the content of this concept. For some of them, it seems to be a simple strategy for selling products to city services; for others, it offers a way to build up new strategic partnerships and to develop business plans. The general focus of this concept lies on improvements and gains in energy efficiency through research on multi-flow interaction. Based on the findings, a strategy for actions and implementations will be developed and embedded into municipal climate protection programmes to foster strategic planning and urban resilience.

2 Research

One of the key points of the project is that it is not possible to develop a comprehensive analysis of a complex system like a city from a single point of view. The precondition of examining the city as a whole body in order to improve its overall metabolism, instead of testing small-scaled actions, is particularly challenging.

In order to provide an understanding of cities, which would be as close as possible to their realities (there is no unique 'reality'), the EIFER working methodology on smart cities is relying on following conditions:

– An interdisciplinary team, experienced in urban topics
– An intercultural team, in order to separate urban subjects from national/cultural ones
– A direct exchange with urban stakeholders and urban experts (municipalities, utilities, industries, consultants)
– A direct connection to further city research projects
– Review of projects and best practices
– Workshop discussions and conference presentations (national and international)
– Review of networks for distribution of information and innovations
– Review streams of stakeholder groups using scientific papers, articles, business news and newspapers

The EIFER research on smart cities is combining the knowledge of architects, urban planners, engineers in energy and economy, physicists and experts in sociology and politics. Each professional has their own understanding of a city and can all contribute to building up a value chain in which analysis and new concepts contribute to the sustainability and resilience of entire cities.

There is no doubt that a municipality or a similar organization is the only stakeholder able to coordinate an urban concept such as a smart city as no other entity is in charge of so many local interests with long-term responsibility. Nevertheless, a municipality only owns a part of the infrastructure. Consequently, one of the first steps is to set up an alliance with the required partnerships for implementation. In the case of smart cities, the concept addresses the relationship between municipalities and entities responsible for urban infrastructure (mainly utilities), with the support of ICT industrial products and services. As mentioned before, the extended concept of energy efficiency in a system context has to include all steps and sectors related to energy. The EIFER approach actually concentrates on energy-related flows such as mobility, transport, supply, disposal, etc., together with their infrastructure. The extended concept of energy efficiency for flow optimization does not only mean to reduce the use of energy needed for a specific flow but to look for new energy production possibilities, fuel switching or complete process switching and potential overlapping of the flows and other alternative solutions.

The success of a city concept depends on several elements concerning its implementation: its level of complexity in terms of officials' involvement and cooperation, its technical complexity, its cost and business model, its added-value, its duration, the overall acceptance as well as the potential contribution to the city's communication and attractiveness. Some of the elementary topics of the research frame are mentioned more specifically below.

2.1 Scale

One of the critical challenges as mentioned before is a conceptual systemic analysis of the city as a whole. Many approaches are focusing on specific fields of activity, on smaller parts of cities, or both.

2.2 Time Frame

Municipalities are facing the gap of how to include larger parts of cities and how to achieve short-term and middle-term improvements, even beyond the administrative boundaries. In this context, the relevance of smart city concepts in comparison to the multitude of existing approaches and labels needs to be assessed.

2.3 Disciplines, Fields of Expertise Involved

The research, technical and managerial challenges arising along the way to encompass many disciplinary fields require inputs from civil engineering, architecture, urban design, governance, sociology, computing science, systems mechanical, physics and many more.

2.4 Infrastructure

Research activity will include monitoring and integrating all conditions of a city's infrastructure, for example, energy power, water, sewage, communication, roads, bridges, seaports, subways and major buildings. Each of these urban flows is directly linked to one subsystem and uses at least one infrastructure.

2.5 Levels of Smart Components

On the way to a smart city, EIFER has identified three preliminary levels which each single flow will have to pass through.

On the first level, smart components of every flow will be able to send data to a third partner involved. In the field of electricity metres, those components can be found in Sweden where smart meters have been installed in all private households that are able to send the consumption of electricity on regular intervals (e.g. monthly). These appliances are only able to inform others about their condition/situation/status. This level is called the information or metering layer.

The second level will enable sthe smart components to communicate with other partners (like providers of the urban flows). They can send data to other components or participants, receive information back from the outside world and give personalized advice to the users about the best usage of energy or saving potentials. The example for this case is a smart metre that comes with a display and is ready for dynamic tariffs. The meters will still send the consumption of energy at regular intervals, but they will be able to receive information from the outside world and display these for the customers. This level is called the communication or linking layer.

The final level is control and operation, also called the control or automation layer. These appliances will be able to control other components.

The implementation and the bottom-up structure create an overall approach for the urban resources management. This includes all the other previous steps. This is where the ‘smart city’ will deal with ‘smart solutions’ that benefit the entire city.

The return on experience is crucial to evaluate the replication and dissemination potential of a concept, especially in those above mentioned fields. For this reason, EIFER’s methodology includes a connection to other urban projects, in order to collect and share empiric data.

3 Results

In 2011, the empiric returns on experiences are not sufficient to provide a data-based evaluation of smart cities. A deductive analysis is providing some elements to assess the relevance of this innovation field, for which the first prototypes are still expected.

There are still several deficits which need to be filled in the field of urban management. For example, there are few concepts which analyse and address entire cities. Supply and transport infrastructures can be improved by ‘smart’ components, independently from cities, but an adaptation to the specificity of urban environments and the potentials of win-win situations between municipalities and stakeholders such as utilities must still be worked out.

The idea of ‘smart cities’ is an opportunity to improve aspects of the urban super-system which has remained undeveloped until now. A preliminary study of approximately 30 city concepts and labels, related to sustainability or resilience set up at EIFER, showed that interdisciplinary systemic understanding or recommendations are still missing.

For a real breakthrough, some difficulties must still be overcome. There is still a need for research and conceptual refining, as there is no final definition for ‘smart cities’ yet (neither from the side of supporting entities nor from the cities themselves). The fact that several stakeholders—sometimes direct competitors—will be expected to collaborate and to implement flow crossing solutions will automatically lead to disparate ‘smart cities’. Depending on the local structures regarding markets, legislation, administrative relationships, economy, social classes, geography as well as local problems and interests, each implementation will have its own specificity and its own level of impact. Consequently, it is probable that a direct comparison between cities will not provide much usable information. A difficulty will then also be to set the border between what is a ‘smart city’ and what is not.

The systemic-oriented approach addresses the entire city, contrary to the single so-called lighthouse projects which are on a smaller scale. This reveals several new opportunities and the synergy effect. One is the surpassing of scaling up highly sophisticated model projects into the urban reality. This scale shift encourages the linking of municipalities, utilities and industry, and a closer co-operation between them. To optimize the interaction of flows in urban areas, five key elements must be considered: flow optimization, real-time management, linking, metering and automation.

An adaptation to the specificity of urban environments and the potentials of win-win situations between sectors must still be worked out as the smart city concept is not yet ready to function as a guideline for cities. The success of a city concept also depends on several elements concerning its implementation: its level of complexity in terms of officials' involvement and cooperation, its technical complexity, its cost and business model, its added-value, its duration, the acceptance for it as well as the potential contribution to the city's communication and attractiveness.

However, the diversity of cities is not adapted to monolithic solutions; local adaptation is a necessity. The 'smart city' project will contribute to more sustainable and more resilient cities if it involves the mentioned sectors and addresses some remaining gaps of urban knowledge and management. If this remains under the name of 'smart cities' or not, it does not really matter, as the concept behind the name offers new potentials and opportunities.

4 Discussion

The contribution of research organizations, such as EIFER, to the sustainability and the resilience of cities is not only a contribution to the development of new concepts and approaches but also an assessment of their relevance. Considering the diversity of concepts and ideas as well as the long history of urban planning and management, research must provide monitoring, or at least some evaluation keys. The limited investment capacities of cities and the fact that large-scale implementations drain resources for many years shall be taken into account. This raises questions like: 'Are smart cities cost-effective? Can their contribution to resilience and sustainability, particularly through the scope of energy efficiency, be measured and thus proved? Is this innovative concept improving the understanding of cities and enlarging the number of solutions to optimize their metabolism through their infrastructure?'

5 Final Conclusion

Municipalities are major contributors to the national and international climate protection commitments. On the fields of energy efficiency and sustainability, however, they are reaching the limits of their abilities. To combat this, new levels of co-operation are needed, and the smart city programme can offer this. Together with the aforementioned sectors, it addresses some remaining gaps of urban knowledge and management, thus offering new potentials and opportunities to improve energy efficiency in cities. Therefore, it will contribute to more sustainable and resilient cities.

Resilient Food Systems for Resilient Cities

Julien Custot, Marielle Dubbeling, Arthur Getz-Escudero, Jon Padgham, Rafael Tuts, and Sylvie Wabbes

Abstract Food and nutrition security in cities have gained political importance since 2007 and 2008. During this time, high food and fuel prices resulted in widespread reports of riots and social unrest in cities around the world. The projected impacts of climate change coupled with urbanization will put even a greater strain on urban populations whom, as net consumers, rely mainly on the market for their food. As such, food and nutrition security of urban dwellers are needed for more resilient cities. This paper highlights why and how food, agriculture

J. Custot (✉)
FAO – Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00153 Rome, Italy
e-mail: julien.custot@fao.org

M. Dubbeling
Senior programme officer RUAF Foundation (International network of Resource centres on Urban Agriculture and Food security), Kastanjelaan 5, 3833 AN Leusden, the Netherlands
e-mail: m.dubbeling@ruaf.org

A. Getz-Escudero
School of City & Regional Planning/Sustainable Places Research Institute, Cardiff University, Glamorgan Building, King Edward VII Avenue, CF10 3WA Cardiff, UK
e-mail: getzaa@cardiff.ac.uk

J. Padgham
International START Secretariat, 2000 Florida Ave., NW, Washington, DC 20009, USA
e-mail: jpadgham@start.org

R. Tuts
Urban Environment and Planning Branch, United Nations Human Settlements Programme – UN-HABITAT, P.O. Box 30030, Nairobi 00100, Kenya
e-mail: raf.tuts@unhabitat.org

S. Wabbes
Emergency Operations and Rehabilitation Division, Food and Agriculture Organization of the United Nations, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy
e-mail: sylvie.wabbescandotti@fao.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_14,

and natural resource management are to be part of disaster risk reduction, urban management and climate change policies. In this context, the specific and important contribution of urban and peri-urban agriculture (UPA) to the food system is underscored. The benefits of a multidisciplinary territorial approach to support local food systems centred on cities are then described. In particular, we highlight how integrating sustainable diets, management of natural resources and ecosystems with strengthened urban-rural linkages contributes to more resilient cities. Lastly, this paper illustrates how local authorities play a key role in promoting these multi-sectoral and multi-actor approaches to enhance more resilient food systems.

Keywords Agriculture • Cities • Food system • Urban • Climate change • Urban-rural linkages • Natural resources management

1 Food and Agriculture Relate with the City

1.1 Urbanization Impacts on Food, Agriculture and Natural Resources Management

We are currently witnessing a second urbanization wave. By 2050, the large majority of the additional three billion people will live in Asian and African medium-sized cities. With the expansion of population will come increasing use of land and other natural resources (water, fossil fuels, wood/forests, etc.). Pressures will be greater where the urban and institutional infrastructure is weaker. Some of the cities that will be created do not even exist yet, while the ones that do exist are ill-equipped to handle such large-scale expansions.

For such rapid urban growth to be sustainable, there is a need for 'decoupling', that is, to enhance the quality of life while minimizing resource extraction, energy consumption and waste generation and simultaneously safeguarding ecosystem services. Decoupling will depend on how cities are planned and how city-based energy, waste, transportation, food, water and sanitation systems are expanded and/or reconfigured. In this regard, there is a clear role for food systems thinking and strategies, including urban and peri-urban agriculture. Indeed, well-planned and well-managed urban agriculture can play a key role in decoupling as part of the overall food systems within a city region.

1.2 Food and Agriculture Contribute to Disaster Risk Management and Reduction

Climate change impacts the four dimensions of food security: *food availability* (lower production due to extreme weather events, change in the availability of land

and water, technologies, crop varieties, animal breeds, etc.), *food access* (loss of livelihood assets, infrastructure, income, employment, etc.), *food supply stability* (food price fluctuation and dependency on imports and food aid) and *food utilization* (food safety hazards associated with pests, animal and human disease).

There is therefore an urgent need to both adapt to and mitigate against the effects of climate change, especially to ensure food and nutrition security for present and future generations. 'Climate Smart Agriculture', promoted by the Food and Agriculture Organization of the United Nations (FAO), provides some orientations for policies regarding management of land, water and biodiversity and ecosystem services (carbon emission reduction and carbon sequestration) (FAO 2010).

Moreover, due to the increase in frequency and scale of disasters (man-made and natural disasters), another challenge is to prevent, prepare and manage risks for agriculture, fisheries and forestry sectors combined. To support government capacities to handle disaster risk reduction (DRR) for food and nutrition security and resilient livelihoods, FAO has elaborated and is proposing a framework (FAO 2011) programme based on four pillars:

1. Institutional strengthening and good governance for DRR in agriculture sectors
2. Information and early warning systems on food and nutrition security and trans-boundary threats
3. Preparedness for effective response and recovery in agriculture, livestock, fisheries and forestry
4. Mitigation, prevention and building resilience with technologies, approaches and practices for food and nutrition security

Policies should also consider three cross-cutting priorities:

– Capacity development of individuals, institutions and the enabling environment or policies and legal frameworks
– Knowledge management, advocacy and communication
– Strategic partnership and financing

With the rising level of risks in cities due to a high concentration of the population living in urban areas, the policies will have to be increasingly implemented at the local level. Local authorities will have to address the different dimensions of a food system. Exchanging experiences, benchmarking and city-to-city cooperation will prove to be necessary. However, local actions alone will not be enough: local authorities need to join forces in order to influence the agenda at national, regional and global level. Associations and networks of local authorities, such as ICLEI, are showing leadership by anticipating this mounting challenge.

2 Specific Roles of Urban and Peri-urban Agriculture and Forestry in Creating More Resilient Cities

2.1 Urban and Peri-urban Agriculture and Climate Change

Urban and peri-urban agriculture and forestry (UPA/F) can be defined as the growing of trees, food items and other agricultural products (herbs, pot plants, fuelwood, fodder) within the built-up area of the city and in the peri-urban areas. UPA/F includes urban horticulture, livestock, (agro-)forestry and aquaculture as well as related processing and marketing activities. The growing body of research on UPA/F reveals that UPA/F can help answer a number of key urban challenges such as urban poverty reduction and social inclusion, enhancing urban food security and nutrition and contributing to urban environmental challenges by urban greening and recycling urban organic wastes and wastewater (de Zeeuw et al. 2011).

More recently, UPA/F is also recognized as an important component for a strategy for climate change adaptation and mitigation. For example, UPA/F was recognized at the International Tripartite Conference on Urban Challenges and Poverty Reduction in African, Caribbean and Pacific countries as having high potential for improving the urban environment and urban adaptation to climate change (UN-HABITAT 2009). A review of the literature indicates that UPA/F helps cities to become more resilient in the following ways:

(a) *UPA/F reduces the vulnerability of the urban poor and enhances their coping capacity by:*

- Reducing the incidence and impacts of floods and landslides on the urban poor (see b)
- Enhancing access to nutritious food and diversifying food sources and thereby reducing the impacts of disturbances in food supply from rural areas or imports and increases in food prices
- Diversifying income opportunities, creation of 'green jobs' and safety net in times of economic crisis
- Enhancing community building and acting as a source of innovation and learning

(b) *UPA/F reduces the impacts of higher rainfall (average/extremes):*

- UPA/F can keep low-lying zones free from construction so that floods have less impact, storm water run-off is reduced, and excess water is stored and infiltrating in the green open spaces.
- By applying (agro-)forestry on steep slopes, building on risk prone slopes is prevented and (the impacts of) landslides are reduced.
- UPA/F reduces the heat island effect by providing shade and enhancing evapotranspiration; also CO_2 and dust are captured.

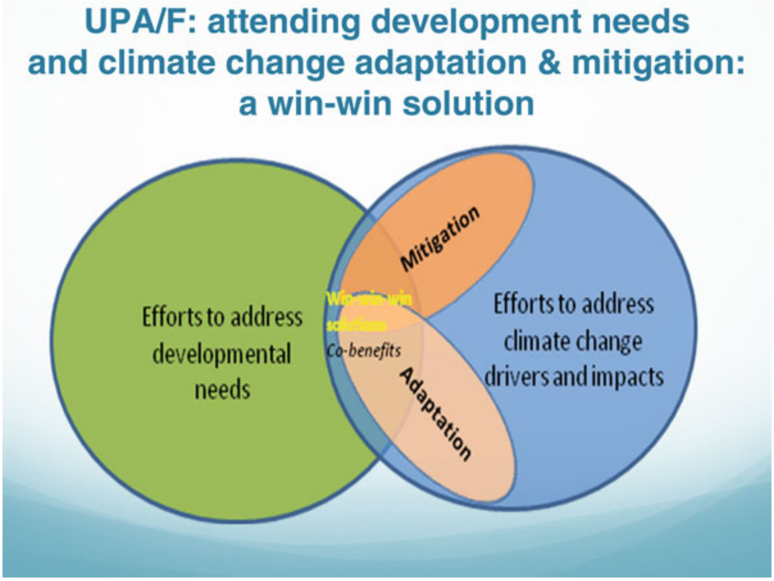


Fig. 1 Urban and peri-urban agriculture and forestry: a win-win situation

(c) *UPA/F contributes to reduction of the urban energy use and greenhouse gas emissions:*

- UPA/F produces fresh food close to the city (hence, less energy use for transport, cooling, storage, packaging).
- UPA/F enables productive reuse of the organic wastes, which will reduce methane emissions from landfills and reduce energy use in production of fertilizers.
- Reuse of urban wastewater in UPA/F will free freshwater for higher value uses and reduce emissions from wastewater treatment.

UPA/F can play an important role in responding to a range of challenges faced in all countries when building more resilient cities. As pointed out by World Bank (2010), there is a need for innovative solutions that combine climate change adaptation and mitigation with the attention for local development needs in order to produce meaningful co-benefits (see Fig. 1). The promotion of safe, sustainable and multifunctional urban and peri-urban agriculture is certainly one of the innovative strategies that meet this requirement.

Metropolitan, municipal and other local government institutions directly concerned with urban and regional planning and development can play a proactive and coordinating role in enhancing urban food security and city resilience by including UPA/F in local climate change adaptation and disaster risk reduction strategies.

In order to strengthen climate change adaptation in urban areas, city governments may take the following measures:

- Protecting and stimulating sustainable UPA/F in flood zones and wetlands and on steep slopes in order to prevent construction in such areas and to reduce run-off.
- Promotion of (agro-)forestry in urban and peri-urban areas in order to reduce the urban heat islands effect, to reduce landslides and to enhance biodiversity and landscape management.
- Facilitating (safe) reuse of urban wastewater and organic wastes in order to reduce waste disposal into landfills and open water systems and promote recycling of nutrients. Urban wastewater can be recycled and safely applied in a number of uses including floriculture and fruit crops irrigation, irrigation of forest plantations, combating desertification, providing fuelwood[1] and turning steep slopes and low-lying lands into urban 'green lungs', that can also be used as recreational areas while creating flood buffers for neighbouring housing areas.
- Integration of UPA/F in social housing and slum-upgrading programmes by including space for home gardens or community gardens, street trees for shade and fruits, 'productive parks' combining productive with recreational and educational functions.
- Making municipal land available to groups of urban poor households through medium-term lease arrangements or providing occupancy licences to the urban poor producing informally on municipal land under the condition that they adopt safe and sustainable production practices. The land that is provided might be land that is earmarked for other uses but not yet in use as such or land that is not fit for construction (e.g. zones prone to earthquakes, landslides and earthquakes, land under power lines, ecological valuable areas).
- Involvement of groups of urban poor in the maintenance of open green spaces such as greenbelts, green fingers, parks and other open spaces and the collection and recycling of urban wastes (green jobs).
- Providing training and technical assistance to urban producer groups and supporting them to strengthen their organization and improve their production, processing and marketing activities and related food safety measures.
- Preferential municipal food procurement from family- and community-based farms located within the city and its environs for its government canteens, school feeding programmes, etc., and facilitating direct marketing of fresh and ecologically produced food from local producers to urban producers (establishing farmers markets, special labels and support for infrastructure development).

For urban agriculture to play a role in climate-optimized development, innovation of UPA/F systems and practices is also needed for UPA/F itself to become more resilient to climate change. How will increase in rainfall, floods and temperature patterns affect UPA/F, and what can we do to solve such problems? Strategies could

[1]In many cities, attempts to decrease pressure on wood energy (fuelwood and charcoal) by subsidizing gas or electric technologies have not succeeded. The prognostic for many regions, such as in Africa, is that wood energy will continue to be the main source of energy for cooking and heating of the majority of their population.

include adjustment of cropping patterns, selection of adapted crop varieties, diversification of cropping and/or farming systems, rezoning of urban agriculture/land use and improved water management.

Various cities are already including UPA/F in their climate change adaptation programmes or adapting urban agriculture to climate change such as Trinidad, Bolivia; Casablanca, Morocco; Toronto, Canada; and Freetown, Sierra Leone.

2.2 Methodology for Assessment of UPA

The role of urban and peri-urban (UPA) agriculture in providing food security could take on increasing importance in the context of the current food crisis. However, the current knowledge base with respect to UPA's possibilities and limitations in meeting the current and future urban food and nutrition security needs is not sufficient to inform policy responses for addressing the critical issues emerging with relation to urban food provisioning and land use planning, particularly in the context of climate change and other drivers of global environmental change. The limited availability of comprehensive and comparative studies on urban agriculture makes it difficult to understand under what specific conditions this activity can deliver its potential public health, social, economic and environmental benefits and what new risks may emerge related to UPA.

Assessments can help to address significant knowledge gaps and needs that exist with respect to how increasing risks from climate change could impact food produced in and around the cities. Assessments provide an opportunity to advance understanding of how risks and opportunities may change in the future for UPA systems and producers and the broader food system, by systematically compiling and synthesizing location-specific knowledge connecting urban and rural areas, analysing current trends and combining that with projections of urban growth, environmental and demographic change and climate change.

To address this knowledge gap, cities have recently initiated an assessment to examine climate change risks to UPA and vulnerability of producers and those involved in the urban food chain. The assessment is led by (START), and local teams are comprised of city-based researchers; the teams are multidisciplinary and have members with direct ties into policy and practitioner communities. The assessment primarily draws from secondary sources and also includes focus group discussion, interviews and surveys to gain more in-depth and contextualized understanding of key issues. The results will help develop recommendations for further research areas, capacity building needs and policy and investment needs.

The assessment examines the current climate trends and how the intensification of these trends, approximately 20 years into the future, could impact urban food production, livelihoods and infrastructure of urban food systems. The lower temporal boundary of the assessment is the present and the period of the last few preceding decades (i.e. back to the 1970s). In this context, the assessment examines current vulnerabilities and what is needed to better manage current climate and non-climatic risks. The upper boundary of the assessment is 2030, a period that

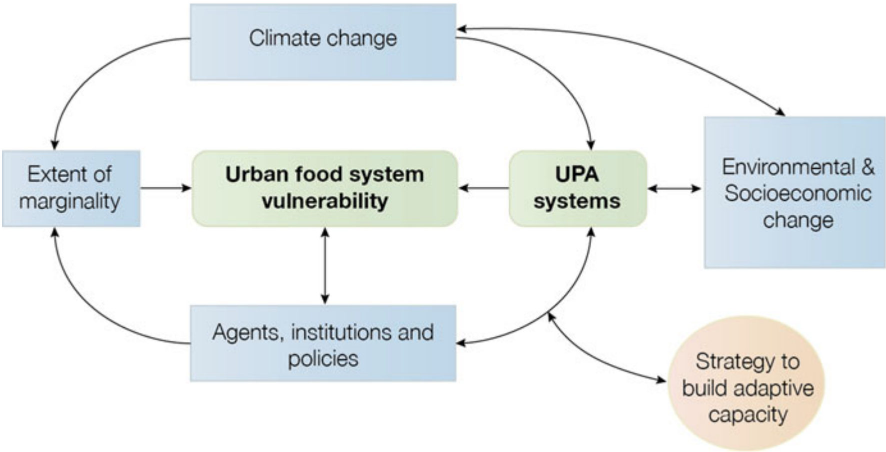


Fig. 2 The assessment framework for UPA systems

is reasonably within the decision-making framework of city officials. Over this time frame, a key issue concerns how might future non-climate trends (e.g. urban and peri-urban land development, urban growth rates, demographic change, changes in the agricultural sector, pollution, water use) interact with or be influenced by increasing climate risks.

For this assessment, climate change is considered within the broader context of multiple and interacting drivers of global change (e.g. rapid urbanization, demographic shifts, energy demand, dietary changes, pollution, ecosystem degradation). The assessment will explore both direct and indirect climate risks as well as non-climate dimensions of vulnerability and how these interact with, or could be amplified by, increasing climate risks. The assessment framework (see Fig. 2) illustrates how climate change could directly impact UPA systems and change the degree of marginality of UPA land and water resources, for example, heat stress on crops and livestock and flooding of crops located in marginal areas of a city. It also indicates routes through which indirect impacts from climate change, mediated through environmental and socioeconomic change, could affect UPA systems; an example of this would be increased rural to urban migration. Strategies to build institutional capacities create a more favourable policy environment and engage and empower producers and other actors in the urban agriculture value chain offer opportunities to promote more resilient urban food production systems.

2.3 Ways Forward

International organizations and resource centres, such as the International Network of Resource Centres on Urban Agriculture and Food Security (RUAF) Foundation, hope to support cities that are already developing a city climate change strategy to include UPA/F component in their strategies. Municipal staff and staff of local organizations should be trained in the integration of UPA/F in the city climate change strategy and land use planning. It would be important to make available planning guidelines and ‘best practices’ manuals for different types of UPA/F to understand which are the most appropriate UPA/F models (e.g. farming in flood zones, agroforestry on steep slopes, community gardening, promotion of aquaculture) for the partner city, as well as potential demonstration projects. Other important components would be to support design and implementation of demonstration projects and locations where UPA/F would have the highest climate change impacts and facilitate ‘learning in/from practice’. Next to the assessment outlined above, there is also a need for development of indicators and tools to monitor the adaptation and mitigation impacts and co-benefits of UPA/F activities.

3 Getting the Food System in the Urban Strategies

3.1 Integrating Food Systems into Urban Planning

A major challenge to the viability of urban agriculture remains to be land availability and access. To reconcile the needs posed by urban growth (housing, industries and infrastructure) with the need for urban agriculture activities that can be of high economic and social value, urban agriculture should be included in urban planning and municipal development plans. Moreover, taxation rules and legal frameworks are necessary to provide security and incentives for producers.

Formal acceptance of urban agriculture as a legitimate use of urban land is a crucial first step towards effective planning for, as well as regulation and facilitation of, the development of urban agriculture. Another essential step is to include urban agriculture and city region food systems as a separate land use category in land use plans and change existing zoning categories to include urban agriculture.

It is important to consider planning at the city region level where there are key opportunities to plan for land mosaic patterns that protect valuable ecosystems and biodiversity hotspots, preserve natural corridors preventing flooding and landslides, optimize and expand existing network infrastructure, promote compact cities and planned extensions and construct built environment that uses water and energy efficiently. In this regard, agriculture must be considered as a key land use feature in the city region.

This integration of food systems in city region planning must be supported by urban management, incentive and governance measures (Sonnino 2009; Cadriff School of City and Region Planning). In terms of urban management, special attention needs to be paid to health control, storage and processing, land legislation, land tenure systems, use of vacant land and ensuring access to water. In terms of urban governance, it is important to ensure the inclusion of vulnerable groups, with

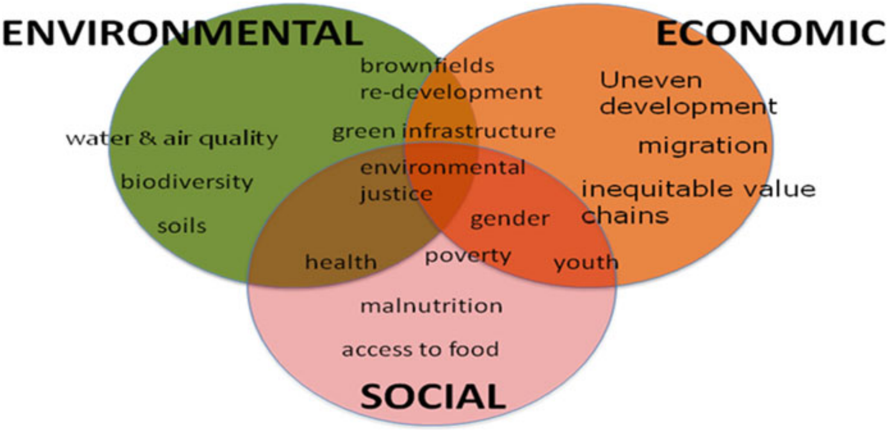


Fig. 3 Benefits of strengthening the urban-rural linkage

special attention to gender, youth and migrant workers. While the voice of these groups needs to be enhanced, it is important to ensure transparency related to the integration of food systems in the urban decision-making processes.

3.2 Strengthening Urban-Rural Linkages

There are numerous reasons as to why local and regional food systems are important to urban, peri-urban and rural areas, and these cut across and connect environmental, economic and social dimensions (Fig. 3).

Utilizing a food systems approach can serve to integrate rural and urban communities through vibrant markets – linking livelihoods of producers with the potential for greater accountability regarding food safety and more direct accessibility and nutritional benefits for food and nutrition security to consumers. Improved food system integrity can provide strategies for addressing hunger, obesity and other dietary and nutritional challenges facing cities, in part by reducing dependence upon high fat and sugar foods produced and distributed through fast food chains and instead providing locally sourced fresh fruits and vegetables.

Especially in poor communities where ‘food deserts’ (a spatial analysis of the distribution of food-retailing outlets) of low access might exist, policy can support for community gardens, local provision to school canteens and other institutional kitchens and the incentivizing of local supply to grocery, bodega or street vendor outlets. These all are practical responses taken up by municipal authorities and local food system stakeholders in city regions across the global North and South.

3.3 Food System Innovations: Emerging Programmes, Policies, Toolkits and a Multi-stakeholder Approach

At a wider level, a food system planning approach can help stabilize and develop local and regional economies through the stimulus of local flows and transactions for inputs, wholesale and retail enterprises, and the structured demand made possible with the procurement potential of the public-financed food.

There is ‘an urgent need for integrated urban food policies that create new linkages and new relationships between different stages and actors in the food chain to improve food provisioning and to create positive connections between food, health, the economy, the environment and culture’ (Lang et al. 2009). Multi-stakeholder processes have emerged in a wide variety of political and social contexts to address food system policy and practices at the local and regional level. Academic research is trailing behind the pace of innovation taking place in city regions and awakening social and natural scientists, planners and policymakers to the problem-solving potential emerging at this scale. The variety of supporters for these transformations include consumer groups, social justice and anti-hunger organizations, environmental and public health causes and a range of professional associations, including those within the traditional urban and regional planning community.

The innovations have their origin in both top-down and bottom-up processes, ranging from urban-rural roundtables (San Francisco) and food policy councils (Chicago and Toronto). Cities such as Kampala and Dar es Salaam are equally innovative in empowering street vendors and small producers, while weaving urban food production into the fabric of their cities which overcomes a bias in urban planning against agriculture inside or nearby the urban core. In addition, some municipal level food system integration can leverage national food security frameworks and small (family) farmer support programmes, such as Brazil’s *Fome Zero* and *Bolsa Familia* policies or the US Department of Agriculture’s *Know Your Farmer, Know Your Food* programme.

A body of case studies is building that details and analyses the levels of urban-rural cooperation in evidence around the world, telling the stories behind the processes of catalysing farmers’ markets and the patterns of public-private partnership forming wholesale and aggregation facilities that promote local and regional products.

Further innovation and cross-sectoral opportunities exist, especially the potential to link climate change adaptation and mitigation, the sustainable use of biodiversity, and the environmental services provision of food-producing landscapes is considerable. Some conditions are however required. Incentives and supportive policy instruments need to be shaped and provided. The training and monitoring systems are to be put into place in order to localize and signal better resource management, while rewarding their improvement. The transaction costs and complexities of individualized payments can be overcome through the creation of mechanisms that reward associations of farmers and other land managers with not only direct payments, but also greater access to markets, or improved services, or other benefits.

It should be more productive to adopt a ‘city region’ approach to encompass the range of issues that link a city with its surrounding hinterland and to develop an approach to planning that combines dimensions of landscape ecology, social justice and economic development strategies and which is based upon multi-stakeholder processes, in order to favour more resilient, equitable and sustainable food systems.

There is also a need to develop a network of cities championing food system strategies as a core feature of resilient cities. ICLEI can play a coordinating role regarding contribution of local authorities. Such a network has to be closely associated with other partners: NGOs, academics, research, training and resource centres, such as RUAF or START. The UN-System, particularly FAO and UN-HABITAT in their respective domains, can contribute with a leading role on this at the global level.

Multi-actor policies and processes are vital for further integration in urban policies, at various levels scaling up from neighbourhood to city region, towards global climate change and food security agendas. Along the way, they can bring co-benefits regarding adaptation and mitigation strategies and practical solutions. The commitment of local authorities mirrored by research and support – from global to local levels – will help to close gaps identified in this paper.

4 Conclusion

In this paper, we have seen how urbanization impacts agriculture, food and nutrition security and natural resources management. Cities must insure the food and nutrition security of their citizens. Agriculture, interacting with the surrounding ecosystem, is therefore a component of any strategy and policy for more resilient cities. Policies need the support and commitment of the mayors for designing and implementing local food systems. Food and agriculture are to be integrated in the urban planning and territorial development, supporting stronger urban rural linkages. It needs a multi-stakeholder approach, including public sector, private sector and civil society. All these actors need to work at different geographical scales. Networks and associations of local authorities, along with international organizations, resource centres and institutions, should advocate for better integrating the food and agriculture agenda and the urban agenda while providing appropriate support to local authorities. In the coming years, major international meetings with a focus on food and agriculture or on urban design and development will take place. They are periodical, such as ICLEI Resilient Cities congress or the World Urban Forum, or exceptional, such as Rio+20 or Milano Expo 2015 which theme is ‘Feeding the Planet: Energy for Life’. It will give the opportunity to bring all actors together in order to share experiences, showcase examples and assess implementation of local policies.

References

Cardiff School of City and Regional Planning. www.cardiff.ac.uk/cplan/.

de Zeeuw, H., van Veenhuizen, R., & Dubbeling, M. (2011). *The role of urban agriculture in building resilient cities in developing countries*. Paper Foresight project on Global Food and Farming Futures published by the Journal of Agricultural Science, Cambridge University Press.

FAO. (2010). Climate smart agriculture: Policies, practices, and financing for food security, adaptation and mitigation, http://www.fao.org/docrep/013/i1881e/i1881e00.htm; FAO Climate Smart Agriculture, http://www.fao.org/climatechange/climatesmart/en/

FAO. (2011). *Disaster risk reduction for Food and nutrition security Framework programme*. http://www.fao.org/fileadmin/templates/tc/tce/pdf/FAO_Disaster_Risk_Reduction.pdf

Lang, T., Barling, D., & Caraher, M. (2009). *Food policy: Integrating health, environment and society*. Oxford: Oxford University Press.

RUAF. www.ruaf.org and www.etc-urbanagriculture.org.

Sonnino, R. (2009, November). Feeding the city: Towards a new research and planning agenda. *International Planning Studies, 14*(4), 417–427, p. 419.

START. www.start.org.

UN-HABITAT (2009). *International Tripartite Conference on Urban Challenges and Poverty Reduction in African, Caribbean and Pacific Countries, 8–10 June 2009.* Nairobi, Kenya.

World Bank (2010). *Cities and climate change an urgent agenda*, Urban Development and Local Government. Urban Development Series Knowledge Paper. Washington, USA.

Urban Agriculture Casablanca

Urban Agriculture, Its Conceptualization, and the Importance of Action Research

Christoph Kasper and Andrea Rau

Abstract This paper deals with three main issues in the context of urban agriculture: first, the conceptualization of urban agriculture as an urban development strategy by using the possible positive synergies created through an interweaving of urban and rural spheres, second, the opportunity to improve the living conditions and qualities of life of urban inhabitants in terms of social development and income creation based on urban agricultural activity, and third, the importance of the action research approach in finding answers to the question of how can urban agriculture contribute to a more healthy, independent, and sustainable provision of food for cities (and regions), using Casablanca, Marocco, as an example.

The ideas, thoughts, analyses, and results presented below should all be considered in the context of the inter- and transdisciplinary research project *Urban Agriculture as an Integrative Factor of Climate-Optimised Urban Development, Casablanca, UAC*, within the framework of the Future Megacities research programme funded by the German Federal Ministry of Education and Research (BMBF).

Keywords Emerging megacity • Multifunctionality • Open space system • Urban agriculture • Urban development • Urban-rural linkages

---

C. Kasper (✉)
Department of Landscape Architecture and Environmental Planning, Chair of Landscape Architecture. Open Space Planning, Technische Universität Berlin, GOR 1-1, Salzufer 12, Berlin 10587, Germany
e-mail: christoph.kasper@tu-berlin.de

A. Rau
ZEWK Kubus – Cooperation and Consulting for Environmental Questions, Technische Universität Berlin, FR 7-1, Franklinstr. 28-29, Berlin 10587, Germany
e-mail: andrea.rau@tu-berlin.de

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_15,

Abbreviations

AUC	Agence Urbaine de Casablanca (City Planning Authority for Casablanca Region)
BMBF	Bundesministerium für Bildung und Forschung (German Federal Ministry of Education and Research)
DRA	Regional Authority of Agriculture, Casablanca (Direction Régional de l'Agriculture, Casablanca)
IRHUAE	Inspection Régionale de l'Habitat, de l'Urbanisme, de l'Aménagement et de l'Espace de la Région du Grand Casablanca (Regional Authority of Housing, Urbanism and Spatial Planning, Casablanca)
UAC	Urban Agriculture as an Integrative Factor of Climate-Optimised Urban Development, Casablanca (BMBF – Future Megacities Research Project – 2005–2013).

1 Preface and Research Aims

The inter- and transdisciplinary research project *Urban Agriculture as an Integrative Factor of Climate-Optimised Urban Development, Casablanca, UAC* (Urban Agriculture Casablanca 2011), aims to analyse and examine the extent to which urban agriculture can make a relevant contribution to climate-optimized and sustainable urban development as an integrative factor in urban growth centres. Under the direction of professor Undine Giseke (Technische Universität Berlin – Department of Landscape Architecture and Environmental Planning – Chair of Landscape Architecture/Open Space Planning), the entire team – consisting of more than 65 experts involved in science, research, and administration, as well as partners from the public sector, service organizations, industry, and local civil society organizations – is focusing on the question of whether and how a multifunctional and productive open space system that contributes to climate-optimized urban development can be created in the emerging megacity Casablanca. The project will run for a total of 8 years (2005–2013).

The team's research is being carried out in order to generate integrated results and approaches in a real inter- and transdisciplinary manner. The project therefore places the three dimensions of agriculture, urban development, and climate change together in a new perspective framework, while simultaneously placing all three in a new operational constellation under the heading Governance/Technical Support (see Fig. 1). This methodological approach makes it possible to generate integrated results through the answering of various subqueries, where the relevant (research) questions are looked at through the filter of four dimensions by the transdisciplinary team.

This raises the following questions: What will the open space in the megacities of the future look like? What will its function be? And how can it become an integral part of cities, which are growing at a pace that cannot be controlled through

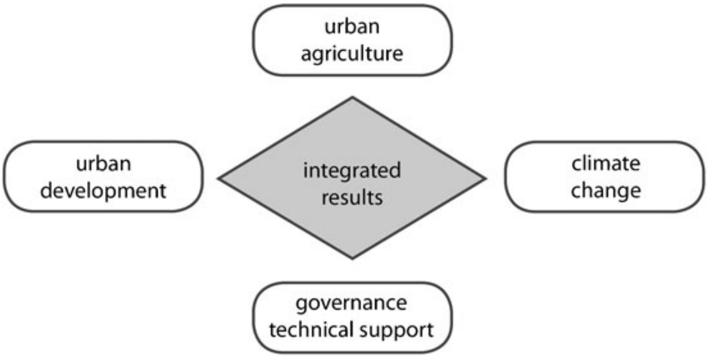


Fig. 1 Project Rhombus: the perspective framework and its four dimensions (UAC project graphics)

planning – in as far as it exists – and which are characterized to a large degree by informal spatial development? Who are the stakeholders and who creates the space? How can they be approached? Securing and allocating agricultural land in peri-urban areas today could be a possible approach for future mega-urban open space systems (Giseke 2011).

2 An Emerging Megacity: Casablanca

The Casablanca region is the largest and most densely populated area of Morocco and the economic engine of the entire country. Within a mere 100 years, Casablanca has grown from a small coastal settlement of 20,000 inhabitants to a metropolis of 4.6 million. Casablanca, as a future megacity, faces many different challenges. These, to name but a few, include considerable – and partially uncontrollable – spatial creep, fragmented space, and substantial population growth, an increasing gap between rich and poor, problems of providing adequate housing, of guaranteeing adequate environmental and living standards including the provision of food, and of maintaining the technical infrastructure. On the other hand, future megacities also have a great potential as creative pools of innovation due to their concentration of (human) resources on the point of intersection between urban and rural spheres.

At the same time, in the current development processes, foundations are being laid with regard to whether open space can be preserved within this urban region in order to make a long-term contribution to the sustainability of cities and its quality of life. And even if the current discussions about creating adequate future open space systems for megacities may not appear to be an immediate problem, they are nonetheless fundamental to the future quality of cities. Currently, if we look at Grand Casablanca's disperse, incoherent, and highly dynamic structure (see Fig. 2), it becomes clear that the classical open space systems, which also need to

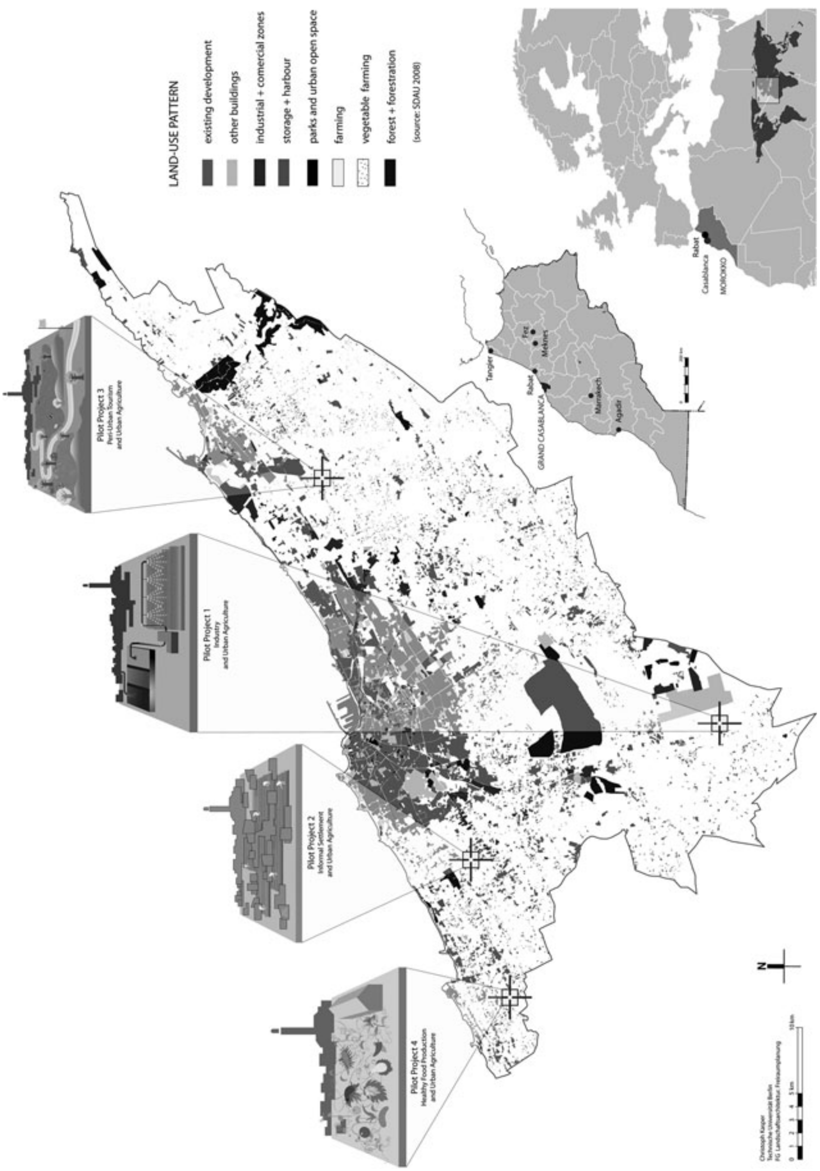


Fig. 2 Land use in Grand Casablanca and the four UAC pilot projects (C. Kasper)

be subsidized, no longer provide an answer. The goal is to create a new generation of a multifunctional productive infrastructure by dovetailing the current agricultural activities with the urban fabric in order to improve the resulting synergies in peri-urban areas and to steer their development. Particularly in informal peri-urban settlement areas, the generation of a new type of productive, green, and attractive spatial structures through urban agriculture offers possibilities of counteracting urban sprawl and surface sealing in the region. Furthermore, urban agriculture can be conceived and used to improve the living conditions of inhabitants in terms of social development and income creation.

As a phenomenon of current megacity-specific development processes, we consider urban agriculture to be all of the spatial dimensions and dynamics of the development process in today's urban growth centres that lead to new hybrid and climate-sensitive links between rural and urban space. The result is a new form of reciprocal urban-rural linkage that will shape the nature of future urban development and living conditions.

3 The Conceptualization of Urban Agriculture

One of the project's starting points is to understand landscape as a constructive urban element and to ask whether and in what ways a lasting integration of open space systems can be realized within the dynamic of urbanization. The project is conceptually based on the thesis that it makes sense to develop an open space system for a mega-urban area on the basis of agricultural space because it has a special potential for the development of multifunctional spatial systems. In this process, the focus is on the exploitation of the potential of open space. Besides the typical functions such as recreation, the project also concentrates on additional ecological, social, and spatial functions such as food production, water reuse systems, and active risk management. The overall goal is to convert agricultural areas into a productive, multifunctional, and green urban infrastructure by establishing diverse agricultural cultivation and to gain co-benefits through multifunctionality. This spatial system is to be understood not merely as a functional infrastructural space but also as a working and living environment for a portion of the urban population. In the process, the focus is on today's peri-urban areas, meaning that urban farmers become spatial producers of a new urban milieu – the *rurban*.

Urban-rural linkages are not merely a case of two distinct spheres that intertwine in a new manner, but also define the future relationship between the city and its integrated landscape. The development of tomorrow's megacities according to these two spheres is what is referred to as *dual-track urbanism*.

But the first step, which serves as an important basis for understanding the mechanisms of spatial production, is to understand the agricultural space, its different inhabitants, its practices, productivity, and soil qualities, and equally, how it is perceived and valued within the region. Based on different analyses and studies concerning potential areas for urban agriculture and multifunctional spatial systems, we developed different spatial categories based on their potentials (an autobiographical approach based on culturally specific space), which form the possible green productive infrastructure of Grand Casablanca. These categories range from inner-city micro areas and districts to expansive areas of intensive production on the urban periphery.

4 Research on Different Levels

In addition to the trans- and interdisciplinary approach, it is also necessary to work on a variety of scales in order to answer research questions. For this reason, the UAC research project works on three different scales that are partially linked with one another (cross-scaling), and the results of the research can be both up- and downscaled. Examples of the work done on the macro-level include the urban development analysis, the potential space analysis for urban agriculture, the common future search workshops, both sectoral and integrated scenarios, as well as different models, exhibitions, and large public awareness-raising events such as *Vive Casa* in 2009 and 2011. On the meso-level, various activities such as integrated case studies, creative workshops about multifunctional spatial systems, and a large international research competition have taken place. The main elements of the micro-level are the four UAC pilot projects, which follow the action research approach. In addition to the different scales involved, it should also be mentioned that special attention is being is paid to the different types of research being carried out as part of the UAC project: transdisciplinary research, basic research (sectoral research), future research, and action research. In the following sections, this chapter will discuss the role that action research is playing on the pilot project scale.

5 Action Research on the Micro-level: The Four UAC Pilot Projects

As part of the research, four pilot projects within the UAC research project have been successfully developed and established from the very beginning. Each pilot project (PP) combines urban agriculture with a relevant topic: PP1 *Urban Agriculture and Industry*, PP2 *Urban Agriculture and Informal Settlements*, PP3 *Urban Agriculture and Periurban Tourism*, and PP4 *Urban Agriculture and Healthy Food Production* (see Fig. 2).

To highlight the importance of action research on the micro-level, this paper solely examines the *Urban Agriculture and Informal Settlements* pilot project 2. It shows that, particularly in informal peri-urban settlements, the generation of productive, green, and attractive spatial structures through urban agriculture has the potential to offer improved living conditions in terms of social development

Fig. 3 The Douar Ouled Ahmed: urban structures in a rural context that form a megacity-specific spatial pattern

and income generation. This pilot project explores synergies, concentrating on an understanding of informal processes and a wish to increase inhabitants' enthusiasm for various forms of urban agriculture.

6 Pilot Project 2: Urban Agriculture and Informal Settlements

PP2 is located in Ouled Ahmed, a little douar ('douar' originally meant village) on the western edge of Casablanca at a junction between urban and rural space. The area is currently subject to considerable and highly dynamic transformation pressures (see Fig. 3). Migration to Ouled Ahmed is driven by the availability of affordable housing at a location close to the city. The result of this rapid increase in population is an absence of infrastructure, or rather an infrastructure that is unable to keep pace with this increase. This problem is visible in several ways, for instance, in high levels of unemployment, excessive numbers of school children in inadequately large classes, and the pollution of agricultural land through the production and disposal of waste.

7 Participation and Cooperation with Stakeholders as a Crucial Theme

The objective of PP2 is to raise awareness within the target group (i.e. the population of informal settlements) in the areas of cycles and urban mining (water, valuable material/waste/garbage), healthy diets and nutrition, climate change, and the fight against poverty. Techniques and practices used in the pilot project are increased training of the douar's inhabitants and teachers, the practical and theoretical training of pupils about gardening and farming (e.g. each pupil serves as a representative and disseminator of knowledge about organic gardening), and the teaching of their families and the dissemination of knowledge at regional and local levels.

The organization of the people involved in the pilot project (Moroccan and German scientists, civil organizations, and administrations) allows a combination of top-down and bottom-up communication strategies and integrates inhabitants in project activities, while also allowing for the formation of social alliances in the douar and the self-organization of its inhabitants. By working with the community's most important stakeholders, it is thus possible to generate sustainable and goal-oriented solutions. Stakeholders include the Union of Associations of Ouled Ahmed, the inhabitants of Ouled Ahmed, the school principal, teachers, and pupils at the primary school, as well as different levels of the community's administration.

8 The Three Components of PP2

The pilot project works with the following three components:

A community garden: A community garden has been initiated by the UAC research project in Ouled Ahmed, establishing an interim-use contract as an instrument. A local donor has made his land available for the duration of the project, which has been integrated into the UAC project. The community garden is to be used to teach local women organic farming, giving them the opportunity to use agricultural products to financially contribute to their households. The women are invited by an association and taught by a female teacher. It is an important objective that the women themselves become multipliers in the area of organic farming, healthy nutrition, and sustainability.

A school garden: The idea of the school garden, which is run by a primary school, is to create a facility where organic farming can be practised. The pupils and teachers may then act as multipliers for the concept of urban agriculture and the topics of healthy nutrition and resource-efficient social practices through reuse. Furthermore, pupils and teachers will have access to the Internet by way of a web-based teaching module (in development within the UAC research project as part of a web-based public information service), giving them an opportunity to familiarize themselves with and learn about aspects of climate variability and climate change.

The treatment and reuse of hammam wastewater: In the Grand Casablanca region, 2.1 million m^3 of potable water, which is provided by a public-private partnership, is used in the hammams (public baths). The main supply of potable water is from surface water collected in large barrages outside of the Casablanca city region. Well water is also used in Moroccan hammams. In the hammam that we are investigating, well water is currently being used. Due to the discharge of untreated wastewater and the unregulated pumping of groundwater, saltwater intrusion is now occurring. In order to qualify an urban-rural linkage, the water available from the urban system (i.e. hammams) will be reused in the rural system (resource efficiency), which serves as the basis for the other two components (the school garden and community garden). A systematic evaluation of the synergies between informal settlements and urban agriculture revealed that the treatment of moderately polluted water from the hammams so that it can be reused for agriculture has an immense potential to conserve water, which is indeed a scarce resource.

9 Perspectives

As an interim result after 6 years of research in Casablanca, it is clear that the conceptualization of urban agriculture, making use of the urban-rural linkages as a sustainable urban development strategy, holds a great deal of promise. The mixture of transdisciplinary research, basic research (sectoral research), future research, and action research has proven to be especially important when working on the broader social and scientific problems. The spatial association in these projects has come to be seen as a fundamental element and has to take place on a variety of scales with corresponding up- and downscaling. A recursive procedure that leads to a spiral-shaped working model that – despite inherent uncertainties – is useful for finding practical solutions is equally important. And, in addition to the involvement of numerous stakeholders with a variety of backgrounds, only a combination of bottom-up and top-down strategies will prove to be expedient, especially when working in a complex and highly dynamic system such as a megacity. For the generation of knowledge and results, the micro-level and the action research approach in the form of pilot projects is especially valuable, as it is here that the first implementations can be made. Our research team is presently working on further implementations in the Grand Casablanca region in conjunction with the various administrations (AUC, DRA, and IRHUAE) involved, which, despite the somewhat informal process, have played a significant role in the mechanisms of spatial production. The project is characterized by the parallel development of theory, basic research, and applied research on different levels, which requires a high level of communication.

References

Giseke, U. (2011). Urban Agriculture Casablanca. Design as an integrative factor of research. Technische Universität Berlin. special *Topos* insert – *The International Review of Landscape Architecture and Urban Design*, issue 74, Germany, p. 48.

Urban Agriculture Casablanca. (2011). http://www.uac-m.org. Accessed 10 Sept 2011.

Adapting Cities to Climate Change: Scenarios for Urban Neighbourhoods in the City of Essen

J. Alexander Schmidt and Hannah Baltes

Abstract Big agglomerations are deeply affected by the impacts of climate change particularly in dense areas. Currently, the climate of these areas is affected by urban structures. Consequently, the whole Ruhr region has to deal with climate adaptation. Most cities in the Ruhr region have some distinctive features that differentiate the urban climate from the climate of its surroundings. For example, there are large industrial brownfields in Essen that neighbour very dense inner city areas, with a high potential for developing urban heat islands. The problems of the urban climate will amplify with ongoing climate change and will lead to various problems and impacts on the city and its population. As a result, the city of Essen adopted the pilot project "City Faces Climate Change – Integrated Strategies for Essen" in the ExWoSt-Program "Urban Strategies for Climate Change – Municipal Strategies and Potentials" funded by the German Federal Ministry of Transportation, Building and Urban Development. While this project is still in progress, nearly half of the duration of the project is now over. In turn, this paper will present only the initial results of this project.

Keywords Adaptation • Climate change • Urban planning • Urban development

1 Project

The ExWoSt model project "City faces Climate Change – Integrated Strategies for Essen" deals with the question of how cities in big agglomeration areas can be adapted to climate change and its challenges. In this project, it is necessary

---

J.A. Schmidt (✉) • H. Baltes
Institute of City Planning and Urban Design, University of Duisburg-Essen,
Universitätsstraße 15, 45141 Essen, Germany
e-mail: Alexander.schmidt@uni-due.de; Hannah.baltes@uni-due.de

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_16,

to work on different scales and levels because urban climate change can vary in the different areas of the city. To define concrete measures for climate adaptation, different levels must be observed such as the whole city, a district or a building. All the measures that are taken on the different levels complement each other and address different stakeholders (e.g. city planning authority, public housing agencies, private developers and companies and private homeowners).

1.1 Objectives

The expected impacts of climate change affect different departments of the planning authority and stakeholders. This is reflected in the following objectives of the project:

- Identify, estimate and analyse conceivable impacts of climate change
- Define adaptation demand on the level of the whole city and on the level of the chosen quarters
- Development of a planned measures programme for handling climate change
- Development of a small-scale adaptation strategy to deal with climate change (e.g. in the dense inner city areas)
- Development of scenarios for pilot quarters

2 Method

The project works on different scales to develop an integrated strategic concept including detailed measures for the city of Essen. This concept shows what measures are reasonable for different types of quarters of the city to adapt Essen adequately to climate change. Although the project includes measures for the whole region or the whole city, there are also measures for specific quarters, blocks or buildings. For a precise and application-oriented concept, working on different scales and levels is essential.

Initially, it was necessary to develop urban strategies focusing on adaptation to climate change. For this, the large-scale scenario “Cool City” was created. Afterwards, the project worked on the scale of urban quarters. In this project, two-quarters will be analysed in detail as pilot areas – one new development quarter which will be constructed during the next few years and one existing quarter – to show how to adapt existing buildings to climate change. On the quarter scale, the simulation tool “envimet” was used. “Envimet” can determine the microclimate of a quarter, which depends, among other things, on the building structure, the existing green open space and the quality of the soil. It is also possible to simulate this for specific atmospheric conditions. For this project, a hot summer day was chosen because such atmospheric conditions will be intensified by climate change and will have negative repercussions on the residents. The "envimet" simulation shows the mentioned microclimatic conditions by comparing the status quo with planned measures. For the simulation, parameters such as building types, surface varieties and the impact of wind and temperature were included into the programme. The programme calculates values for 24 h, so it is possible to establish deviations during a 1-day run. The results can be analysed according to different factors, for example, temperature, wind and thermal comfort. In both pilot areas, the status quo and the planned measures scenario will be simulated and analysed. The simulation of the status quo shows already existing problems so that subsequently the criteria observed in the planned measures phase is adequate. The simulation of the planned measures phase illustrates whether the measures produce designated effects, if changes need to be made, or whether new problems are generated.

2.1 Expected Climate Change

The sensitivity of the area, in this case the Ruhr region, depends on the structure of the settlement and the existing social and economic framework. As the population density of the Ruhr region is very high and the adjacent cities merge together, there is a high potential of urban heat islands developing. Additionally, simulations of regional climate models (four regional climate models were used: STAR2, WETTREG, REMO10, CLM) show that in the Ruhr region an increase of hot summer days and a decrease of cold days will be expected. Furthermore, there will be an increase of extreme weather events such as heavy rainstorms. Yet prognoses about precipitation are still unreliable: the trend goes to dry summers and rainy winters, but the average rainfall during the year will be the same like today. The changes will lead to drought and water shortage in the summer (Fig. 1).

The expected changes affect the whole region and also the city of Essen. Precisely they are:

- Increase of the annual temperature up to +2.1 K
- Increase of the maximum temperature in summer up to +1.9 K
- Increase of hot summer days ($t_{\text{max.}} \geq 25°\text{C}$) up to +95%
- Increase of hot days ($t_{\text{max.}} \geq 30°\text{C}$) up to +150%
- Increase of tropical nights (minimum temperature at night ≥20°C) up to +300%
- Increase of the heat island effect in inner city areas
- Increase of temperature on the outskirts of the city
- Increase of heavy rainfall
- Increase of drought in summer

Because of these changes, the thermal load in buildings will increase especially during heat periods. This will cause an enhancement of air ventilation with an enormous energy demand. Heavy rainfall determines an overstress of the sewage and drainage system. To disburden these systems it is necessary to enhance the infiltration by reducing the surface sealing.

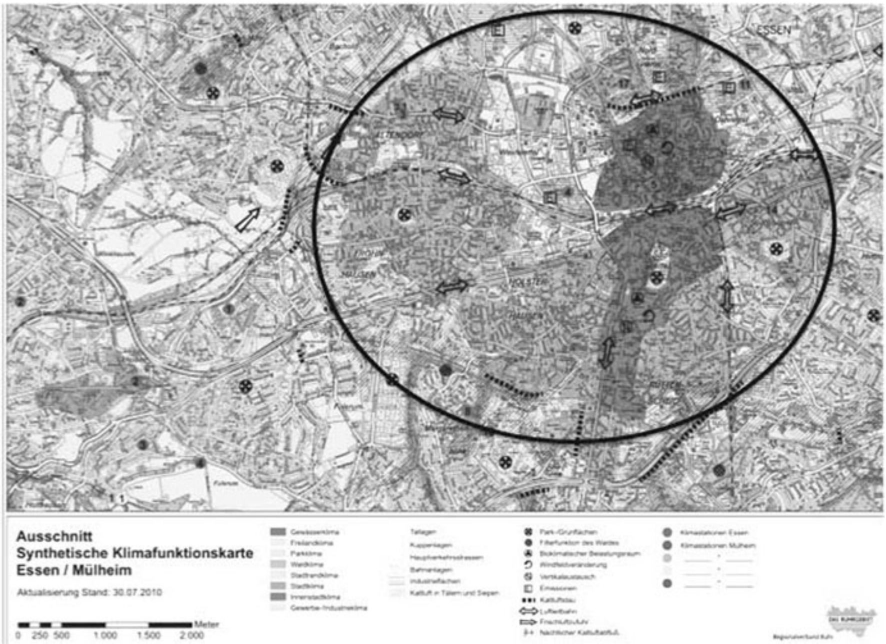


Fig. 1 Cut-out of the regional climate map (Source: RVR)

3 Large-Scale Scenario: "Cool City"

After considering the regional climate prognoses and the expected impacts for the city of Essen, a large-scale scenario was developed for the inner city area where the majority of the climatic impacts occur. This "Cool City" scenario schematically shows the margin for climate adaptation. The main idea is to develop huge green corridors combined with water surfaces within the inner city, which produces airflow corridors to cool and alleviate climatic burdens in specific areas. At first sight, this scenario seems to include big changes in the existing parts of the city, but some of these changes will also be necessary to handle the demographic change, negative growth and the following urban shrinking process (Fig. 2).

This scenario enables the planners to develop a negative growth and shrinking process for the urban area with regard to climate change and its requirements. The details of all the necessary measures and the design of the green open corridors are not defined at present because a lot of different conditions and requirements must be considered. As to that, the scenario "Cool City" can be seen as a strategy for Essen.

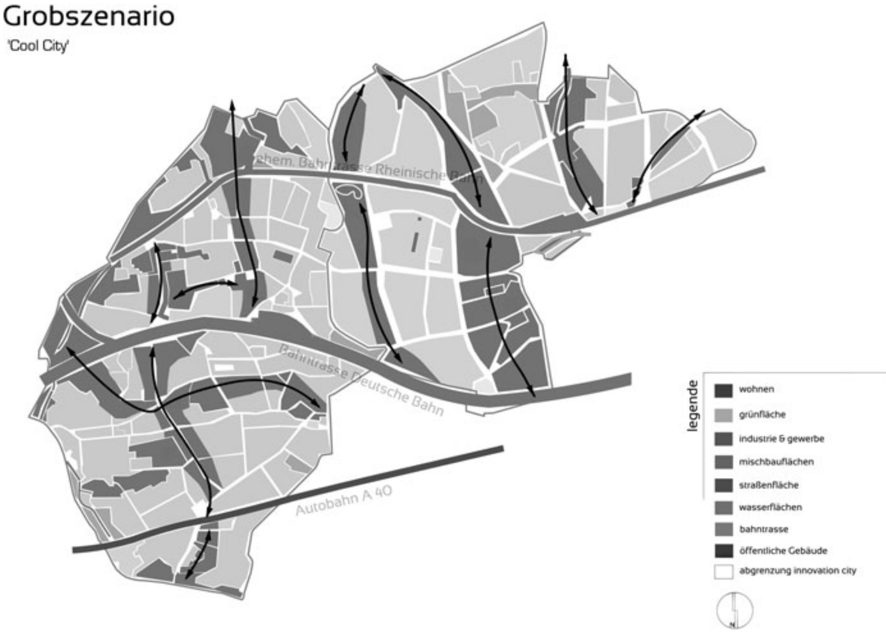


Fig. 2 Large-scale scenario "Cool City" (Source: University of Duisburg-Essen, Institute of City Planning and Urban Design)

4 Small-Scale Scenario

On the basis of the results on a macro level, two small-scale scenarios will be developed during this project: one for a new planned quarter and one for an existing quarter. The process in both pilot areas is comparable. At the beginning, the area will be analysed in terms of form, urban structure and the conditions of the micro climate. This will be the basis to determine appropriate measures and to define the creative scope. Subsequently, new drafts for the pilot areas will be developed which accomplish the input from the "envimet" simulation and the existing conditions. After that, the drafts will be simulated again to ascertain how the initial situation should be developed further in the next planning process.

At the moment, the work on the first pilot area (the new planned quarter) is finished, while the work on the second quarter is still in process. Hence, in the following part, only the results and the process for the first quarter will be explained further.

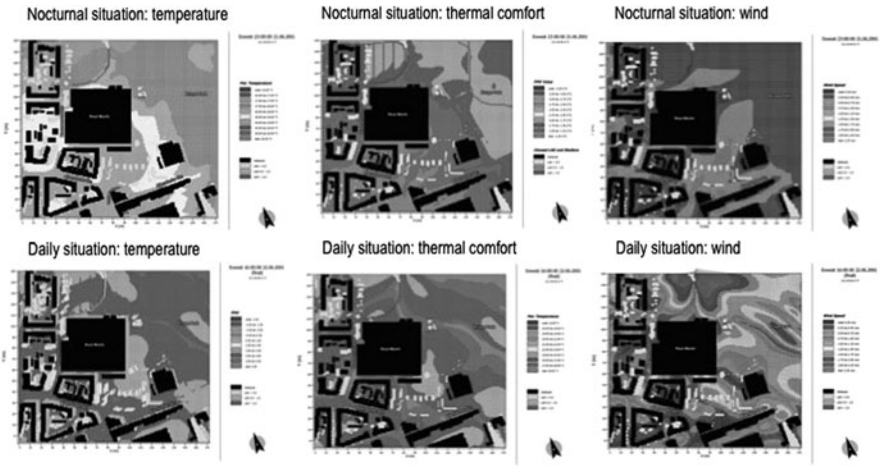


Fig. 3 "Envimet" simulation of the status quo (Source: University of Duisburg-Essen, Applied Climatology and Landscape Ecology)

4.1 Status Quo

The quarter is located in the inner city district of Altendorf, near the city centre. Altendorf is climatologically one of the most burdened areas in Essen as the degree of soil coverage is very high, the building structure is very compact, and there is a dense perimeter of block development and minimal green, open space. Additionally, the basic structures of the buildings in some parts are in need of renovation, and there are no high-quality residential areas. At the eastern border of Altendorf, a new park was developed. This park enhances the existing situation and provides a big potential for a positive development in the locality.

The pilot area is adjacent to this park. Today, the site contains a huge supermarket with parking lots, but it will be relocated in the upcoming years. The site will be reused for residential areas because of the particular living quality enhanced through its close proximity to the park. An initial analysis shows that the current use of the pilot area acts as a barrier between the surrounding residential areas and the new park because pedestrians cannot directly walk across. Adequate and easy access to the park is essential for Altendorf and its inhabitants because of the lack of green open space and the very dense building structure in the neighbourhood.

Primarily, the status quo was simulated with "envimet". From this simulation, it was possible to determine zones with specific problems, which should be eliminated by context-sensitive measures. The results reveal that the quarter has a high thermal load because the site's surface is sealed by almost 100% (Fig. 3).

The existing dense blocks in the surroundings amplify this effect because they avoid natural air ventilation or air exchange. Essentially, there is no cooling down effect even at night. The results from the "envimet" simulation, aspects of urban planning and the demands of the owners were combined to generate a framework for the new scenario:

- Avoidance of closed building blocks to prevent heat accumulation
- Arrangement of buildings in a way that they afford natural ventilation
- Building orientation east-west to assure a cold air flow from the park
- Adaptation of building height to the context (three to four floors)
- Adaptation of the buildings to the context in the western part of the pilot area
- Shading of the south facades of the buildings in order to avoid heating up
- Avoidance of extensive surface sealing
- Minimization of traffic areas
- Accessibility of public green open spaces
- Creation of green open spaces
- Planting of single trees for more shaded areas

4.2 Scenario

On the basis of these requirements, the scenario was developed. In this draft, the western part of the area has a higher density than the rest. The new structure is similar to existing building blocks to create a gentle transition between the existing and new neighbourhood. The blocks have an open structure with a connection to green open spaces to enable air ventilation. In the centre of the area, from east to west, there is a green axis, which joins Altendorf and the new park. In this axis, there is a small water surface to cool down the temperature and to enhance living standards. The height of the buildings is between three and four floors similar to the existing buildings in the surroundings, but they create some variety for a more interesting urban structure. The south-facing facades received greening in order to avoid excessive solar exposure. This could be trees in front of the buildings (which can provide shade to pedestrians and the street surface), and it is also possible to apply facade greenery. Because of the chosen building structure and the small, narrow streets, it was possible to minimize the sealed surfaces to avoid heating. In contrast to the existing buildings, all the new buildings have flat green roofs, which also avoid heating and which retain precipitation to disburden the sewage and drainage system especially when there is heavy rainfall. An alternative to green roofs is a combination of green roofs and roofs with solar panels to combine climate adaptation and mitigation (Fig. 4).

The "envimet" simulation of the draft shows that the new building structure leads to an improved microclimate in comparison to the current one. There is a reduction of temperature throughout the pilot area and also in some existing parts; temperature decrease in areas with shading facilities and the highest reduction of temperature, up to 5 K, is to be found in the eastern part of the pilot area close to the park (Fig. 5).

Fig. 4 Draft of the small-scale scenario (Source: University of Duisburg-Essen, Institute of City Planning and Urban Design)

5 Conclusion

The results of this project illustrate that impacts on the microclimate are not solely produced by high-tech measures, but that the urban form, structures, building typography and the integration of open space all have a part to play. In areas

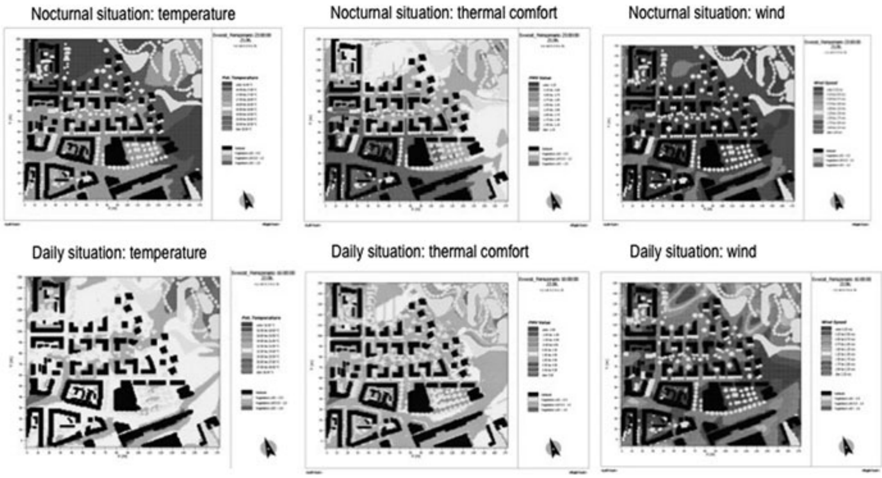


Fig. 5 "Envimet" simulation of the scenario (Source: University of Duisburg-Essen, Applied Climatology and Landscape Ecology)

with new development, it is particularly necessary to integrate the topic of climate adaptation into the planning process. For existing development, high-tech measures and building typography takes precedent.

The measures taken for climate adaptation, amongst others, avoid heat islands, and so they lead to a decrease of energy consumption as less people use air conditioning in the summer. Consequently, there is a substantial decrease in CO_2 emissions. This again shows how climate adaptation and climate mitigation interact. Moreover, green public spaces with a cooling down effect not only reduce climate stress but also have an influence on the walkability of the city and the health of the population. In turn, urban climate adaptation can also be seen as an opportunity for higher urban quality.

Combining Urban Development with Climate Change Adaptation Using a Systems Approach

Christian Walloth

Abstract This chapter aims to stimulate a new way of thinking about urban development using examples from Central and Eastern European (CEE) cities. It suggests to integrate common approaches in urban development with measures of climate change adaptation. This chapter also recommends to employ a systems thinking approach of mapping interdependencies between elements of the urban system to identify the most rewarding measures that satisfy both the needs of urban development and climate change adaptation. By addressing these needs simultaneously, synergies can be realized.

Keywords Decision-making method • Resilience • System thinking • Urban development • Urban systems

1 Overview

This chapter is about mainstreaming resilience measures within the scope of common urban development. In Sect. 2, resilience targets are contrasted to common urban development targets, taking examples from Central and Eastern European (CEE) small- and medium-sized cities. This chapter then demonstrates how development and resilience targets can be prioritized by mapping interdependencies within the complex urban system using a systems approach (Sect. 3). Considering the methods presented, further urban system studies are suggested (Sect. 4).

C. Walloth (✉)
Institute of City Planning and Urban Design and Main Research Area "Urban Systems", University Duisburg-Essen, Universitätsstrasse 15, 45117 Essen, Germany
e-mail: christian.walloth@stud.uni-due.de

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_17,

2 A Combined View on Urban Development and Climate Change Adaptation Is Needed in CEE

An analysis of common development targets of Central and Eastern European (CEE) small- and medium-sized cities indicates that they do not match with the general resilience targets. This might need to change considering the recent extreme weather events. By recognizing the mutual interdependencies between resilience and development targets, this chapter suggests a method for selecting measures that serve both the needs of urban development and climate change adaptation.

Central and Eastern European 'cities in transition' (Mykhnenko and Turok 2007) have to cope with a number of challenges including demographic, political, and legal changes; rising demands by citizens and business for better urban infrastructure and services; as well as mitigation and adaption to climate change. For example, this is reflected in the overall goals of the development strategy of Niš, a city in Serbia, which includes 'job creation, business development, institutional capacity upgrading, and a general improvement of the quality of life in accordance with sustainability principles' (Stanković et al. 2010). Similarly, the development of tourism, local partnerships, value-added products, and local governmental capacity were key targets for local economic development of the town of Horezu in Romania (Vasilache 2010). Economic and institutional development are at the forefront of governments agenda as exemplified by Ada's (Serbia) development axes: tourism, agriculture, industry, environmental protection, communal infrastructure, road infrastructure, technical equipment of the local government, and human resources (Koš et al. 2010). A summary of these urban development targets is classified in Table 1.

In addition to these urban development targets, Table 2 provides a summary of the community resilience targets which were identified by Cutter (2009) and Hahn et al. (2003). Although the region has recently experienced heat waves (e.g. in Romania and Bulgaria in 2007), various floods (e.g. in Czech Republic 2002 and Poland 2010), and even droughts (e.g. in Ukraine 2010), it seems that climate change

Table 1 Classification of selected CEE development targets

Domain	Development goal
Political	– Building the institutional capacity to act
Economic	– Creating jobs
	– Developing the local economy: tourism, agriculture, industry
	– Supporting local partnerships
	– Developing value added products
Societal	– Improving quality of life
	– Investing in human resources
Technical and infrastructural	– Increasing quality and quantity of communal infrastructure, esp. roads
	– Strengthening the technical equipment of the local government
Ecological	– Protecting the environment

Sources: Koš et al. (2010), Stanković et al. (2010), and Vasilache (2010)

Table 2 Exemplary resilience targets

Domain	Resilience goal
Political	– Increasing the ability to implement mitigation and recovery measures
	– Building institutional capacity to assess, mitigate and manage risks
Economic	– Diversifying the local resource base
	– Safeguarding access to local or (inter-)national emergency funds and insurances
Societal	– Increasing community risk awareness and disaster preparedness
	– Strengthening community participation
Technical and infrastructural	– Strengthening the basic infrastructure and services, e.g. communication, health systems
	– Applying and enforcing building codes
Ecological	– Managing land use

Sources: Cutter (2009) and Hahn et al. (2003)

adaptation and urban resilience does not even make the priority list in the cities' urban development plan. This becomes clear when comparing exemplary resilience targets of socio-economic and ecologic systems (Table 2) with those aforementioned targets of urban (and municipal) development in CEE (Table 1).

However, urban development measures may unintentionally increase or weaken urban resilience or climate change adaptation. For instance, despite the focus on economic and institutional development, urban development strategies in CEE subsume measures which can increase urban resilience (e.g. against flooding and/or drought). For example, the Hrušov development zone in the city of Ostrava (Czech Republic) is a partially contaminated brownfield prone to flooding, which is scheduled to be redeveloped and cleaned (LUDA 2009). Although the project's goal is economic development, it will also increase the city's resilience against further floods. Evidently, adaptation to climate change is unintentionally carried out in the frame of regular urban development (i.e. infrastructure renewal and reconstruction). As long as a common approach to integrate adaptation measures with urban development is still missing, potential negative effects of urban development on urban resilience can still occur. Some development measures may in fact lead to maladaptation, making the urban structure even more vulnerable (e.g. 'cooling or water supply technologies that may increase energy consumption' (EC 2009)).

This kind of dependency between urban development and resilience targets calls for an approach to specifically select measures which serve both targets. An approach to identify combined development and resilience measures will be presented subsequently.

3 System Thinking Supports Understanding of Urban Systems and Allocation of Development Resources

In order to identify and plan combined development and resilience measures and to realize synergies systematically, instead of by coincidence, it is suggested to apply a systems approach in urban planning. A systems approach can, by reflecting interdependencies among subsystems of the urban system, reveal the city's 'sensitive and vulnerable natural and human systems' (UN-HABITAT 2009). System models often involve the use of an impact matrix and/or a system diagram, as demonstrated in various research and urban development projects (e.g. Vester and von Hesler 1980). The impact matrix alone is frequently used in systems (and participatory) approaches (e.g. Cole et al. 2006). For illustrative purposes, a section of an exemplary system diagram of a city, derived from the analysis of selected literature sources for the purpose of this chapter's reasoning, is depicted in Fig. 1.[1]

A part of the corresponding impact matrix is given in Table 3.

This example illustrates two important characteristics of a system model:

1. The complexity of a city can be captured and represented in an understandable manner, accounting for the important dynamic interactions within the urban system.
2. The societal, economic, ecological, infrastructural, and political aspects can be integrated in one system model in order to analyse and understand the interdependencies between all of these aspects.

The insights that can be gained through this systems thinking approach are twofold: first, creating the impact matrix reveals direct interdependencies between elements of the urban system; second, working with and/or simulating the model helps to reveal the system's (un)intended and (un)expected reactions on potential impacts (a software tool can be used for simulation of the urban system).

Through the elaboration and application of an urban system model, measures of joint development and resilience can be identified. In order to do so, a system model of the city is first developed. Subsequently, each target for urban development and resilience (as shown in Tables 1 and 2) is linked to an according element of the system model. For example, the resilience target 'building institutional capacity to assess, mitigate, and manage risks' is linked to the urban system element 'regional governmental capacity'. The amended model of the urban system allows then, by looking at the selected paths of actions, for three different analyses of the system:

1. The first analysis starts with a specific target and explores the levers through which this target can be facilitated. Figure 2a depicts how to focus on a target of development and/or resilience and the levers influencing this target directly or indirectly. In such a way, resilience and/or development levers which strengthen (or weaken) the target under analysis can be identified. In the example shown,

[1] This diagram draws on research work documented by Chan and Huang (2004), Rotmans et al. (2000), Vester and von Hesler (1980), Vester (2002), and Walz et al. (2007).

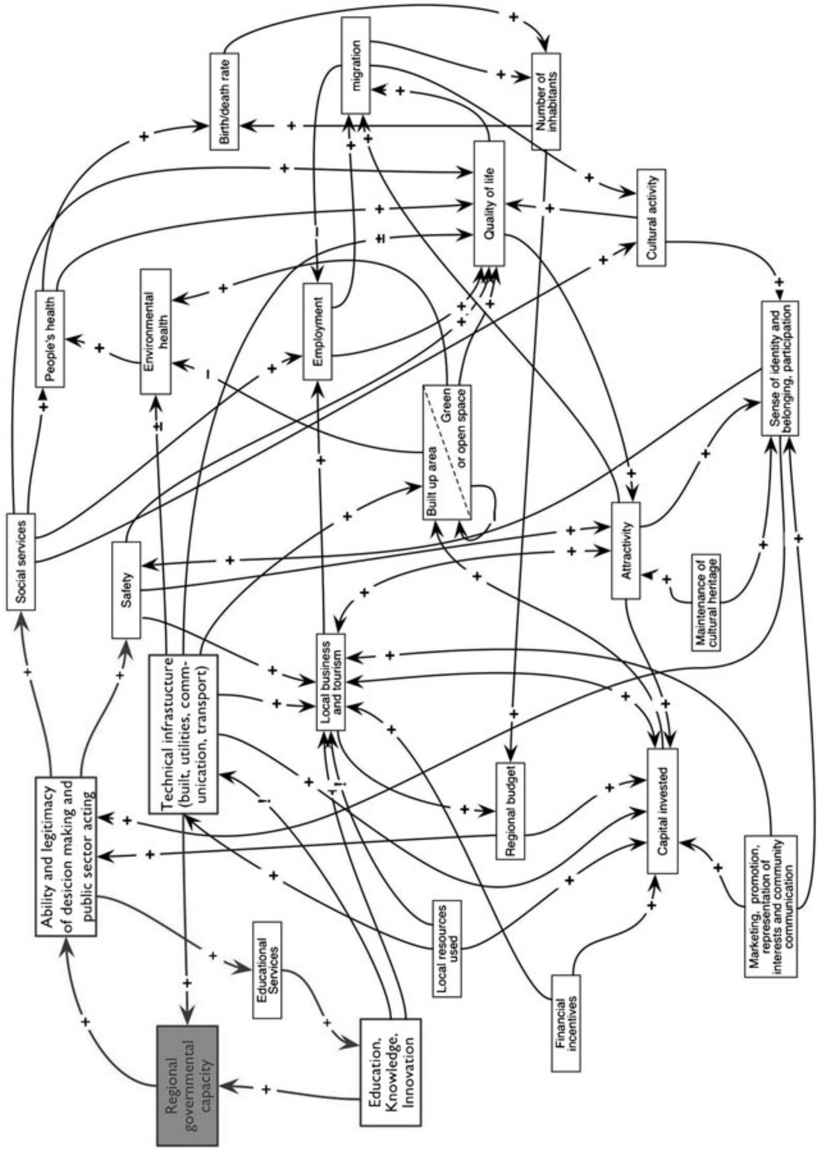


Fig. 1 Section of an exemplary urban system model for illustrative purpose

Table 3 Part of the impact matrix corresponding to the exemplary urban system model

Impact from ↓ on →	01	02	03	04	05	06	07	08	09	10	...
01 Governmental capacity		+									
02 Ability of decision making			+	+	+						
03 Social services									+		
04 Safety								+			
05 Educational services							+				
06 Technical infrastructure	+							+			
07 Education, knowledge, innovation	+					+		+			
08 Local business and tourism											
09 People's health											
10 Local resources used						+		+			
...											

the target is to increase regional governmental capacity, which is considered useful for both strengthening resilience and (economic) development. It can be seen from the exemplary model that the direct levers positively influencing governmental capacity are knowledge and some technical infrastructure like communication systems used by governmental entities. Further, indirect levers strengthen (or weaken) the direct levers. Side effects contribute to other elements of the urban system. For example, increased level of education in the community has a positive effect on local business and may lead to building a smarter infrastructure. The interplay among targets, direct and indirect levers, and side effects is where potential synergies can be found. Levers can be weighted in order to account for direct and indirect effects (Table 4).

2. The second analysis focuses on the outcomes of a potential target or policy decision. Using the same target introduced above reveals that a strengthened regional governmental capacity will increase the ability for decision making and acting, facilitating the implementation of actions for urban resilience, climate change adaptation, and economic development (Fig. 2b). This ability, in turn, allows to influence the level of education and other public services provided.
3. The third analysis is similar to the second with one important distinction: change is not induced from within the urban system (i.e. through target settings or policy decisions), but change is the result of an external impact (e.g. a storm, drought, or flood). Increasing the urban system's resilience against such external impacts should be one goal of internal target setting and policymaking. Hence, analysing which elements of the urban system are directly and indirectly impaired by an external impact helps to set priorities. As depicted in Fig. 2c using the exemplary urban model, a natural hazard like a flood or heat wave will have negative effects on people's health, (some) infrastructure, and – by destroying assets – the capital invested.

Urban developers and policy makers can systematically draw on insights gained from these three complementary analyses of the urban system. Applying the method described above, a set of potential levers and targets can be evaluated with regard

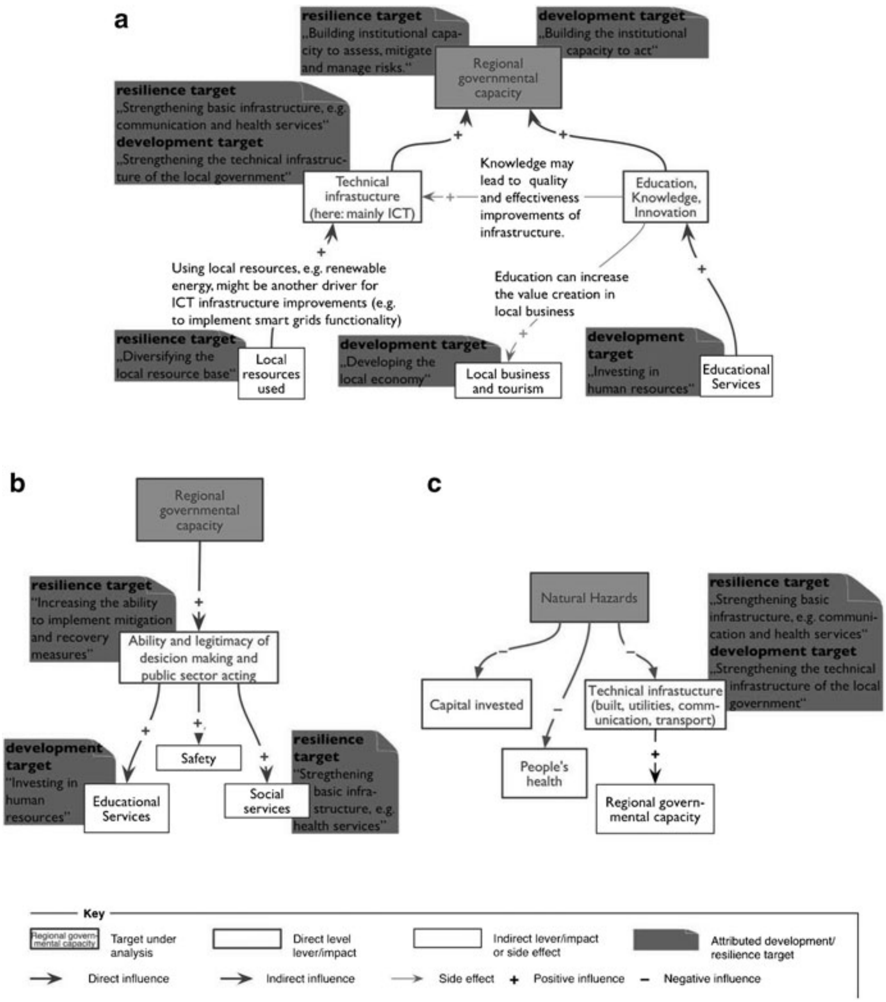


Fig. 2 Attribution of resilience and development targets to the elements of the urban system for ananalysis of paths of actions using three views: (**a**) levers, (**b**) effects and (**c**) external impacts. (**a**) A view on direct and indirect levers and side effects strengthening regional governmental capacity. (**b**) A view on impacts of a strengthened regional governmental capacity. (**c**) A view on the effects of external impacts

to their effects on development and resilience. The levers and targets can then be compared based on the scoring process described and depicted below (Fig. 2a, b, c and Table 4). Decision makers can then select those measures which target both urban development and resilience aims and which subsequently lead to synergies.

Table 4 Development and resilience scores of levers which strengthen governmental capacity

		Score	
Contribution	Weight	Resilience	Development
Target			
– Governmental capacity	100%	1	1
Direct levers			
– Technical infrastructure	100%	1	1
Indirect levers			
– Educational services	50%		0.5
– Local resources used	50%	0.5	
Side-effect			
– Local business and tourism	50%		0.5
Direct effects			
– Decision making ability	100%	1	
Indirect effects			
– Educational services	100%		1
– Social services	100%	1	
Direct exposures			
– Technical infrastructure	100%	1	1
Total score		4.5	5.0

4 System Analyses of CEE Cities Should Be Performed with the Aim to Influence Policies and Funding Schemes

The approach presented above demonstrates how local decision makers can select those measures which satisfy both common urban development and resilience targets. The analysis of the urban system allows to identify the direct and indirect and positive and negative levers for any potential resilience and development target. A subsequent scoring of the various targets against each other reveals those which have the largest overall positive impact on urban development and resilience, thereby exploiting synergies of direct and indirect levers. In this way, the approach presented helps to allocate urban development resources to the most effective measures. The overall process leading to decision making is depicted in Fig. 3.

The approach presented is based on system sciences, and one of its major advantages is the inclusion of all urban domains in an interdisciplinary way. Hence, this approach helps to overcome any potential sector focus of urban development work and helps to identify cross-sectoral synergies. The overall process is designed for practical use in decision-making settings. As part of this process, the scoring and weighing of levers is currently only a rough and linear indication of direct and indirect dependencies within the urban system. Comprehensive research of urban systems in CEE and elsewhere is therefore required in order to include better

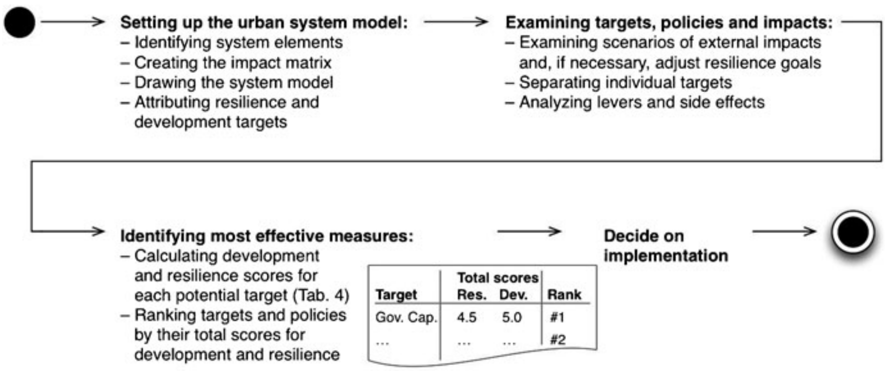


Fig. 3 Decision making process to identify combined urban development and resilience measures

functions of interdependencies among the systems' elements. The implications of such studies will reach far beyond the presented decision-making approach. Based on the improved understanding of the urban system, its inherent levers and feedback circles, policies can be improved and funding schemes adapted.

References

Chan, S.-L., & Huang, S.-L. (2004). A systems approach for the development of a sustainable community – The application of the sensitivity model (SM). *Environmental Management, 72*(3), 133–147.

Cole, A., Allen, W., Kilvington, M., Fenemor, A., & Bowden, B. (2006). *Understanding whole-of-systems sustainability in the Motueka Catchment*. Technical Report. Landcare Research.

Cutter, S. (2009). *A framework for measuring coastal hazard resilience in New Jersey communities*. White paper. Urban Coast Institute.

EC. (2009). *Adapting to climate change: Towards a European framework for action.* White paper COM(2009) 147 final. European Commission.

Hahn, H., De Le'on, J., & Hidajat, R. (2003). *Comprehensive risk management by communities and local governments. Component III: Indicators and other disaster risk management instruments for communities and local governments*. Study report. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Koš, Š., Šećerov, V., & Čolić, R. (2010). *Local ownership: A cornerstone of successful planning*. The Case of Ada in Serbia.

LUDA. (2009). *Reference Case Ostrava*. Dresden: Institute of Ecological and Regional Development. http://www.luda-europe.org/partners/refcit/ostravaLC.htm

Mykhnenko, V., & Turok, I. (2007, February). *Cities in transition: East European urban trajectories 1960–2005* (Working Paper 4). Centre for Public Policy and Regions, University of Glasgow.

Rotmans, J., van Asselt, M., & Vellinga, P. (2000). An integrated planning tool for sustainable cities. *Environmental Impact Assessment Review, 20*, 265–276.

Stanković, M., Popvić, N., & Milosević, D. (2010). The city of Niš development strategy. The implementation, updating and fine-tuning process.

UN-HABITAT. (2009). Cities in climate change initiative. Fact sheet. UN-HABITAT Sustainable Urban Development Network (SUD-Net), Urban Environment and Planning Branch.

Vasilache, A. (2010). Common challenges, common solutions. The experience of participatory planning processes in Romania.

Vester, F. (2002). *Die Kunst vernetzt zu denken* (5th ed.). dtv.

Vester, F., & von Hesler, A. (1980). *Sensitivitätsmodel l*. Umlandverband Frankfurt.

Walz, A., Lardelli, C., Behrendt, H., Gret-Regamey, A., Lundström, C., Kytzia, S., & Bebi, P. (2007). Participatory scenario-analysis for integrated regional modelling. *Landscape and Urban Planning, 81*(1–2), 114–131.

Towards Resilient Architecture

The Case of Brøset, Trondheim, Norway

Annemie Wyckmans

Abstract Transitioning towards a more sustainable and resilient architecture requires a balance between eco-efficiency, architectural quality and quality of life at the building, neighbourhood and urban level. In Trondheim, Norway, a 35-ha site is being developed into a high-quality, low-emission neighbourhood in which the most convenient choice is the most environment-friendly one, including transport and land use, stationary energy, consumption and waste and climate change adaptation. Long-term intensive interdisciplinary and cross-institutional co-operation is pursued between local and national governments, research and education, industry and end users in order to reach this ambitious goal.

In summer of 2010, a parallel commissioning process was initiated to devise a holistic master plan for the Brøset site, with a final delivery in January 2011. The results show that the Brøset project and process, rare in a Norwegian and international context, entail far-reaching implications for people's lifestyles, neighbourhood organisation and national urban planning and governance strategies.

This chapter describes the development of the Brøset neighbourhood and the Norwegian programme 'Cities of the Future', including the scope, stakeholders, performance criteria and financing schemes. The importance of facilitating this kind of process is analysed as a proactive form of supporting transition towards a more resilient society, allowing for leeway from tight economic limits in order to find 'golden opportunities' through interdisciplinary and cross-institutional co-operation. In conclusion, we discuss how this process can contribute to creating scenarios for a built environment in which eco-efficiency is successfully combined with liveable, functional, robust and attractive architecture for all the actors involved.

Keywords Interdisciplinary • Performance • Policy • Quality • Stakeholders

A. Wyckmans (✉)
Department of Architectural Design, History and Technology, NTNU Norwegian University of Science and Technology, Alfred Getzvei 3, N-7491 Trondheim, Norway
e-mail: annemie.wyckmans@ntnu.no

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_18,

1 Brøset, Trondheim and the Norwegian Programme 'Cities of the Future'

Can architecture and planning create a multiplier effect and contribute to urban resilience? And can this be achieved while maintaining a high quality of life and a stimulating built environment?

These questions form the background for the design of a sustainable, resilient and green neighbourhood in Brøset, Trondheim, Norway. The core of the project, generated by Trondheim municipality in co-operation with researchers, industry and citizens since 2006, is to find out how issues of lifestyle, design and technology can be combined in the built environment to generate environmental quality, architectural quality and quality of life.

During summer of 2010, a parallel commissioning process (http://www.trondheim.kommune.no) was initiated by the Municipality of Trondheim to devise a holistic plan for the Brøset site, with a final delivery of the proposals in January 2011. For the commissioning process, four Nordic project groups were chosen amongst more than 30 international applicants. During 6 months, these teams worked intensively on developing proposals in order to turn the 35-ha Brøset site into a low-emission neighbourhood for about 5,000 inhabitants, creating synergies between transport and land use, energy, consumption and waste and climate adaptation. Throughout the process, three seminars were conducted where project groups shared and discussed their ideas with the other participants, the municipality and researchers and end user representatives.

This process embodies the core characteristics of the Norwegian Cities of the Future programme (2008–2014) (http://www.framtidensbyer.no). The programme, headed by the Ministry of Environment, includes 13 Norwegian cities and their suburban regions: Oslo, Bærum, Drammen, Sarpsborg, Fredrikstad, Porsgrunn, Skien, Kristiansand, Sandnes, Stavanger, Bergen, Trondheim and Tromsø. Aiming to combine climate change adaptation and mitigation with resource efficiency and high quality of life, it targets four main sectors: land use and transport, energy (including new, existing and historic urban areas), waste and consumption and climate change adaptation. In order to identify favourable scenarios for adaptation and mitigation, the participating cities are relying on intensive co-operation with other stakeholders, including site owners, industry and inhabitants.

2 Merging Environmental Quality with Quality of Life and Architectural Quality

In a country that continuously scores high on the UN Development Programme's Human Development Index (HDI 2011), with vast oil and gas revenues, building resilience is mainly regarded as a preventive long-term measure, aiming to create successful transition strategies towards resilient urban futures. Uncertainty with regard to the future impacts of climate change, combined with a long turnover time for existing built structures and steadily resistant industry and politicians, creates complex challenges for city managers.

Holistic design requires tailoring to an often local and unique, existing urban situation, typically combining incomplete but quantifiable output with urban qualities that are difficult to measure. In order to get resilience policies implemented, the best chance for success is to create win-win scenarios that provide robust solutions with increased quality of life and an attractive built environment, while reducing potential vulnerability to climate change. Part of this strategy consists of creating environmental diversity, transferring focus from risk to performance and distributing vulnerability amongst several rather than one singular point of impact in sectors such as transportation, storm water treatment, consumption and energy supply.

Land use aims to improve accessibility for non-motorised and public transport, often in combination with centrally located green structures, culture and commercial activities. Efficient use of energy in new, existing and historic buildings and districts is combined with optimal adaptation to the specific characteristics of local sites and climate in order to reduce energy demand to the largest extent possible. Functions such as kindergartens, schools and community centres are to be located in shared facilities, to reduce the thermal envelope and corresponding energy demand, to enable exchange between buildings with complementary energy loads and to encourage intergenerational encounters and understanding. Waste is potentially reduced through the focus on consumption amongst private and public actors, second-hand markets and improvement of waste-based district heating systems.

Green and blue structures are increasingly integrated into qualified densification strategies. Living and working areas are complemented with green roofs and facades to catch rainwater and provide additional insulation; existing brooks covered during the 1960s are opened up again for local leisure as well as storm water treatment, while trees, parks and shrubberies contribute to clean air. In addition, the existing building stock is upgraded to withstand the consequences of future climate change. Building roofs are being reinforced to tolerate intensive rain and snow loads, and building envelopes are proofed against humidity, fungus and rot caused by higher humidity. The Brøset neighbourhood is paying particular attention to creating continuous green pathways that connect surrounding nature areas from the hillsides and fjord, not only to promote walking amongst its inhabitants but also to create good conditions for biodiversity. In addition, the project is promoted as a socially inclusive neighbourhood, providing affordable housing units of different sizes and different levels of ownership and tenancy, for example, to create a balanced distribution amongst various age, ethnic and income groups.

However, the development of the Brøset neighbourhood is controversial as it is currently used as farmland, and in addition houses a psychiatric facility which is to be relocated in a few years. Neighbours are worried about the loss of biodiversity and having local leisure areas and green infrastructure replaced with a dense high-rise housing area. On the other hand, the area is one of the few central urban spaces left to develop in a city coping with a steadily increasing population and demand for commercial areas. During the past years, the municipality has consciously given priority to an urban densification policy combined with environment-friendly public transport and accessibility of local services for everyday life by bicycle and foot, rather than allowing for urban sprawl. In addition, the intensive co-operation between the municipality and the site owners (Statsbygg Public Construction and Property Management, St. Olavs Hospital Trondheim University Hospital and South-Trøndelag County Authority) provides good opportunities for a holistic and high-quality development in which environmental issues, social equity and economic viability are core priorities.

3 Holistic Performance Criteria

A toolbox of indicators, models and statistics is being developed in order to evaluate the progress of the Cities of the Future programme and to ensure that the results are objective, measureable and verifiable (the outcome of which is continuously disseminated on the programme's own website) (http://www.framtidensbyer.no). Tools include greenhouse gas accountancy and life cycle analysis (http://www.misa.no) to assess the environmental impact of policy scenarios, as well as risk assessment and environmental management systems. Implementation of tools for climate change adaptation is less advanced than for mitigation, but several cities have started to downscale national vulnerability profiles and conduct GIS analyses, and combine them with visualisation techniques in order to increase dissemination to policy makers and the general public (http://www.klimagis.no).

However, not all results are easily assessed in this manner, particularly when aiming to combine environmental performance with an attractive, functional and liveable realm. How does one measure qualities such as diversity and accessibility, assess directionality in existing standards and legislation, or evaluate the effect of the built environment on people's lifestyles? In the Brøset project, so far, a combination of various quantitative and qualitative methods has been used to assess the viability of transition scenarios: focus groups, space syntax, interviews, mapping of people's everyday habits, case studies, greenhouse gas emissions accounting, life cycle costs, secondments and design activism (http://www.broset.com). The project group hopes that clustering the information retrieved by these different methods will provide the integration and interoperability necessary to create a balance between environmental, social and economic sustainability, not only in the Brøset neighbourhood itself but with leverage effects towards its urban, regional and national context.

4 A Broad Stakeholder Platform

Resilience requires institutional and societal capital as well as robust physical infrastructures. By creating sturdy communities of practice, the Cities of the Future programme aims to maintain its local and national impact also after its official ending in 2014.

Four ministries are participating in the Cities of the Future programme: Transport, Oil and Energy, Local Government and Regional Development, and Environment (head of the programme). Linked to each of the 13 participating cities is a range of local stakeholders such as industries, building owners, research and educational institutions and non-governmental organisations co-operating to move urban development beyond the minimum requirements demanded by national legislation. On a national level, the Norwegian Association of Local and Regional Authorities and the Confederation of Norwegian Enterprises joined the programme in 2009 (CIVITAS 2010).

The 13 participating cities and their suburban regions cover about half of Norway's population, providing a large network for transfer of knowledge and experiences. This provides an excellent national learning and discussion platform to help stakeholders share their ideas and experiences with each other and increase the development of successful projects. Intensive interaction with policymakers, industry and citizens aims to create holistic, visionary and manageable neighbourhoods in which people want to live.

Alongside city managers, other stakeholders participate in creating this network as well. In Trondheim, for example, the Norwegian University of Science and Technology (NTNU) has since 2007 created an Industry Forum, a User Forum and an Interdisciplinary Forum (Wyckmans 2011). The foundation for these actions was laid in 2007 when NTNU and the corresponding research institution SINTEF Building and Infrastructure invited a wide range of stakeholders to a workshop on carbon-neutral neighbourhoods. This included Trondheim municipality, the Norwegian State Housing Bank 'Husbanken' (http://www.husbanken.no), the Norwegian State Agency for promoting environment-friendly restructuring of energy consumption and generation in Norway 'ENOVA' (http://www.enova.no), the Ministry of Environment and the construction industry. With the support of the Norwegian State Housing Bank, NTNU and SINTEF developed these ideas further in close contact with the policymakers and politicians of Trondheim. Trondheim municipality embedded the vision in its political strategy and suggested Brøset as a potential site.

5 Financing Schemes

The Norwegian Cities of the Future programme encompasses incentive schemes for infrastructure and transport, stationary energy, waste and consumption and climate change adaptation, related to the respective ministries. These comprise amongst others an incentive scheme for improved public transport and reduced car use of about 40 million euros in 2009 and 2010 each (CIVITAS 2010). In addition, the cities can apply for national funding to further reduce CO_2 emissions from the transport sector.

A range of overarching strategies are implemented on the national level to aid the participating cities, such as taxes that encourage environment-friendly lifestyles, and funding schemes that increase the development and implementation of new technologies. At ENOVA (http://www.husbanken.no), participating cities can apply for funding for their pilot projects, competing on an equal level with other candidates. As of 2010, the Norwegian State Housing Bank (Wyckmans 2011) distributes up to 625,000 euros per year in funding to participating cities, related to housing quality (climate, environment, universal design and architectural quality).

The Ministry of Environment earmarked three million euros in 2009 and four million euros in 2010 to the programme. The cities should contribute from their own budget an amount of money equal to this national funding to implement various measures and strengthen their expertise. In addition to national funding, the participating cities spend significant amounts of their own budgets to finance environmental efforts. A survey performed by CIVITAS shows that it is difficult to assess the balance between cities' own financing and the funding obtained from the Cities of the Future programme, as several measures would have been carried out anyway. The cities, however, do report on considerable strengthening of existing measures and co-operation with other institutions as a large benefit of the programme (CIVITAS 2010).

6 The Way Ahead

The 13 cities participating in the Norwegian Cities of the Future programme are learning, experimenting and complementing each others' activities with different perspectives. Evaluating the multiplier effect of these actions, sometimes planned, sometimes unforeseen, maintains a huge challenge for all of the stakeholders involved, and requires a more-than-average drive from the participants. New, extended roles and interactions arise, threading outside of long-standing sectoral, institutional and cultural boundaries. A specific example of this is the planned development of an environmental centre at the Brøset site, in co-operation between local government, academia and industry, that can oversee the daily management of the neighbourhood, encourage user participation, assess and measure the performance and functionality of the various measures in use, promote the creation of bioregional networks of local products and services and help transfer the positive and negative experiences to other projects and stakeholders. Including students in this work, promoting a direct interface with diverse stakeholders in planning, standards, institutions, products and communication, aims to encourage near-future transfer to industry and public government, generating momentum and building capacity for the resilient architecture of the future.

This chapter has been written as part of the interdisciplinary research project 'Towards Carbon Neutral Settlements – Processes, Concept Development and Implementation', which runs from 2009 to 2012, and is financed by the Norwegian Research Council in co-operation with the City of Trondheim and the Norwegian State Housing Bank, TOBB Trondheim and Vicinity Housing Co-operative and Trondheim Energy. The project involves close interaction with Trondheim

municipality and a wide range of stakeholders, including citizens and industry. The project group includes disciplines such as industrial ecology, architecture and planning, engineering and social sciences.

References

Brøset. *Towards a carbon neutral housing settlement*. The website of the Brøset research project, including research reports, examples, and an update on breakfast seminars and other activities. http://www.broset.com. Accessed 18 April 2012

CIVITAS. (2010). *Framtidens Byer statusrapport 2010* (in Norwegian). CIVITAS AS. Available for download at http://www.regjeringen.no/nb/sub/framtidensbyer/aktuelt-2/nyhetsarkiv/nyheter-2011/statusrapport-2010.html?id=624587. Accessed 18 April 2012

ENOVA. *The Norwegian State Agency for promoting environment-friendly restructuring of energy consumption and generation in Norway*. http://www.enova.no. Accessed 18 April 2012

Framtidens Byer. *The Government website of the Cities of the Future programme* (in Norwegian, with summaries in English). http://www.framtidensbyer.no. Accessed 18 April 2012

HDI. (2011). http://www.undp.org/content/undp/en/home/presscenter/pressreleases/2011/11/02/2011-human-development-index-norway-at-top-dr-congo-last.html. Accessed 18 April 2012

Husbanken. The Norwegian State Housing Bank. http://www.husbanken.no. Accessed 18 April 2012

KlimaGIS. *Simulation and visualisation of climate change* (in Norwegian). http://www.klimagis.no. Accessed 18 April 2012

MISA Environmental Systems Analysis. http://www.misa.no. Accessed 18 April 2012

Trondheim Municipality website, displaying the Brøset planning project and the results of the parallel commissioning process (in Norwegian). http://www.trondheim.kommune.no. Accessed 18 April 2012

Wyckmans, A. (2011). Environmental learning from the ivory tower to the town square: The case of Trondheim, Norway. In K. Otto-Zimmermann (Ed.), *Resilient cities: Cities and adaptation to climate change – Proceedings of the Global Forum 2010,* Local sustainability 1, Chap. 15. Dordrecht: Springer Science + Business Media B.V.

Towards More Resilient Water Infrastructures

Engelbert Schramm and Jörg Felmeden

Abstract Currently, cities are confronting a multitude of challenges including climate change, demographic change, urbanization and land subsidence. Resulting flooding, droughts and other disturbances could lead to water shortages, severe interruptions, hydraulic problems or underutilization of water infrastructure systems. One way that cities can become more resilient is by diversifying their water resources and reducing their dependency on central water infrastructures. Water infrastructure systems consisting of decentral or semi-central partial systems would be more resilient because a failure in these systems would only affect a small part of the urban area. Instead of an incremental improvement of the water infrastructure, there is a need for system innovations that will allow an adaptive development to changing conditions and which will ensure that future sustainability challenges are met. However, moving towards more resilient water technologies is seen as controversial for built-up areas. To answer the question if a transformation to a more resilient water infrastructure in built-up areas is feasible (technically and economically), a balancing and assessment of the corresponding effects have been done by way of comparing a "transformation" scenario with a reference scenario "business as usual". If one takes a long-term period of observation (70 years), the costs balance of the scenarios "reference" and "transformation" both turn out to be on a comparative level. By contrast, the consumption of environmental resources in the scenario "transformation" is almost twice as low as in the "reference".

Keywords Climate change • Eco-efficiency analysis • System innovations • Vulnerability • Water infrastructure

---

E. Schramm (✉) • J. Felmeden
Water Infrastructure and Risk Analyses, Institute for Social-Ecological Research (ISOE) GmbH, Hamburger Allee 45, 60486 Frankfurt am Main, Germany
e-mail: schramm@isoe.de; felmeden@isoe.de

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_19,

1 Existing Water Infrastructures Increase Urban Vulnerability

Water plays a pivotal role in the constitution of any given city. Up to the nineteenth century, most European cities solely obtained their water supply from local resources. In turn, material exchange between cities and their surroundings was kept to a minimum, and this made cities less vulnerable to natural disasters and wars (cf. Schramm 2010). Today, municipal water management is usually founded on a central system of water supply and sewage disposal facilities and networks (water infrastructure system). In 2007, nearly 99% of the German population was provided with drinking water by the central public drinking water supplies, and approximately 95% of the German population discharged their wastewater through the public sewer system into appropriate wastewater treatment plants (Statistisches Bundesamt 2009).

The public water infrastructure systems prove to have a long lifespan due to a high capital investment and long depreciation time. For example, the lifespan of sewer systems can be up to 100 years, and for other facilities, such as dams for water supply, they may even be longer. The capital intensity of the central infrastructure causes a high degree of fixed costs. The fixed costs of the central water systems constitute about 70–80% of the overall costs, regardless of the operating performance (ATT, BDEW, DBVW, VDGW, DWA, VKU 2008). Appropriate depreciation spans are the result.

The established central water infrastructures produce high path dependencies due to their high capital intensity and the long lifespans of their material components. Also, the established decision routines, the experiences of administrations and the well-rehearsed daily operation contribute to their persistence (Wolf and Störmer 2010).

For these reasons, the flexibility of a central water infrastructure is low, and its capability to adapt to changing context conditions is limited (Hillenbrand and Hiessl 2006). Depending on the global, regional or local characteristics, these conditions can be:

- Climate change, with changing amounts of precipitation in winter (increase) and summer (decrease), increase of extreme weather events or dry periods
- Demographic change which on the one hand leads to a strong decline in the population within shrinking areas such as Germany and to an underutilization of the centralized water infrastructures, while on the other hand, it can lead to a high population growth, as in Chinese megacities, with the risk of an insufficient water supply and wastewater systems (cf. Bieker et al. 2010)

According to de Graaf (2009), cities are in a highly vulnerable position due to uncertain future developments such as climate change, urbanization and land subsidence. They should therefore change their water management and reduce their dependency on large-scale and energy-consuming water infrastructures.

2 Potentials of More Resilient Water Infrastructure Systems

Resilience can be described as the scope of disturbances a system can tolerate while still remaining within the same state or domain of attraction (Gunderson and Holling 2002; Folke 2006). The vulnerability of any system is reflective of its exposure and sensitivity to hazardous conditions and its capability to cope with, adapt to or recover from the effects of those conditions (Smith and Wandel 2006). Urban systems should behave in a way that they buffer such disturbances. Some important disturbances result from changing context conditions occurring related to climate, socio-economics or urban population; urban growth and rapid urbanization are other challenges because of the scale effects restricting conventional interactions of the town (or agglomeration) and its hinterland.

Infrastructure systems consisting of decentral or semi-central partial systems would be more resilient in that a failure of a partial system would only affect a small part of the urban area (cf. Wikramanayake and Corea 2003). By using a mixed "portfolio" of multiple water resources, including local and external resources, urban areas become less dependent on a single source of water that might be disrupted in the future. Multiple and local water resources enable cities to reduce supply vulnerability by strengthening coping capacity, recovery capacity and adaptive capacity (de Graaf 2009; Kluge and Libbe 2010). "A diversity of water sources underpinned by a range of centralized and decentralized infrastructure providing cities with the flexibility to access a 'portfolio' of water sources at least cost and with least impact on rural and environmental water needs" (Australian Prime Minister's Science Engineering and Innovation Council Working Group 2007).

As de Graaf (2009) noted, it is possible to reduce the vulnerability of cities with the help of changed water management as well as by transforming the given water infrastructure systems. In recent years, new technological possibilities for increasing the mentioned capacities were introduced including new ways of supply, discharge, treatment and reuse of water and wastewater (cf. DWA 2008; Merkel et al. 2010; Rygaard et al. 2009). Instead of an incremental improvement of the water infrastructure, there is a need for system innovations which will allow an adaptive development of the water system to changing conditions and which will make sure that future sustainability challenges can be met (Daigger 2007; Felmeden et al. 2010; Tukker et al. 2008; Wolf and Störmer 2010).

In between possible technological and organizational actions, the following exemplary developments should be considered as part of the fundamental system innovations allowing for a more resilient urban water infrastructure system (cf. Kluge and Schramm 2012):

- Water supply with different water qualities, adapted to industrial and domestic water consumption and various purposes
- Separated discharge and appropriate treatment of different domestic wastewater streams (e.g. rainwater, grey water, black water), in order to reuse water, energy and nutrients

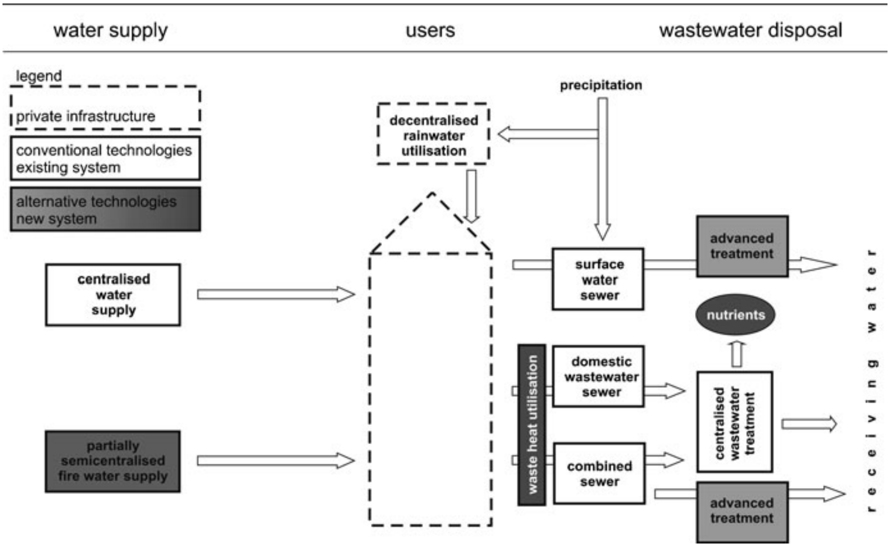


Fig. 1 Outline of the system "reference" (business as usual)

- Progress in information and communication technologies (ICT) enabling the centralized management of semi-centralized and decentralized systems
- Improved operation safety and performance of decentralized facilities
- Cutting urban creeks from sewer systems

When it comes to these innovations in the water infrastructure systems, scenarios are a means of allowing the projection of divergent but inherently consistent solutions and to derive consequences for strategic decisions with respect to these visions of possible futures (Nowak and Guenther 2009). Based on the above-mentioned status quo, the problem situation "central infrastructure as hypothec" has been examined for German context conditions. Therefore, assumptions such as a declining population, more extreme weather events and a sluggish economy were made. The two resulting scenarios, "reference" (business as usual) and "transformation" (system innovations), have different effects on natural resources (e.g. water and energy) and socio-economics (e.g. governance, future business development for the utilities and other enterprises) (Kluge and Schramm 2012).

The "reference" scenario is characterized by business as usual: central water infrastructure systems are rehabilitated without questioning their technological and organizational principles. However, technological innovations such as waste-heat utilization, reuse of nutrients and energy and decentralized rainwater utilization are made to optimize the centralized system (cf. Fig. 1).

Contrarily, the "transformation" scenario follows a radical conversion of the infrastructure (distinguishing different water and wastewater qualities and adequate on-site or semi-central treatment technologies) to reuse water, energy and nutrients

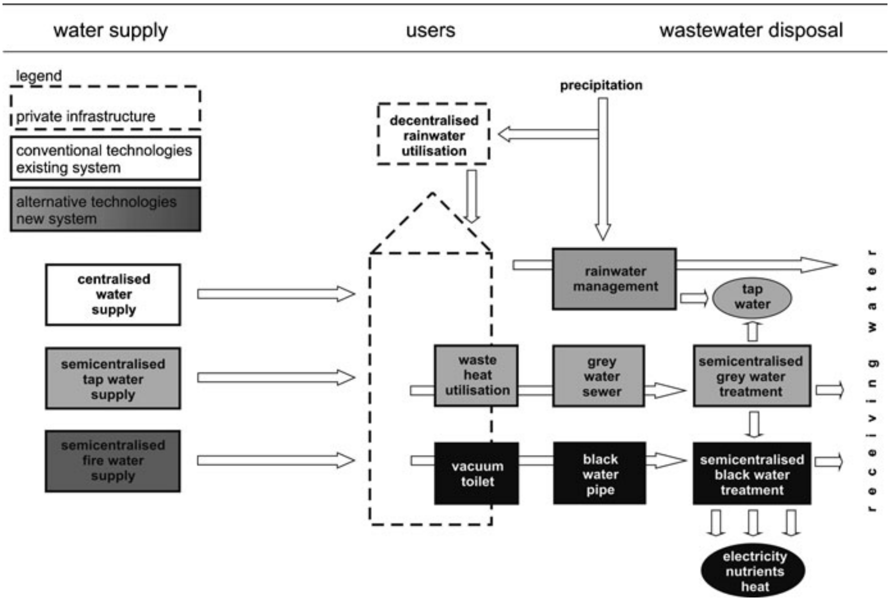


Fig. 2 Outline of the system "transformation" (system innovations)

(Felmeden et al. 2010). The outline of the "transformation" system in Fig. 2 consists of more regional and local water and wastewater systems and loops (e.g. including waste-heat utilization and water reuse in case of grey water and reuse of energy and nutrients of black water by using water-saving vacuum toilets for collecting).

3 City Model "netWORKS"

Based on the generalizable terms of urban development conditions in nearly all large German towns, the city model "netWORKS" was developed in order to allow a systematic analysis and evaluation of the above-mentioned scenarios of municipal water infrastructures. "netWORKS" is a monocentric, clustered city that is described by the basic data shown in Table 1.

The city model "netWORKS" is divided into 16 different sub-areas. Each of these sub-areas shows typical settlement structures and characteristics in water demand as found in large German cities and which can be assigned to the following four categories: inner core, inner city periphery, periphery and external territory (Fig. 3). Independent of specific local conditions, "netWORKS" is a simplified model focusing on just one of the sub-areas of each category. In reality, some sub-areas may not occur at all in a given city, and others might be found severalfold in different districts of that city.

Table 1 Basic data of city model "netWORKS"

Characteristic	Figure	Unit
Settlement area (gross)	5,000	ha
Population density	100	inhabitants/ha
Workplace density	50	workplaces/ha
Mean annual precipitation	650	mm/year
Sealed area	35	%
Run-off coefficient	0.8	–
Ratio of combined/separate system	60/40	–
Specific drinking water demand	45	m^3/inhabitant/year
	10.5	m^3/workplace/year
Infiltration water	2,000	m^3/ha/year

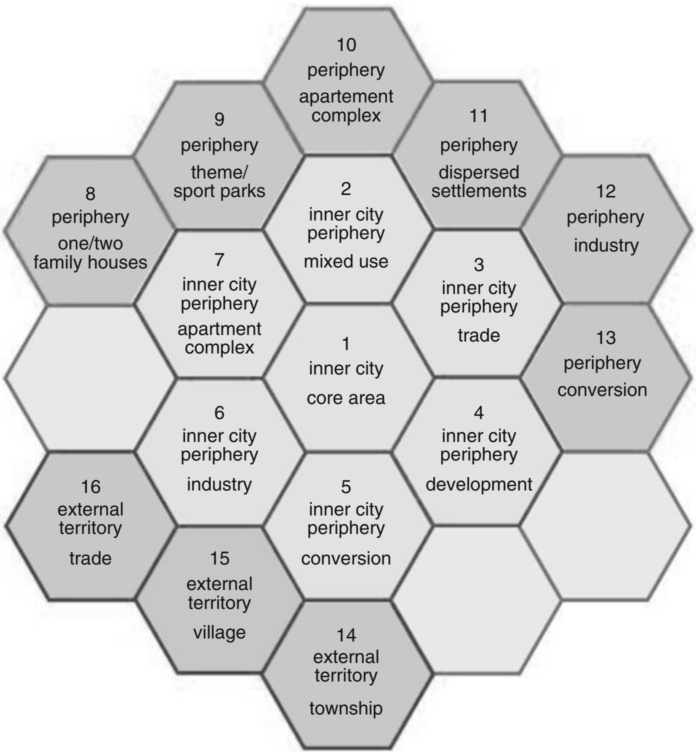


Fig. 3 City model "netWORKS" with sub-areas

Data and information were discussed, and feedback was given in expert meetings with representatives from the German partner cities: Bielefeld, Chemnitz, Cottbus, Essen, Hamburg and Schwerin.

4 Underlying Requirements for the Transformation of Existing Water Infrastructures

Implementing system innovations in existing water infrastructures (and its transformation) affords several considerations. First, the investments of existing infrastructures have to be considered. As much as possible, existing sewers (and facilities) are subject to conversion in order to reduce effort and costs of transformation and to be able to use existing components for other water-related purposes, depending on their state of repair and the quality of the drained wastewater stream (operation of wear).

Water and wastewater utilities should be consolidated and managed in one hand following a rising need for coordination within the water/wastewater sector and the overlapping responsibilities vis-à-vis other disciplines like waste and energy management (caused by increased differentiation of mass flows and reuse of water, energy and nutrients). When comparing the cost balance of the "transformation" and "reference" scenarios, it becomes obvious that "transformation" comprises more differentiated cost types (due to more differentiated water/wastewater streams) and greater varying amounts of specific costs for water supply and wastewater disposal than "reference" (cf. Felmeden et al. 2010). Cherry picking by third parties must be prevented, and losses (e.g. less drinking water demand) must be compensated by occurring returns (e.g. energy reuse).

The entire transformation of existing water infrastructures requires an adequate period of time (e.g. scenario horizon of 70 years) due to the long lifespan and depreciation times of the present water systems. Furthermore, a transformation of urban water infrastructures will not occur simultaneously in all sub-areas of a city, but there will be spatial and temporal differences (Kluge and Libbe 2010).

Due to the technological developments and more marketable solutions for domestic water infrastructure (e.g. efficient decentralized treatment plants or tap water cycles), comprehensive concepts on an urban level will be required considering domestic and municipal water infrastructure. A synchronization of municipal and domestic water infrastructure is an upcoming necessity, and water and wastewater utilities have the chance to either control this process or to lose control and to be driven by these specific developments at domestic level.

5 Eco-efficiency of a More Resilient Water Infrastructure System

So far, the potential of new water technologies is accepted mostly for green fields but is seen as controversial for built-up areas. To answer the question if a "transition" towards a more resilient water infrastructure in built-up areas is feasible (technically and economically), a balancing and assessment of the corresponding effects compared to the reference scenario, "business as usual", have been performed. Based on this assessment, the results of a participatory impact assessment were

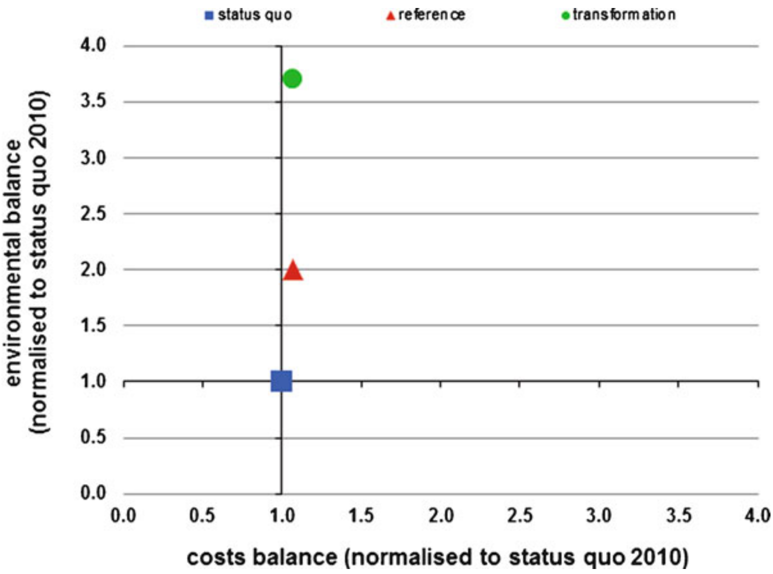


Fig. 4 Comparative eco-efficiency analysis (Figures and tables according to Kluge and Libbe 2010)

evaluated by applying the eco-efficiency analysis (Felmeden et al. 2010). Thereby, the environmental aspects (water, energy and operating materials) and the economic aspects (costs and revenues) get connected, and an integrated evaluation is carried out. Figure 4 outlines the eco-efficiency of "transformation" and "reference" shown within their normal framework as the initial state "status quo".

Taking a long-term period of observation (70 years), the costs balance of the scenarios "reference" and "transformation" are on a lower level compared to the "status quo", but both are still on a comparative level. By contrast, the consumption of environmental resources in the scenario "transformation" is almost twice as low as in the "reference".

The sensitivity analysis which has been undertaken shows that the results of costs comparisons regarding the "reference" and "transformation" scenario are relatively stable (cf. Felmeden et al. 2012).

6 Conclusion

According to the scenarios considered, a sustainable transition to more resilient water infrastructures is technically possible and economically feasible even in built-up areas. Thus, it is possible to overcome restrictions and path dependencies of existing static water infrastructure systems, and the resilience of cities will be improved as well.

A first big-scale realization has been accomplished by the city of Hamburg (Skambraks 2011). It is up to municipalities to realize further big-scale projects and thus achieve the transition towards more resilient water infrastructures in the long run.

Practical adaptation of urban water systems to changing context conditions does not only require a technical transformation of the system but also needs the experience and knowledge of community members to characterize pertinent conditions, community sensitivities, adaptive strategies and decision-making processes related to the adaptive capacity of the water system and the resilience of the urban system as a whole.

Further research is necessary regarding the specific requirements for such a transformation, taking into consideration the interfaces with city planning and other technical infrastructures.

References

ATT, BDEW, DBVW, VDGW, DWA, VKU. (2008). *Branchenbild der deutschen Wasserwirtschaft*. wvgw, Bonn.

Australian Prime Minister's Science Engineering and Innovation Council Working Group. (2007). *Water for our cities: Building resilience in a climate of uncertainty*. http://www.dest.gov.au/NR/rdonlyres/820A62AC-B373-4AD9-A7CA-1373D31A4283/17375/WaterforOurCitiesreport.pdf. Accessed 12 Jan 2011.

Bieker, S., Cornel, P., & Wagner, M. (2010). Semicentralised supply and treatment systems: Integrated infrastructure solutions for fast growing urban areas. *Water Science and Technology, 61*(11), 2905–2913.

Daigger, G. (2007). Wastewater management in the 21st century. *Journal of Environmental Engineering, 11*(7), 671–680.

de Graaf, R. (2009). *Innovations in urban water management to reduce the vulnerability of cities: Feasibility, case studies and governance*. Doctoral thesis, TU Den Haag.

DWA (Hrsg.). (2008). *Neuartige Sanitärsysteme*. Hennef: Themenband.

Felmeden, J., Kluge, T., Koziol, M., Libbe, J., Michel, B., & Scheele, U. (2010). *Öko-Effizienz kommunaler Wasser-Infrastrukturen. Bilanzierung und Bewertung bestehender und alternativer Systeme* (netWORKS-Papers Nr. 26). http://www.networks-group.de/veroeffentlichungen/index.phtml. Accessed 12 Jan 2011.

Felmeden, J., Michel, B., & Schramm, E. (2012). Assessment and evaluation of existing and alternative municipal water infrastructures. *Water Research* (in preparation).

Folke, C. (2006). Resilience: The emergence of a perspective of social-ecological systems analyses. *Global Environmental Change, 16*, 253–267.

Gunderson, L. H., & Holling, C. S. (Eds.). (2002). *Panarchy. Understanding transformations in human and natural systems*. Washington, DC: Island Press.

Hillenbrand, T., & Hiessl, H. (2006). Sich ändernde Planungsgrundlagen für Wasserinfrastruktursysteme. Teil 1: Klimawandel, demographischer Wandel, neue ökologische Anforderungen. *KA Abwasser Abfall, 53*(12), 1265–1271.

Kluge, T., & Libbe, J. (Hrsg.). (2010). *Transformations management für eine nachhaltige Wasserwirtschaft. Handreichung zur Realisierung neuartiger Infrastrukturlösungen im Bereich Wasser und Abwasser*. Berlin: Difu.

Kluge, T., & Schramm, E. (2012). *Wassermärkte der Zukunft: Systemische Innovationen – weltweit*. Oekom, München (forthcoming).

Merkel, W., Bräker, J., Rohn, A., & Staben, N. (2010). Technische Optionen und typische Einsatzbereiche (Datenblätter). In T. Kluge & J Libbe (Hrsg.), *Transformationsmanagement für eine nachhaltige Wasserwirtschaft*. Berlin: Difu.

Nowak, M., & Guenther, E. (2009, April 26–30). *Scenario planning: Managing the effects of demographic change on East German wastewater companies*. Paper presented at IHDP Open Meeting 2009 7th International Science Conference on the Human Dimensions of Global Environmental Change, Bonn, Germany.

Rygaard, M., Albrechtsen, H. J., & Binning, P. J. (2009). *Alternative water management and self-sufficient water supplies*. London: IWA-Publishing.

Schramm, E. (2010). Vom Abwasser zur Ressource. In T. Kluge & J. Libbe (Hrsg.), *Transformationsmanagement für eine nachhaltige Wasserwirtschaft. Handreichung zur Realisierung neuartiger Infrastrukturlösungen im Bereich Wasser und Abwasser*. Berlin: Difu.

Skambraks, A. K. (2011, May 22–25). *Hamburg water cycles in the settlement Jenfelder Au – Integrating the infrastructure services of water and energy*. Paper presented at the International Conference Cities of the Future – Sustainable Urban Planning and Water Management, Stockholm, Sweden.

Smith, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16*, 282–292.

Statistisches Bundesamt. (Hrsg.). (2009). Öffentliche Wasserversorgung und Abwasserbeseitigung 2007, Fachserie 19, Reihe 2.1. Wiesbaden.

Tukker, A., Charter, M., Vezzoli, C., Stø, E., & Munch Andersen, M. (Eds.). (2008). *System Innovation for Sustainability 1: Perspectives on Radical Change to Sustainable Consumption and Production*. Greenleaf Publishing, Sheffield

Wikramanayake, N., & Corea, E. J. H. (2003, June 23–26). Alternative technology for urban wastewater treatment: Case studies and issues of implementation and sustainability. In P. Bizier & P. DeBarry (Eds.), *Proceedings of the World Water and Environmental Resources Congress 2003*. American Society of Civil Engineers, Philadelphia, PA.

Wolf, M., & Störmer, E. (2010). Decentralisation of wastewater infrastructure in Eastern Germany. *Network Industries Quarterly, 12*(1), 7–10.

Building 'Equitable' Urban Resilience: The Challenge for Cities

Wendy Steele and Nidhi Mittal

Abstract Cities and their institutions are key players in building urban resilience to the risks posed by climate change. However, neoliberal policies further the transition from the state as the ultimate risk manager within urban settlements towards the private sector, households and individuals. Such shifts have significant justice and equity implications for climate change adaptation at the local level, particularly for the most vulnerable (i.e. children living in urban poverty). Drawing on examples from both developed and developing countries, the key challenges for building 'equitable' urban resilience through climate change adaptation measures at the metropolitan scale are highlighted.

Keywords Equity • Urban resilience • Cities • Children • Climate change adaptation

1 Introduction

More than half of the world's population now lives in cities. Within both the developed and developing country context, there are increasing calls for the need to re-think urban policies and planning practices to better create more resilient urban settlements (Newman et al. 2009). In this chapter, we purposively draw attention to the contemporary understandings of urban resilience within the context of climate change, with a critical focus on how questions of equity are being addressed in

W. Steele (✉)
Urban Research Program/Climate Change Response Program, Griffith University, 170 Kessels Road, Brisbane 4111, Australia
e-mail: w.steele@griffith.edu.au

N. Mittal
Humanitarian Policy Team, Save the Children UK, 1 St. Johns Lane, EC1M 4AR London, UK
e-mail: n.mittal@savethechildren.uk

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_20,

the quest for the 'climate-resilient city'. We argue for climate-resilient cities that enable adaptation for the most vulnerable and emphasize the role of democratic urban governance in driving this.

2 Urban Resilience: The Great Risk Shift

The convergence of rapid urbanization with anthropogenic climate change and the disproportionate effects of this on the urban poor and those most vulnerable have been emphasized extensively in both the academic literature and international policy reports (i.e. Bicknell et al. 2009; UN 2011). As the United Nations Global Report on Human Settlements *Cities and Climate Change* (2011) emphasizes, the more affluent in our society are less vulnerable, with the impacts of climate change felt most by the most marginalized groups which include (but are not limited to) the urban poor, children, women and the elderly. The disproportionate exposure to climate risk in urban areas by such vulnerable groups includes:

- Greater exposure to hazards (e.g. through living on flood plains or unstable slopes)
- Lack of risk-reducing housing and infrastructure (e.g. poor-quality housing, lack of drainage systems)
- Less adaptive capacity (e.g. lacking the income or assets that allow a move to better quality housing or less dangerous sites)
- Less state provision for assistance in the event of a disaster (e.g. needed emergency responses and support for rebuilding or repairing homes and livelihoods; indeed, state action may increase exposure to hazards by limiting access to safe sites for housing)
- Less legal and financial protection (e.g. a lack of legal tenure for housing sites, lack of insurance and disaster proof assets) (UN 2011, p. 24)

In line with the UN report, the need for dynamic urban processes, which include a redistribution and dispersal of power among actors within multi-level governance and institutional systems, has underpinned contemporary understandings of urban resilience (Adger 2003). Key questions driving the contemporary focus of the resilient city include: how might urban systems accommodate future shocks and crises in whatever (un) expected forms they might take? And how can we best prepare our cities to be 'resilient', to 'survive'? (Linovski 2010, p. 1). Central to the urban resilience and adaptation meta-narrative is the important counterpoint concept of *vulnerability* or the (in)capacity (through circumstance, networks and resources, etc.) to respond to, recover from or adapt to economic, ecological and social risk/stress (Kelly and Adger 2000). Reduced vulnerability and enhanced adaptive capacity (IPCC 2001) are the twin sides of enabling adaptation of urban systems exposed to the rising intensity of interrelated shocks and stresses.

Yet whilst vulnerability and adaptive capacity remain the necessary starting point for understanding urban resilience, there is increasingly an overemphasis on the need to build resilient cities as a homogenous whole—in terms of urban systems, planning practices, institutional regimes and financial systems—rather than considering the multifarious differences in human (and non-human) vulnerability. Most recently at the international level, urban resilience has been re-cast and offered as an economic and performance model, one that focuses on the reliability and efficiency of urban performance in response to climate change through a focus on private investment, demand-driven strategies, policy mainstreaming and local resilience upgrading (ICLEI 2011). If, as the white paper suggests, the ‘how to’ of urban resilience is as important as the ‘how much’, then the details of this process need careful attention and consideration. For whom and for what does the contemporary ‘resilient cities’ agenda serve as the policy emphasis shifts from risk to opportunity? Can we simply overlay resilience onto existing inequities in the urban response to climate change? The danger, as Stilwell (1993, p. 36) cautions, is that ‘the economic is hard-headed: the social is soft-hearted . . . and social justice is achievable at an economic cost which we cannot typically afford’.

Urban history has demonstrated that metropolitan policies and plans have often served to compound rather than improve conditions of poverty and inequity. In both developed and developing countries, the shift away from the welfare state model that characterized the post-war era and the pursuit of privatization, contracting out, deregulation, market-based solutions, downsizing and cost cutting has led to a strong politico-administrative emphasis on so-called economic efficiencies. Urban policy and planning re-badged as a ‘strategic enabler’, rather than provider, increasingly operates within a de-regulated governance framework. This style of planning rests on promoting rather than restricting entrepreneurial activity and development that largely serves to support market-led prosperity. Often this involves increased processes of *symbolic inclusion*, but the reality is *material exclusion* for those most marginalized (Miraftab 2004).

There has been a great risk shift from the state as the ultimate risk manager towards the private sector, households and individuals (Hacker 2006; Steele and Gleeson 2011). Institutional reform, in concert with technological and political change, has given status and influence to complex public–private partnerships and interests especially in the field of infrastructure and urban management systems. These shifts have significant justice and equity implications for climate change adaptation at the metropolitan level and combine to inhibit local government resilience and capacity building particularly for those most vulnerable. To illustrate this shift, we turn now to examples from both the developed and developing countries and highlight the dangers of adaptation that romanticizes cities whilst ignoring the multitude of currently existing inequities (and in some cases horrors), particularly for children.

3 Cities and Climate Change: Sadder, Meaner, Angrier?

We have entered what some are describing as 'The Age of the Anthropocene', defined by the impact of *homo urbanis* on the planet that will endure long after our cities disappear (Kolbert 2011). This level of urbanization has developed at an unprecedented scale, with many cities experiencing rapid population and development growth. This poses a number of challenges to cities and their communities including growing conditions of urban poverty amidst increased levels of affluence, high rates of homelessness and burgeoning slum areas (GRNUHE 2010). Nearly 62% of urban areas in sub-Saharan Africa have slum populations. Such urban 'landscapes of despair' (see Dear and Wolch 1987), underwritten by economic marginalization and political invisibility, are too often met with policy, planning and disciplinary silence. To overlay 'urban resilience' on already existing inequities raises important questions around for whom and for what this adaptation activity serves.

For example, in Australia nearly 70% of the population lives in the five largest cities located on the vulnerable coastline. The highly concentrated nature of the urban population in Australia, coupled with the relatively fixed nature of much of the metropolitan built form, serves to magnify climate-related risks and vulnerabilities from extreme weather and natural disasters (i.e. sea level rise, heat waves and drought). As Glaeser (2011, p. 1) points out, 'on a planet with vast amounts of space, we choose cities . . . the city has triumphed'. But what sort of cities have emerged? Who are the winners and who are the losers within these carbon-intensive urban settlements in the face of climate change?

Since the 1980s, Australian cities have experienced waves of micro-economic reform that have given new status and influence to private interests in urban public policy and services. The outcome has been an increasing emphasis on growth over sustainability, shareholders/stakeholders rather than citizens, velocity over quality and economic efficiency over equity (Steele and Gleeson 2010). There is a clear social gradient to climate policy and urban resilience planning whereby the poor do not have ready access to climate change adaptation measures or schemes. At the individual level, green consumption has been urged, and households are encouraged to make their housing secure and independent through water and energy improvements at the dwelling/site level. But change at this level is reliant on homeowners with the upfront financial capacity to build expensive eco-design houses or fully engage in the green initiative rebate schemes (i.e. solar) (Steele and Gleeson 2011). At the collective level, urban policies continue to support and promote car-dependent cities despite the rhetoric around achieving urban resilience through low-carbon urban futures. The VAMPIRE index (see Dodson and Sipe 2008) spatially mapped oil and mortgage vulnerability in Australian cities and highlights 'a highly regressive pattern in which the impacts of higher fuel costs and increased interest rates fall on those with the least capacity to absorb them' (p. 1).

The implications of the great risk shift have become particularly acute in cities facing high levels of growth, outdated infrastructure and diminishing resources in the face of climate change. Australia's largest cities have been described as 'sadder, meaner and angrier places to live . . . under siege from higher house prices, to mortgages, electricity prices, toll roads, congestion . . . collapsing in on themselves' (Irvine 2011, p. 1). The great risk shift transcends national and international boundaries. In cities in India, the poor are facing the brunt of inflated and unaffordable land markets, being pushed to the margins of the city and leading lives fraught with environmental hazards (Mittal 2010).

Amidst these changes, there are dangers in romanticizing the adaptive capacity of 'resilient cities' whilst ignoring the multitude of currently existing urban inequities (and in some cases horrors), particularly for vulnerable groups such as the urban poor and children. Despite the grandiose and 'triumphant' image of cities as hubs of education, employment and prosperity, children continue to constitute some of the world's most vulnerable populations exposed to life-threatening environments (Baker 2009).

4 Cities and Children

Half of the world's population—nearly 3.2 billion people—live in cities (Bicknell et al. 2009). By 2030, it is predicted that 60% of all urban dwellers will be below the age of 18 (Haub 2009). Climate change is increasingly being acknowledged as an important driver of displacement and migration of natural resource-dependent rural populations in cities in low- and middle-income countries like Indonesia, Vietnam and India (Barrios et al. 2006). Children constitute nearly half of those who are affected by climate-related disasters and displaced to urban areas (Reale 2008). Many of these children mix with urban poor populations and reside in informal settlements in serious poverty conditions, often in unsafe locations such as low-lying flood plains, hillsides, unstable marshy slopes, near rubbish dumps and along open drains. Despite such unacceptable living conditions for the vulnerable and marginalized populations, urban governments are currently either unwilling or unable to provide basic services or support for them to lead a fulfilling and normal life in the following key ways:

4.1 Health and Survival Threats

The urban life of climate-displaced children is fraught with a multitude of health and survival risks, many of which are shared with urban poor children as a whole. The majority of the urban poor children live in unhygienic conditions, lacking access to services such as health care, safe and adequate water and sanitation, drainage and waste management. Only 40% of the children from urban poor households in India receive vaccinations, and almost half are underweight for their age. The inherent lack of immunity due to poor nutrition, coupled with infrastructural inadequacies like clogged drainage systems in urban settlements, means that migrant children may also be at a much greater risk from preventable diseases and vector-borne infections like diarrhoea, malaria and dengue (Bartlett 2008).

4.2 Education and Learning Barriers

Climate-displaced children in cities may also confront an erosion of learning and growth opportunities. The *urban advantage* may be misplaced due to the interruption of school for children for long extended periods and the failure to complete or even start primary education. Research shows that the poorest children in slums are less likely to be in school, with the lack of an official residency status or inability to produce mandatory documents such as birth certificates working against them (Giani 2006).

4.3 Vulnerability to Abuse and Exploitation

As displaced children in cities struggle to make their ends meet or support families, they may be exposed to exploitative work conditions as child labourers, working in factories or doing odd jobs as seen in cities like Dhaka in Bangladesh or Durban in South Africa (Reale 2008). The lack of provision for privacy around washing, dressing or sleep makes girls, especially adolescents, easier targets for sexual harassment, violence and abuse of various kinds. They may also face gender discrimination and be engaged in sex work, directly or indirectly in the entertainment industry such as in the Mekong Delta region (ibid.).

4.4 Climate Change Risks in Cities

Predictably, the populations most at risk from climate change in cities will be the urban poor, and among them, the most vulnerable groups are children who have the least coping capacities. This existing urban condition is exacerbated by several factors: the low priority given to urban poverty, compared to rural poverty, by most development organizations and donor agencies; weak research and evidence base of impacts and vulnerabilities of climate change on the most vulnerable groups in the city; lack of political will to integrate the poor into the city fabric; poorly resourced local governments and short and narrow political horizons, which inhibit long-term planning and proactive climate change adaptation actions (Satterthwaite 2008). Within the context of the great risk shift outlined above, urban risk rather than resilience continues to define the lives of urban poor children.

5 Lifeboat Cities: Putting the Equity Back into Urban Resilience

Questions of equity lie at the very heart of urban resilience. With the heightened severity, frequency and duration of climate change-related events, such as increased incidence of flooding in the low-lying urban settlements, the urban poor—particularly children—are most at risk. Whilst every city context is different and will have 'different needs for incorporating marginalized groups into resilience planning' (Tyler et al. 2010, p. viii), the recognition of the existing (in)capacity of cities to address the needs of the most vulnerable and marginalized in the community must be a crucial first step.

Urban areas with weak governance systems—as a result of political instability, exclusion of climate change from the political agenda or lack of governmental resources—are especially constrained in their capacity to address the needs of those most vulnerable, such as children, to climate change impacts (UN 2011, p. 25). The risk shift from the state as the ultimate risk manager within urban settlements towards the private sector, households and individuals has resulted in varying degrees of urban splintering and spatial segregation in the quest for investment efficiency and increasingly privatized performance.

But what is the alternative? It is increasingly recognized that local authorities lack the money to provide basic services, and the international financial resources available are simply not sufficient to meet urban requirements. The UN report on *Cities and Climate Change* (2011) makes clear that addressing the democratic deficit that underpins urban resilience demands fundamental changes in how urban areas operate in order to 'foster closer coordination between local governments and local economic institutions, and build new connections between central power structures and parts of the population who have often been kept outside of the circle' (p. 49). Cities tend to be 'vital crucibles of power' (Merrifield and Swyngedouw 1996, p. 13), and such power imbalances that perpetuate environmental injustice in the city need to be challenged and addressed (Mittal 2010).

A more fundamental connection and resilience pathway is advocated by Gleeson (2010) in *Lifeboat Cities* who argues for the need for an 'ethic of care' as a prerequisite to achieving urban equity. This involves a fundamental shift 'of collective ambition away from mindless, endless growth and towards a new dispensation favouring solidarity, care and natural renewal' (p. 7). Central to this thinking is the need to subordinate the economy to human needs and natures balance; produce to sustain, not to enrich; and foster values of care, repair and renewal, not accumulation and consumption. Specifically, this involves values such as:

- *Justice* (meaning equity, not just the rule of law)
- *Modesty* (meaning restraint as the natural safeguard of civilization)
- *Solidarity* (meaning the recognition and nurturing of human interdependence)

Nowhere is this more evident than in the world's climate constrained cities where, as Gleeson argues, 'among the ranks of the vulnerable it is surely children and young people who are most exposed' (p. 42). The societal shift needed to achieve urban resilience is focused on the transition from conditions of urban complacency towards an ethic of urban renewal and care. As momentum around the 'climate-resilient city' builds, it is timely to reflect on for whose interests, and for what purposes, the policies and practices around urban resilience and adaptation seek to serve. It is imperative that the most affected constituents of the city population be recognized as active agents in carving the future of resilient cities and not be relegated to being passive victims of unjust city processes.

6 Conclusion

Cities are human systems first and built environments second (Steele and Gleeson 2010). Recognition of the plight of the most vulnerable groups and communities (human and non-human) must lead, not follow, urban resilience. A prerequisite to fair and just climate change adaptation at the metropolitan scale is a commitment to equity first—not last—within resilient city policies and planning practices. As outlined in this chapter, the current plight of the urban poor and children in both developed and developing countries is but one illustration of the very real and immediate need to put questions of justice, fairness and equity at the forefront of the burgeoning urban resilience agenda.

References

Adger, N. (2003). Building resilience to promote sustainability: An agenda for coping with globalisation and justice. *International Human Dimensions Program on Global Environmental Change (IHDP), 2*, 1–4.

Baker, L. (2009). *Feeling the heat*. London: Save the Children, UK.

Barrios, S., Bertinelli, L., & Strobl, E. (2006). *Climatic change and rural-urban migration: The case of Sub-Saharan Africa* (Core Discussion Paper). Belgium: European Commission.

Bartlett, S. (2008). The implications of climate change for children in lower-income countries. *Children, Youth and Environments, 18*(1), 71–98.

Bicknell, J., Dodman, D., & Satterthwaite, D. (Eds.). (2009). *Adapting cities to climate change: Understanding and addressing the development challenges*. Sterling: Earthscan.

Dear, M., & Wolch, J. (1987). *Landscapes of despair: From deinstitutionalization to homelessness*. Princeton: University Press.

Dodson, J., & Sipe, N. (2008). *Unsettling suburbia: The new landscape of oil and mortgage vulnerability in Australian cities*. Brisbane: Urban Research Program Griffith University.

Giani, L. (2006). *Migration and education: Child migrants in Bangladesh* (Sussex Migration Working Paper 33). East Sussex: Sussex Centre for Migration Research.

Glaeser, E. (2011). *Triumph of the city*. London: Macmillan.

Gleeson, B. (2010). *Lifeboat cities*. Sydney: UNSW Press.

GRNUHE. (2010). *Improving urban health equity through action on the social and environmental determinants of health*. London: Global Research Network on Improving Health Equity.

Hacker, J. (2006). *The great risk shift*. Oxford: Oxford University Press.

Haub, C. (2009). *Demographic trends and their humanitarian impacts*. Medford: Feinstein International Famine Centre, Tufts University.

ICLEI. (2011). *Financing the resilient city: A demand driven approach to development, disaster risk reduction and climate adaptation – An ICLEI White Paper*. Bonn: ICLEI Global Report.

IPCC. (2001). *IPCC third assessment report: Climate change 2001*. Cambridge: Cambridge University Press. Accessed at http://www.ipcc.ch/ipccreports/far/wg_II/ipcc_far_wg_II_full_report.pdf

Irvine, J. (2011). Sydney is a sadder, meaner angrier city. *Sydney Morning Herald*. http://www.smh.com.au/opinion/politics. Accessed 22 June 2011.

Kelly, P., & Adger, W. (2000). Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change, 47*, 325–352.

Kolbert, E. (2011). Enter the Anthropocene – Age of man. *National Geographic*. http://ngm.nationalgeographic.com/2011/03/age-of-man/kolbert-text. Accessed 22 June 2011.

Linovski, O. (2010). Editorial – Planning for resilience. *Critical Planning, 17*, 5–7.

Merrifield, A., & Swyngedouw, E. (1996). *The urbanization of injustice*. London: Lawrence & Wishart Ltd.

Miraftab, F. (2004). Making neo-liberal governance: The disempowering work of empowerment. *International Planning Studies, 9*(4), 239–259.

Mittal, N. (2010). *Collective strategic action in access to water and sanitation services for environmental justice: The case of MPUSP in Bhopal, India*. A dissertation submitted in partial fulfilment of the requirements for the MSc. Environment and Sustainable Development, Development Planning Unit, University College London, London.

Newman, P., Beatley, T., & Boyer, H. (2009). *Resilient cities – Responding to peak oil and climate change*. Washington, DC: Island Press.

Reale, D. (2008). *Away from home: Protecting and supporting children on the move*. London: Save the Children, UK.

Satterthwaite, D. (2008). *Climate change and urbanization: Effects and implications for urban governance*, UN Expert Group Meeting on Population Distribution, Urbanization, Internal Migration and Development. New York: IIED.

Steele, W., & Gleeson, B. (2010). Mind the governance gap: Oil vulnerability and urban resilience in Australian cities. *Australian Planner, 47*(4), 302–310.

Steele, W., & Gleeson, B. (2011). The great risk shift: The securitization of Australian housing. *Housing Studies, 26*(2), 235–250.

Stilwell, F. (1993). Economic rationalism: Sound foundations for policy? In S. Rees, G. Rodley, & F. Stilwell (Eds.), *Beyond the market: Alternatives to economic rationalism*. Sydney: Pluto Press.

Tyler, S., Reed, S., MacClune, K., & Chopde, S. (2010). *Planning for urban climate resilience: Framework and examples from the Asian cities climate change resilience network.* Boulder: ISET Working Paper.

UN. (2011). *Cities and climate change: Policy directions.* Global Report on Human Settlements 2011. United Nations Human Settlements Program. London: Earthscan.

Climate Change and the Urban Poor: Support of the German Development Cooperation to a City in Bangladesh

Peter Rooney, Christian Schönhofen, Alexander Jachnow, Ishtiuq Hossain, Carmen Vogt, and Alexandra Linden

Abstract In Bangladesh, the cities, as the main centres of growth, have to respond to both the challenges of climate change and urban poverty in the context of rapid urbanization. Metropolitan authorities however have only limited personnel, technical and financial capacity for this task. In Khulna, Bangladesh's third largest city, the existing transportation infrastructure needs to be expanded to meet future needs and to feed into the concept of inclusive city growth. The city's low-lying position along the Rupsha river means it has to deal with increasing incidences of flooding and waterlogging of whole city districts. Furthermore, the influx of poor

P. Rooney (✉) • C. Schönhofen
Sector Team Transport and Communication, Asia, KfW Development Bank, Palmengartenstr 5-9, 60325 Frankfurt am Main, Germany
e-mail: peter.rooney@kfw.de; christian.schoenhofen@kfw.de

A. Jachnow
Good Urban Governance Principal Advisor, German Development Cooperation (GIZ), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, P.O. Box 6091, Road 90, House 10A, Gulshan 2, Dhaka 1212, Bangladesh
e-mail: alexander.jachnow@giz.de

I. Hossain
Good Urban Governance Advisor, German Development Cooperation (GIZ), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, P.O. Box 6091, Road 90, House 10A, Gulshan 2, Dhaka 1212, Bangladesh
e-mail: ishtiuq.hossain@giz.de

C. Vogt
Division of Planning and Development/State and Democracy, German Development Cooperation (GIZ), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Postfach 5180, 65726 Eschborn, Germany
e-mail: carmen.vogt@giz.de

A. Linden
Division 313 – Water, Energy, Urban Development, Geoscience Sector, Federal Ministry for Economic Cooperation and Development (BMZ), Dahlmannstr. 4, 53113 Bonn, Germany
e-mail: alexandra.linden@bmz.bund.de; alexandra.linden1@giz.de

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_21,

from rural areas is leading to an increase in the size and number of slum settlements in the city. The German government has started to work with the city to address these issues, with the aim of sustainably improving the living conditions of the urban population via crucial infrastructure investments and municipal governance reform. In addition to providing technical assistance to the municipality, the German government is planning a major € 10.5 million investment in transport infrastructure through KfW Development Bank (German Financial Cooperation). This chapter illustrates how climate- and poverty-related aspects such as flood protection, road and pedestrian safety and slum access schemes can be integrated within an urban infrastructure development and management approach.

Keywords Climate change • Poverty • Infrastructure investments • Local governance reform • Flood protection • Neighbourhood access • Urban mobility • Pedestrian and traffic safety

1 Problem Analysis

At present, more than 50% of the world's population live in urban areas with an additional increase to 56% expected over the next two decades. Around 98% of the projected global population growth will occur in developing countries (UN-Habitat 2002) and hence is likely to contribute to unplanned urbanization, poverty and the urban resource gap. Meanwhile, local government's role is moving away from direct service provision to coordinating, regulating, monitoring and supporting the private sector (Westfall and de Villa 2001). Bangladesh has a population of more than 150 million, a third of those living in urban areas. With an annual national population growth of approximately 1.5%, the urban population expands at a rate twice as fast. The majority of urban areas have been rapidly growing without proper planning and management. The capabilities of most urban local bodies to provide basic services and a healthy urban environment have not developed in parallel with the pace of urbanization. Though cities contribute directly to the overall economic growth with over 40% of the country's GDP (UGIIP 2002), urban Bangladesh faces severe challenges with regard to the provision of infrastructure and efficient poverty reduction.

Most evidently, urban infrastructure cannot keep pace with urban expansion. Existing drainage, sewerage and public transport systems designed for much smaller capacities are now struggling to fulfil their functions. Figures show that around three-quarters of the urban households accommodate themselves in crowded temporary houses in unplanned informal settlements, often bereft of basic urban services. Over six million people in urban areas remain without access to safe water (UGIIP 2000). Lack of transport infrastructure and facilities is common. Insufficient public services contribute to the vicious cycle of social and economic disempowerment arising out of increasing income inequalities in urban areas.

Existing challenges to city planners are aggravated by the pressing issue of climate change. Bangladesh is considered one of the countries most adversely affected by climate change due to its vast lowlands, the hydrological influence by erratic monsoon rainfalls, as well as high population density, and the lack of institutional capacity. In the recent past, the country has experienced a rise in sea level and increased temperatures. It is predicted that average sea levels may rise by approximately 30 cm by 2050 and hence could elevate flood vulnerability for an additional 14% of the land.

The coastal belt of Bangladesh is known as a zone of vulnerabilities as well as opportunities. Whereas the land is very fertile and there are in principle good possibilities for trading via land and sea, the coastal region is also exposed to a number of climatic effects (rising sea levels, typhoons, river flooding and waterlogging). Khulna, located in the southwest of the coastal belt, is the third largest city in Bangladesh. The city is framed by two big rivers, Rupsha and Bhairab, and in a 50 km distance of the Mongla seaport. In terms of infrastructure development, the most urgent investment needs are identified as improving drainage and transport. Though having a history of being an important industrial and trade centre, around 32% of the 1.4 million population (2007) is classified as poor in Khulna, a higher share than Dhaka and Chittagong. A significant wave of poor climate migrants add constantly to the current 189,000 slum dwellers who reside in roughly 520 slums in the city.

2 Urban Vulnerability in Khulna

Given the country's vulnerability to climate impacts in general and its rapidly growing share of harshly affected poor people, environmental threats are currently the most pressing development concerns in Bangladesh. Recent socio-economic surveys in Khulna indicate that in the past 10 years, an estimated 98% of the population have been affected by climate-induced disasters. The increase in salinity in the Khulna area poses another harsh challenge for the sustainable development of the city: crop yield reduces and food prices elevate, threatening the city's food security.

In general terms, regular flooding cripples the transport system, renders roads and footpaths unsafe and results in substantial financial and economic costs for households, the public and private sector. Such losses include the damage to infrastructure and property and increased costs for transport and health.

As the poor tend to live on marginal land, they are most vulnerable to the impacts of rising sea level and flooding. Floods and waterlogging severely restrict local economic activities in open market areas and poorly accessible settlements during the monsoon season. These events are expected to swell in frequency and intensity over the coming years, further hampering income generation and commercial operation for this vulnerable population group.

The Khulna City Corporation (KCC) is the urban local government institution responsible for the operation and maintenance of municipal services for its citizens. Its limited resources and the increasing demand due to a growing population have made it difficult for KCC to deliver services at a satisfactory level to the citizens, especially to the urban poor. As a result, KCC requires support for investing into physical and technical infrastructure development.

In addition, KCC has a pressing need for technical support to help develop its institutional capacity, especially in the area of urban governance. This includes improved administrative management capacity and accountability, financial management, operation and maintenance of public infrastructure and utilities, as well as involvement of city dwellers and various stakeholders in the process of planning and projects implementation.

3 German Development Assistance in Context of the Government of Bangladesh Poverty Reduction Strategy Paper

In accordance with the Government of Bangladesh Poverty Reduction Strategy, the German Ministry of Economic Development and Development (BMZ) supports long-lasting and sustainable improvement of urban infrastructure and service delivery in a manner strongly linked to citizen participation and governance reform. This includes technical support in the fields of proper planning, tax enforcement and private sector participation. Further, following a specific request for financial support from KCC, BMZ is planning to support infrastructure improvements in the city, which go some way towards addressing the city's needs regarding climate adaptation and poverty alleviation.

Generally, sustainability requires concerted coordination between and active involvement of all stakeholders – in this case, city administration, civil society, business sector and especially poor and marginalized groups.

4 German Financial Cooperation in Khulna

The German Development Cooperation is supporting KCC to strengthen the resilience of Khulna City through a financial grant of EUR 10.5 million via the German Financial Cooperation (KfW). The grant will be used to improve Khulna's transport infrastructure resilience regarding climate change and alleviating urban poverty. The assistance feeds as co-financing into the framework of the larger City Region Development Project (CRDP) which incorporates a wide range of infrastructure improvements in the Dhaka and Khulna City regions. Apart from the KfW assistance, the CRDP project is supported through a USD 120 million loan from the Asian Development Bank (ADB) and USD 50 million from the Government of Bangladesh. Out of these funds, USD 24 million are already planned to be used for essential improvements to the Khulna City drainage network. The FZ investment in transport infrastructure complements these works.

A multi-sector study from 2009 commissioned by KCC and carried out by the Cities Development Initiative for Asia (CDIA) was a starting point for the CRDP. CDIA is a regional multi-donor programme established by BMZ and ADB to promote sustainable and pro-poor urban development in medium-sized Asian cities.

Ahead of the KfW project appraisal, a second CDIA study was carried out in 2011 which further developed ideas for transport sector investments, taking into particular consideration their contribution to climate change adaptation and to improving the situation of urban poor.

All infrastructure investments of KfW and ADB in the CRDP are planned hand in hand with CRDP-funded technical assistance. New infrastructure will be tied to efficiency improvements in the municipal tax collection system.

Generally, the larger urban road network in Khulna is well built, but the minor connections to poor areas are often missing or are in terrible condition. Local mobility is further hampered by a lack of organized public local transport. The conflicting use of the roads by motorized and non-motorized road users in combination with minimal pedestrian walkways or footpaths leads to frequent traffic accidents. During the monsoon season, the transport infrastructure suffers from flooding, and its effectiveness is restricted. Transport along and across the river is also hampered by the very rudimentary docking points for boats. For commuters, negotiating the narrow and shaky ferry piers every day is a time-consuming and nerve-wracking experience.

The measures to be financed by KfW, which are based on the second CDIA study recommendations, seek to address both the above specific transport infrastructure weaknesses and the wider urban climate and poverty issues. In this case, integrating “hard” infrastructure investment with wider development aspects has been achieved without distorting or overcomplicating the overall project design. The measures include:

- Improvement/rehabilitation of strategic roads within the Khulna City
- Improvement of roads in their function as flood protection dams along the Rupsha river, including raising of road embankment levels in areas susceptible to overtopping
- Measures to encourage public transport (town buses and passenger boats across the Rupsha), including optimization of bus terminals, river boat landing jetties, improvement of pedestrian access to bus stations and improvements to traffic management systems
- Measures to support non-motorized transport (e.g. through separation of rickshaw lanes from other traffic, construction of footpaths and pedestrian areas)
- Transport connection of poor areas and slums to the city road network
- Road safety measures, in particular at accident black spots (e.g. through improved signalling, lane guidance, road alignment, reflectors or speed reduction measures)

5 German Technical Cooperation in Khulna

Since 2008, the German Technical Cooperation (GIZ) supports, on behalf of the BMZ, capacity development measures for urban governments within a TC/FC project of the Government of Bangladesh and Financial Cooperation of KfW and

ADB. In addition, technical support to Khulna has started with the provision of experts and advisory services for KCC. GIZ engages in the capacity development of key actors in the KCC and also supports Khulna University in further developing local knowledge on resilience strategies and urban development.

In order to respond to climate change and foster pro-poor development, GIZ focuses on wider capacity development and institutional strengthening for KCC in supporting the coordination between KCC and other local agencies, such as the Khulna Development Authority (KDA), and in other thematic issues, such as health care and sustainable energy development. Furthermore, GIZ supported Khulna in developing concepts for strategic urban development including improved service delivery and urban management.

6 Results

The expected results of the cooperation between the City of Khulna and the German Development Corporation are that in the face of climate change, the general living conditions in the city and in particular those of the urban poor have been improved. This is currently exercised via exemplary investments in transport infrastructure at a number of strategic points, robust against extreme weather conditions and fostering mobility and access to the city for the urban poor. By accompanying infrastructure investments with necessary complementary technical assistance to improve urban governance, KCC will be enabled to plan, construct and maintain its infrastructure in an inclusive manner in the future.

7 Conclusions

German development assistance to Khulna includes both technical and financial support. While GIZ is providing additional institutional development support, KfW is working together with the ADB and the Bangladesh Government in an integrated approach to sustainably improve the urban infrastructure. KfWs measures focus on the transport infrastructure of the city but will also bring about tangible improvements to the urban poor and the city’s climate resilience. There is a danger that development projects lose their focus and effectiveness if they are overloaded with too many wider agendas. Here, however, poverty and climate change components could be comfortably integrated into an urban development project, by concentrating on realistic, project-related measures. It is this “keeping it simple” approach that may be the best guarantee for success.

References

CDIA. (June 2011). *CDRP sub-project: Pro-poor and green urban transport in Khulna*, Report.

UN-Habitat. (2002). *Cities without slums*. World Urban Forum, http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=1751. Accessed 28 Dec 2010.

Urban Governance and Infrastructure Improvement Project (UGIIP). (2000). *Project document*. Dhaka: Internal Report Local Government Engineering Department (unpublished).

Urban Governance and Infrastructure Improvement Project (UGIIP). (2002). *Report and recommendation of the president to the board of directories on a proposed loan and technical assistance grant to the People's Republic of Bangladesh for the Urban Governance and Infrastructure Improvement (Sector) Project (UGIIP)*, RRP: BAN 29041, Dhaka: Asian Development Bank.

Westfall, M. S., & de Villa, V. A. (2001). *Urban indicator for managing cities*. Manila: Asian Development Bank.

The Green Infrastructure Transect: An Organizational Framework for Mainstreaming Adaptation Planning Policies

Yaser Abunnasr and Elisabeth M. Hamin

Abstract When considering the range of spatial planning actions that cities can take to adapt to climate change, many of them fall under the conceptual umbrella of green infrastructure (GI). GI has been defined as the spatial planning of landscape systems at multiple scales and within varying contexts to provide open space, safeguard natural systems, protect agricultural lands, and ensure ecological integrity for cultural, social, and ecosystem benefits (Benedict and McMahon, Renew Resour J 20:12–17, 2002, Green infrastructure: linking landscape and communities. Island Press, Washington, DC, 2006; Ahern, Cities of the future. IWA Publishing, London, 2008). While the traditional definition of GI refers to areas of land that are least intervened by human action, in this expanded definition, we are deliberately including areas that are engineered to mimic natural processes and which provide cost-effective ecosystem services.

Although climate adaptation is a fairly new policy goal for GI (Gill et al., Built Environ 33(1):115–133, 2007; CCAP, http://www.ccap.org/docs/resources/989/Green_Infrastructure_FINAL.pdf, 2011), three key characteristics qualify GI as a suitable tool for adaptation planning including multifunctionality (to match ecosystem benefits with adaptation needs), multi-scalar nature of the spatial elements, and a 'no-regrets approach'. However, GI needs to be matched to the character of the urban environment and coordinated across jurisdictions and planning scales to become an effective adaptation policy. In this chapter, we present a policy framework, the green infrastructure transect, that can help planners and

Y. Abunnasr (✉)
Department of Landscape Design and Ecosystem Management, American University of Beirut, Bliss Street, P.O. Box 110236, Beirut, Lebanon

Y. Abunnasr • E.M. Hamin
Department of Landscape Architecture and Regional Planning, University of Massachusetts Amherst, 109 Hills North, 01003 Amherst, MA, USA
e-mail: ya20@aub.edu.lb; yabunnas@gmail.com; mhamin@umass.edu

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_22,

policymakers identify appropriate GI policies for different urban environments and describe how these policies can create a regional adaptation planning framework.

Keywords Adaptation planning • Green infrastructure • Resilience • Urban regions • Urban and regional planning

1 Introduction

One of the primary principles of green infrastructure (GI) planning is to reconnect communities in urban regions to natural environments (Lewis 1964; McHarg 1969; Noss and Harris 1986; Benedict and McMahon 2002, 2006; Jongman 1995; Jongman et al. 2004; Fábos 2004). This is achieved through practices within and around cities that identify, protect, and create spatial elements that provide ecosystem services that communities depend on (Benedict and McMahon 2006; Forman 2008). Development of community parks and recreation trails, greenways, ecological networks, restored streams, natural reserves, gardens, engineered natural systems, green roofs and facades, and conserved agricultural land are all within the scope of GI. Furthermore, the same spatial areas also provide urban cooling, storm water management, flood water storage, flora and fauna habitat, and biking and walking routes. All of these urban functions must be increased to build resilience to climate change. By connecting ecosystem benefits to community well-being (Nassauer 2006) and adaptation needs, GI planning may be mainstreamed to become an integral part of adaptation planning policies.

A key advantage of the GI approach to adaptation is that it is already becoming an accepted practice (Benedict and McMahon 2002; Ahern 2008). GI has become part of current sustainable planning and design practices in many cities (EPA 2011; Newman and Jennings 2008; Farr 2008). These initiatives function at multiple scales to improve urban living conditions. These may include retention ponds and swales (at the parcel scale), green streets and parks (at the neighbourhood scale), increased tree canopies (at the urban scale), and greenways (at the regional scale). As an accepted practice, GI is also a 'no-regrets approach' (Bedsworth and Hanak 2010) when considered as an adaptation measure. As we move into the future, investment in GI policies will prove to be beneficial regardless of whether climate change scenarios materialize. For example, urban greening results in cleaner air and cooler temperatures that would address current problems (pollution and urban island heat effect) as well as ameliorate future increasing temperatures. As a result, fairly minor changes to the technical specifications for GI could, quite effectively, bring adaptation into mainstream practice. As GI is implemented to accommodate increased flooding, ameliorate rising temperatures, or address the rise in sea levels, communities can take advantage of the cultural, social, and health benefits of cleaner and greener environments, regardless of the future magnitude of climate change impacts.

Furthermore, the same characteristics that qualify GI as a spatial adaptation tool within urban regions (notably GI's multifunctional and multi-scalar properties) make it difficult to mainstream GI into adaptation planning. These characteristics create problems in organizing intervention areas, jurisdictional coordination and implementation, and trade-offs in economic benefits and urban quality.

2 The Green Infrastructure Transect

To address these problems, we propose the green infrastructure transect (GI transect) as a framework to utilize GI as an adaptation policy and to mainstream adaptation into current planning practices. The GI transect is a conceptual tool that integrates GI measures across varying urban contexts and across planning scales. It builds on transect concepts from ecology, landscape planning, and urban planning.[1] We specifically use the urban transect as a stepping stone to develop this framework.

The urban transect (Duany and Talen 2002) was devised as an urban planning tool to plan and design physical environments according to peoples' preferences of where to live and work. The urban transect identifies six zones (urban core, urban centre, general urban, suburban, rural, and natural) with distinct physical boundaries as units of study. These zones form a planning model applicable within many urban contexts. The zones provide the basis for a neighbourhood structure based on walkable streets, mix of uses, transportation options, and traditional architectural styles and housing diversity. The strength of the urban transect is in describing the appropriate built forms and identifying interventions within each urban zone in a simple and comprehensible manner. The concept falls short of specifying the respective open spaces and natural functions that respond to the specific urban contexts and needs within each transect zone.

In contrast, the natural transect used by ecologists and biologists is a scientific method of assessment of habitat. It is based on the fundamental principles of relationships and interdependencies between ecozones and used to assess the physical, biological, and natural processes within and across ecozones. Contrary to the urban transect, it does not specify distinct spatial zones. Rather, the characteristics of different local ecosystems define different habitat zones and the relationship between them. This same principle is later adopted within landscape and regional

[1]In the early twentieth century, the natural transect became one of the foundational tools of ecological research. The evidence that certain flora and fauna flourished symbiotically together, and within a specific mineral and climactic environment, became the ethical basis for the protection of species. Patrick Geddes (1854–1932) adopted the ecological transect as a model to devise the 'valley section' (Geddes 1915). Taken from ridgeline to shoreline, the 'valley section' shows natural conditions with their associated human presence and occupation to show a gradation of human preference for location and work. Based on Geddes, Lewis Mumford's (1895–1990) concept of human ecology was used to develop a decentralized regional vision of metropolitan areas (Mumford 1937). Ian McHarg (1920–2001) applied the natural transect for land conservation in landscape planning showing transitions and relationships within and across natural ecozones (McHarg 1969).

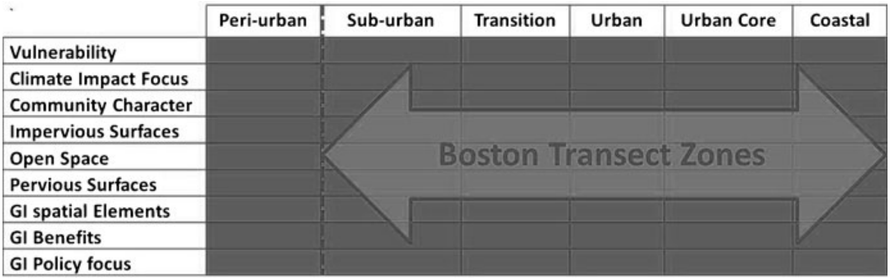


Fig. 1 The green infrastructure transect: concept and organization

planning to assess and understand relationships between land, and natural and human systems in order to plan and manage natural resources within urban regions (McHarg 1969; Picket 2004; Berger 2006).

Overall, the GI transect combines the general principles of urban and natural transects into a single assessment model. The primary characteristics are three: (1) the simultaneous consideration of human and natural systems as a mutual cause-and-effect relationship effecting the functional capability of GI (pervious and impervious surfaces as indicators), (2) the designation of urban zones as unique spatial contexts that may impact the adaptive capacity of communities within, and (3) the explicit consideration that GI is an interconnected system that transcends administrative and political boundaries.

This interconnectedness of GI serves as an impetus and analogy to integrate adaptation policies across the GI zones increasing the local capacity for adaption. We qualify this level of policy integration as 'horizontal integration'. The term is meant to generate targeted GI recommendations specific to each GI zone and coordinate them across boundaries[2] (within scales). This is achieved by mapping and assessing each GI zone against a set of criteria to be able to recommend targeted GI measures. Six GI zones are identified and are intended to represent an alternative model (to the urban transect) of contemporary urban regions. These include coastal (if present), urban core, urban, transition (the middle ground), suburban, and peri-urban zones. In addition, we use the following criteria to assess each GI zone: vulnerability assessment using spatial data (physical and social), identifying the primary climate change impact based on spatial configuration and character, identifying the spatial character of each GI zone, determining the spatial configuration of pervious and impervious surfaces (existing and potential GI), determining GI typology relevant to each zone, and recommending appropriate GI measures within each GI zone (Fig. 1). The sequential process of assessment begins with vulnerability assessment

[2]Cross-jurisdictional coordination was identified as a primary concern when assessing the 4,000 GI networks across the conterminous USA for their ecological connectivity where 10% of the hubs and links cross administrative and political boundaries. When downscaling the same observation to regional and local scales, forest stands, water bodies, and wetlands are not restricted to regional, city, town, or property boundaries (Fig. 4).

and concludes with recommendations providing a specific policy focus to local communities for adaptation and the possible responses through GI.

Furthermore, several existing GI recommendations relevant to adaptation policies call for the protection of forest stands and wetlands or increasing tree canopy or engineering swales and rain garden systems. These GI spatial elements are not restricted to regional, city, town, or property boundaries as they are subject to conditions (i.e. topography, geology, and hydrology) beyond the control of governing bodies. Therefore, analysis and assessment should consider recommendations within each zone and the outward extensions of GI. By mapping adjacent spatial configurations, horizontal integration is attained. This enhances the adaptation capacity of local communities through coordination of policies. Yet, it does not account for coordination across jurisdictional boundaries and planning scales necessary for regional resiliency.

Developing a network of GI increases the resiliency of a region. It provides alternative evacuation routes, species migration routes, CO_2 sinks, flood water storage, buffer zones against rising sea water and reduction in regional temperatures. To achieve a coordinated regional network requires the integration of planning scales (neighbourhood, urban, regional) into a single regional planning framework providing a platform for communication and coordination across jurisdictions. We term this integration across scales as 'vertical integration'.

Vertical integration provides the mean to respond to the multi-scalar and hierarchal nature of GI by considering current planning processes. GI networks are hierarchal especially when planned within urban contexts. When considering GI for storm water management, connectivity of GI elements should be considered across the hierarchy of urban planning scales (street or parcel neighbourhood, city, and urban region) (Kato 2010). For example (Fig. 2), several streets with bioswales and retention ponds in residential yards at the neighbourhood scale can constitute a green corridor at the city scale which, in turn, with city parks can be part of a regional park system (Jim and Chen 2003; Girling and Kellett 2005). But each individual GI element (parcel to regional scales) is planned and implemented differently, depending on the context, size, and planning process. Vertical integration provides a way to unify these processes under a hierarchal single framework that leads to a regional vision.

Integration across scales is necessary to increase the adaptive capacity at both the regional and local levels. The adaptive planning meta-model developed by Kato (2010), for a planning framework to manage GI, is an example of such a process. It is an iterative process designed for the US context. Similar to the GI hierarchy, neighbourhood plans that are participatory in nature form the basis of an urban plan. The sum of the several urban plans could define a vision for a region. In the US context, a bottom-up approach (participatory) could lead to a regional vision. The reverse (top-down planning) may also hold true when considered within other planning and administrative contexts. Regardless of whether the vision (top-down) or local planning (bottom-up) comes first, the intention here is to advocate for a two-way and iterative approach that includes both and provides the flexibility and adaptability to respond as circumstances arise and change.

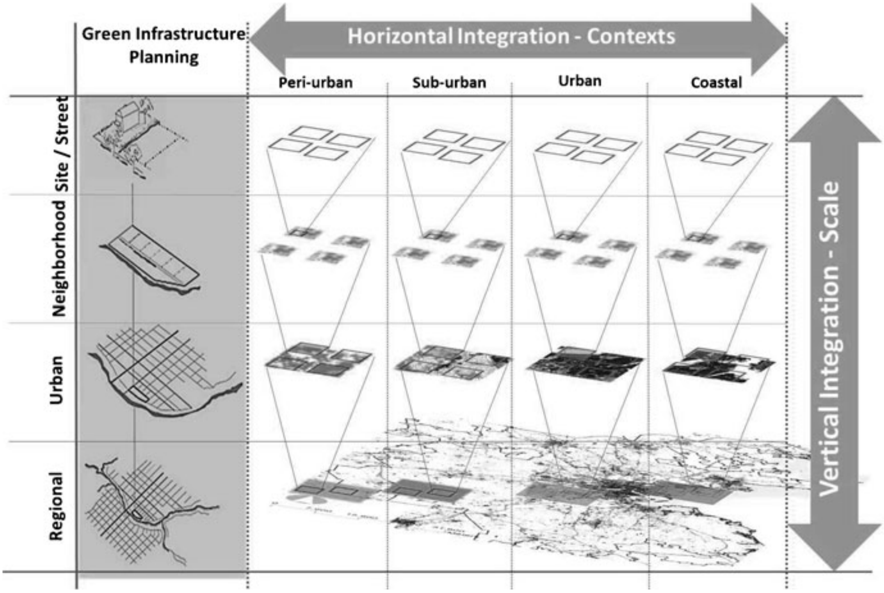


Fig. 2 Multi-tiered GI adaptation planning framework: horizontal and vertical integration

The underlying concepts behind the GI transect point to the spatial, contextual, and administrative interdependencies governing mainstreaming adaptation planning. Vertical and horizontal integration are the primary elements of the GI transect that integrate local and regional plans into a single and flexible adaptation planning framework. To make these ideas concrete, we apply the three-step approach of vulnerability assessment, characterization of existing GI, and GI policies recommendations to the Boston metropolitan region.

3 Boston Metropolitan Region

The metropolitan region of Boston occupies the eastern shoreline of the state of Massachusetts in the USA. It covers a land area of approximately 12,000 km^2, housing 4.5 million people with an average density of 366 persons per square kilometre (Census Bureau 2010). The metropolitan region incorporates 120 towns and 8 regional jurisdictions within its boundary (Census Bureau 2010). It is characterized by an urban core (Boston) as the centre of governance, business, and transportation. From the urban core to the periphery, residential sprawl of varying densities along transportation corridors and around commercial centres is interspersed by forest, wetlands, river basins, and, to lesser extent, agricultural land (Figs. 3 and 4). At the planning level, the state of Massachusetts (MA) has adopted and is implementing smart growth principles to control development and preserve

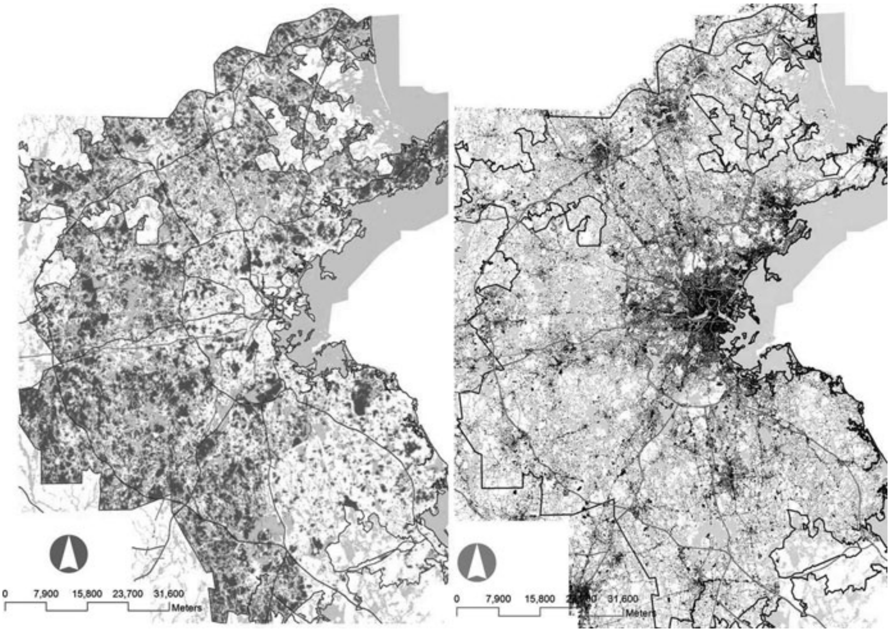


Fig. 3 Metropolitan region of Boston: spatial distribution of pervious and impervious surfaces

natural and cultural assets.[3] Part of the smart growth initiative is the Climate Action Plan (CAP 2007, 2010). The plan is focused on mitigation measures to reduce emissions from buildings, transportation, waste management, and land use. In the 2010 update of the plan, recommendations for adaptation were included as part of addressing causes and effects of climate change.

The NECIA (2007) report on climate change impacts within the New England region shows that Massachusetts climate will resemble the southern states of the Eastern Coast of the USA.[4] Taking the year 2000 as the baseline, the report demonstrates that the metropolitan region of Boston will experience increase in temperatures by 4–7°C in the winter and 3–8°C in the summer, rising sea level of 25–60 cm, and increased precipitation by 20–30%. To address these impacts, the City of Boston identified guidelines for adaptation planning (CAP 2010) that include, in addition to economic and social measures, spatial measures that focus on GI.

---

[3] Since planning is locally based and participatory, the state of Massachusetts may only advance these planning principles through financial incentive means. Towns and cities may develop their comprehensive zoning, recreation and open space, and economic development plans based on smart growth principles in return for financial incentives.

[4] Under the high emissions scenario, the Massachusetts climate will likely resemble that of the current Florida climate and under a lower emissions scenario will resemble the current weather of Northern Carolina.

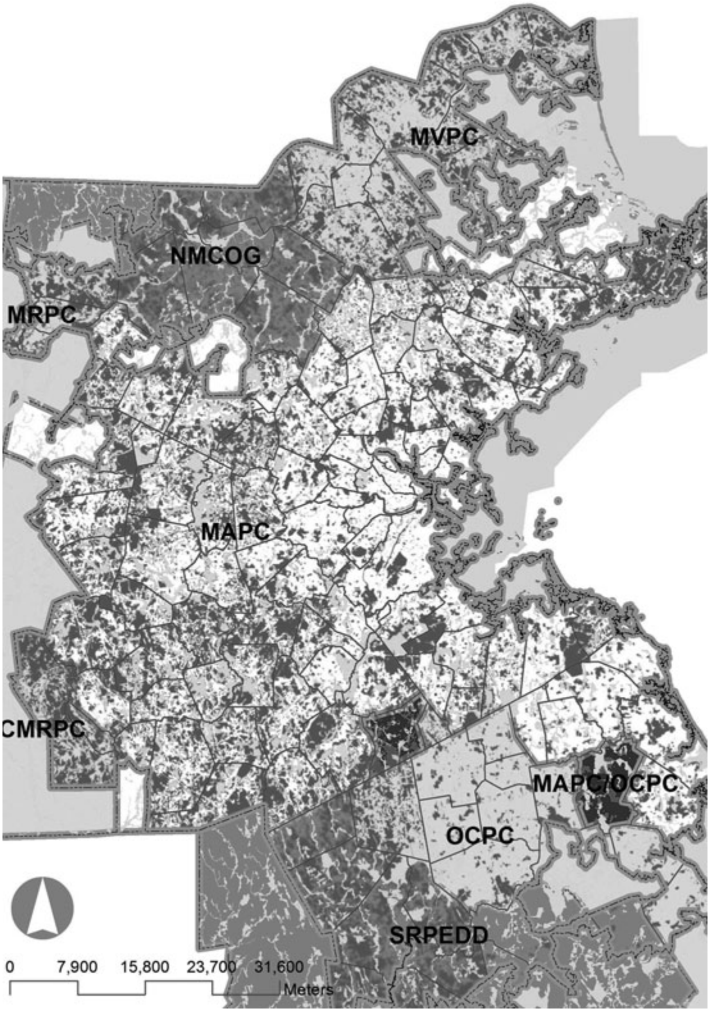


Fig. 4 Metropolitan region of Boston: green infrastructure across town boundaries

The adaptation recommendations for Boston (CAP 2010) set priorities and define the required information and planning priorities and approaches. Out of the 13 recommendations, many focus on GI principles such as greening the city, green roofs, sustainable water management, and protection and increase of large tracts of vegetated surfaces. In addition, planning cross-jurisdictions and scales is identified as a priority to increase the adaptive capacity of the urban region.

In the process of transforming these adaptation recommendations into actions, we apply the GI transect to assess the applicability of the multi-tiered organizational framework to Boston. In the assessment stage, we map vulnerability, climate change impacts, and the physical environment across the GI zones (Fig. 5). Vulnerability

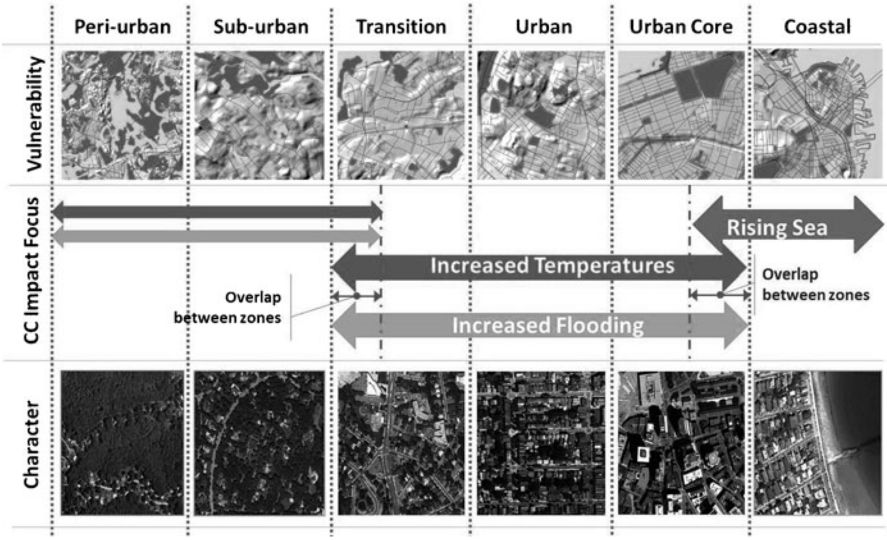


Fig. 5 Green infrastructure transect application to Boston region, step one: vulnerability assessment

is mapped using the following spatial data layers from Mass GIS[5]: topography, open space, roads, location within the watershed, and socio-economic data for each location. Climate impact is mapped according to the NECIA (2007) report showing the magnitude and focus within each zone. Aerial images are used to map the urban character identifying the physical environment of work and housing.

We found that the coastal zone is predominantly impacted by rising sea level, the urban to transition zones are affected by a high magnitude of increased temperatures and flooding, and the peripheral zones are impacted, at a lower magnitude, by temperature rise and flooding. The exposure to physical risks is further exasperated by the effect of the urban heat island effect (UHI) and the gradation of impervious and pervious surfaces across the GI transect. The compounded impacts of climate change and the physical characteristics of the urban region of Boston are grounds to consider different adaptation planning focuses for communities across the GI transect. To be able to devise and recommend GI policies within existing pervious surfaces, which address the variation of vulnerability, we map the existing distribution of GI across the zones.

To map the spatial distribution of GI across the zones, we also use Mass GIS data. We overlay the following layers: impervious surfaces, digital terrain, open space layers (public domain), waterways, forests, roads, and administrative boundaries.

[5]Mass GIS is a spatial data portal managed by the state of Massachusetts that provides a free download service of available data layers across the state. See http://www.mass.gov/mgis/.

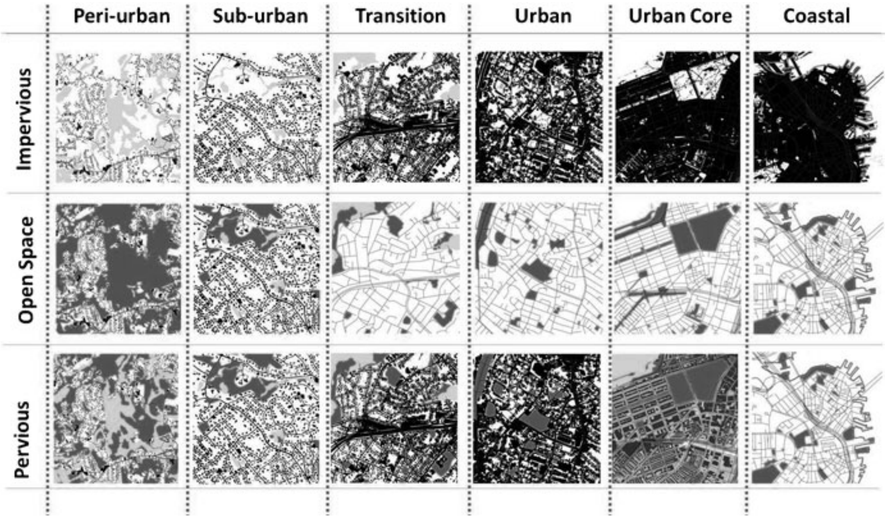


Fig. 6 Green infrastructure transect application to Boston region, step two: existing green infrastructure patterns

We find that open space and unbuilt[6] land increases in area as we move towards the periphery (Figs. 3 and 6). What significantly increases, and not usually included in the inventory of GI, are unbuilt spaces within the private domain (yards, gardens, and school grounds). Since ecosystem benefits are not bounded by administrative limits (Fábos 2004) and increase proportionally with GI area,[7] it is critical to ensure that GI policies simultaneously address land within the private and public domains.

The final step is to identify and recommend appropriate GI policies across the GI transect zones. We distinguish clear complementarities between GI benefits, community needs, and vulnerability requirements (Fig. 7). We list the typologies of GI elements that already exist within each zone or those that could potentially be introduced or enhanced. Ecosystem benefits that are complementary to community needs and climate impacts are also listed in accordance with the spatial typology. By overlaying information from steps one and two, we begin to identify the potential GI policies. For example, the coastal area will benefit from planned retreat – where vulnerable built areas across the coast may gradually be transformed into landscapes for recreation. The resulting coastal landscapes become non-structural[8] defences incorporated as recreational and ecological landscape features. Therefore, the policy

[6]Unbuilt land is considered as potential to increase green infrastructure area within an urban region.

[7]Ecosystem benefits are directly proportional to the amount of land available for GI: the more forested land, the more the potential for temperature control, and the more the golf courses and open land, the more water storage may be achieved.

[8]Non-structural defences are based on naturally occurring or engineered defences such as wetlands, marshes, sand coasts, and eastern dams.

	Peri-urban	Sub-urban	Transition	Urban	Urban Core	Coastal
GI Spatial Elements	• Wetlands • Agriculture • Forest · • water ways • Nature Parks • Greenways • Ecological networks • Agricultural land	• Gardens • Domestic yards • School grounds • Cemeteries • Subdivisions • Wetlands • Forest Stands • Green ways • Street trees • Unused lots • Derelict land • Parks • Swales	• Gardens • Domestic yards • School grounds • Cemeteries • Subdivisions • Wetlands • Forest Stands • Green ways • Street trees • Unused lots • Derelict land • Parks	• Parks • Gardens • Interstitial Spaces • Private sites • Unused lots · • Street trees • Green facades • Green roofs • Parking lots ·	• Parks • Piazzas • Garden • Interstitial spaces· • Street trees • Green facades • Green roofs	• Coastal zones • Wetlands • Coastal parks • beaches· • Rivers ·
GI Benefits	• Water regeneration • Recreation • Ecological connectivity • Biodiversity • Heat reduction • Food production & Clean Air		• (+)Rain water retention · (-)roof heat exchange · Flood storage · Provide opportunities for urban agriculture · (-) Urban island heat · Provide shade & cooling· recreation Increased · (+)real estate value			• Natural defenses • Surge reduction • Recreation
GI Strategy	• Conserve • Protect • Private property • Aggressively increase land under GI • Ecological connectivity	• Conserve • Protect • Reclaim land • Private Property • Reclaim land • Ecological connectivity	• Conserve • Protect • Large land • Private Property • Incentives for private owners • Reclaim land	• Densify GI • Hybrid Systems • City Green	• Densify GI • Green Roofs • Green Facades • Transform pervious to impervious • City Green	• Planned Retreat • Densify coastal GI • Protect Coast

Fig. 7 Green infrastructure transect application to Boston region, step three: identification of GI policies

here would focus on preserving and intensifying all existing GI elements and to define a long-term plan to allow time for legal procedures and financial compensation to take place for the coastal zone transformation. Within the urban zone of the GI transect, policies should address increased temperatures (compounded by UHI) and retention of water run-off. Existing parks and open space, green roofs, green facades, and street planting are spatial elements that should be increased through revisions to building regulations, open space plans, and environmental policies. Through the Biotope Area factor,[9] the city of Berlin is an example where zoning and financial incentives result in an increase in tree canopy and 'at the source' water management. Towards the periphery, policies that enhance connectivity and preserve, conserve, and increase forests, large parks, natural reserves, and biospheres are integral for run-off storage, species migration, temperature control, and water infiltration to ensure ecosystem services at the regional scale.

To ensure consistency across local GI policies with the Boston region, vertical and horizontal integration of policies (Fig. 2) is utilized to coordinate and implement planning projects across town jurisdictions. Planning in Massachusetts

[9]See the City of Berlin, Senate Department for Urban Development: http://www.stadtentwicklung.berlin.de/umwelt/landschaftsplanung/bff/index_en.shtml.

is predominantly participatory and happens at the local (town) scale. This means that parcel and neighbourhood scale plans should build up to form an overall town plan that explicitly considers GI measures for adaptation. The open space plans that are mandatory to US towns could be extended beyond recreation to incorporate ecological and adaptation plans. Town plans then need to build the overall regional vision. This may be achieved by expanding the mandate of regional planning bodies beyond transportation and economic development towards a more active role to coordinate and integrate local plans. Even more, regional bodies should be responsible to monitor and develop regional climate projections that help in providing the vision for regional and local adaptation plans. A hierarchal organizational structure that works in both directions (from local to regional or from regional to local) ensures that all constituents and measures serve an intended local role within a larger regional approach. The proposed structure that we have presented may be a first step in integrating local adaptation planning across scales and jurisdictions using current and accepted knowledge.

4 Conclusion

Adaptation policies run the risk of a piecemeal, systematized approach. It is easy to prescribe a green roof here and a rain garden there and hope that they will add up to a proper systematic approach. However, the challenges of adaptation are too significant for this to be effective. Framing GI planning through the transect approach provides a way to conceptualize a whole system of GI spatial elements, identify coming climate challenges, and plan to integrate local policies at site scale with adaptation needs at the neighbourhood, city, and regional scales. In this chapter, we briefly used Boston as a case study to demonstrate how the GI transect may be applied and how it can assist in interpreting and framing overall GI for adaptation. We conclude that GI will be an effective adaptation policy when it is matched to the physical character of urban environments (urban, suburban, and rural) and the needs of communities they are intended to serve. This approach is a first step in mainstreaming adaptation planning using current GI practices.

References

Ahern, J. (2008). Green infrastructure for cities: The spatial dimension. In V. Novotny & P. Brown (Eds.), *Cities of the future* (p. 2). London: IWA Publishing.

Bedsworth, L. W., & Hanak, E. (2010). Adaptation to climate change: A review of challenges and tradeoffs in six areas. *JAPA, 76*(4), 477–495.

Benedict, M. A., & McMahon, M. T. (2002). Green infrastructure: Smart conservation for the 21st century. *Renewable Resources Journal, 20*, 12–17.

Benedict, M. A., & McMahon, M. T. (2006). *Green infrastructure: Linking landscape and communities*. Washington, DC: Island Press.

Berger, A. (2006). *Drosscape: Wasting land in urban America*. New York: Princeton Architectural Press.
CAP. (2007/2010). *The city of Boston's climate action plan*. City of Boston. December 2007. http://www.abettercity.org/environment/bostoncap.html. Accessed 18 June 2011.
CCAP. (2011). *The value of green infrastructure for urban climate adaptation*. Center for Clean Air Policy, February 2011. http://www.ccap.org/docs/resources/989/Green_Infrastructure_FINAL.pdf. Accessed 18 June 2011.
Duany, A., & Talen, E. (2002). Transect planning. *Journal of American Planning Association, 68*(3), 245–266.
EPA – US Environmental Protection Agency. http://www.epa.gov/. Accessed 20 June 2011.
Fábos, J. G. (2004). Greenway planning in the United States: Its origins and recent case studies. *Landscape and Urban Planning, 68*, 321–342.
Farr, D. (2008). *Sustainable urbanism: Urban design with nature*. Hoboken: Wiley.
Forman, R. T. T. (2008). *Urban regions: Ecology and planning beyond the city*. Cambridge: Cambridge University Press.
Geddes, P. (1915). *Cities in evolution: An introduction to the town planning movement and to the study of civics*. London: Williams & Norgate.
Gill, S. E. (2007). Adapting cities for climate change: The role of the green infrastructure. *Built Environment, 33*(1), 115–133.
Girling, C., & Kellett, R. (2005). *Skinny streets and green neighborhoods: Design for environment and community*. Washington, DC: Island Press.
Jim, C. Y., & Chen, S. S. (2003). Comprehensive greenspace planning based on landscape ecology principles in compact Nanjing city, China. *Landscape and Urban Planning, 65*(3), 95–116.
Jongman, R. H. G. (1995). Nature conservation planning in Europe: Developing ecological networks. *Landscape and Urban Planning, 32*, 169–183.
Jongman, R. H. G., Külvik, M., & Kristiansen, I. (2004). European ecological networks and greenways. *Landscape and Urban Planning, 68*, 305–319.
Kato, S. (2010). *Green space conservation planning framework for urban regions based on a forest bird-habitat relationship study and the resilience thinking*. Ph.D. dissertation, Umass, Amherst; AAT 3409604.
Lewis, P. H., Jr. (1964). Quality corridors for Wisconsin. *Landscape Architecture, 54*, 100–107.
McHarg, I. (1969). *Design with nature*. Garden City: The Natural History Press.
Mumford, L. (1937). *What is a city?* New York: McGraw-Hill.
Nassauer, J. (2006). Landscape planning and conservation biology: Systems thinking revisited. *Conservation Biology, 20*, 677–678.
NECIA. (2007). *Confronting climate change in the U.S. Northeast: Science, impacts, and solutions*: *A report of the Northeast Climate Impacts Assessment*. Union of Concerned Scientists. http://www.climatechoices.org/ne/resources_ne/nereport.html. Accessed 19 June 2011.
Newman, P., & Jennings, I. (2008). *Cities as sustainable ecosystems: Principles and practices*. Washington, DC: Island Press.
Noss, R. F., & Harris, L. D. (1986). Nodes, networks, and mums: Preserving diversity at all scales. *Environmental Management, 10*(3), 299–309.
Pickett, S. T. A., Cadenasso, M. L., & Grove, J. M. (2004). Resilient cities: Meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms. *Landscape and Urban Planning, 69*(4), 369–384.
United States Census Bureau, Data section, http://2010.census.gov/2010census/. Accessed 18 June 2011.

Part IV
Frameworks for Local Response to Climate Change: Challenges and Recommendations

Introduction: Framework for Local Responses to Climate Change: Challenges and Recommendations

Daniel Morchain

1 The Process of Adaptation Is Not New

Life on this planet is constantly adapting to new circumstances and to changes in its surroundings, including variations in climate patterns. However, a faster rate of population growth and rapid urbanization trends, particularly during the last century, have increasingly challenged human and ecosystem responses to both climate and non-climate-related impacts. Furthermore, as non-climate factors – consumption trends, animal farming practices and land-use patterns, in addition to population growth – put additional stress on ecosystem services and man-made infrastructure, climate change impacts further exacerbate these (mostly) negative effects.

Meanwhile, the process of urbanization continues. For the first time in history, in 2008, the majority of the world population, 3.3 billion, inhabited cities. By 2030, the figure is expected to grow to five billion.[1] High and increasing population densities and reliance on a large number of systems interacting in complex ways (such as systems to transport people and goods, water and energy distribution systems, sewerage and waste management systems) make cities especially vulnerable to climate change impacts. These factors threaten the environmental and sustainability ambitions of cities.

The combination of these factors suggests that efforts to mitigate and adapt to the negative impacts of climate change will have to be addressed, largely, at the local

[1] UNFPA – United Nations Population Fund. "State of world population 2007 – Unleashing the potential of urban growth". Available online at: http://www.unfpa.org/swp/2007/english/introduction.html.

D. Morchain (✉)
ICLEI – Local Governments for Sustainability, European Secretariat, Leopoldring 3, 79098 Freiburg, Germany

Stockholm Environmental Institute, Oxford, UK
e-mail: daniel.morchain@iclei.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2, DOI 10.1007/978-94-007-4223-9_23,

level. Although city officials are increasingly more aware of this, the majority are still implementing measures aimed at coping with the impacts of climate change with a reactive rather than preventative approach. The reason for this passivity is that cities face major constraints when trying to implement adaptation measures. These include:

- Insufficient or difficult access to funding
- Lack of coordination at the local government level and across different levels of governance
- Difficulty in building and conducting effective participatory processes with a broad range of stakeholders
- Limited availability of knowledge and its limited exchange between actors (science and policy arena) and between cities
- Insufficient vertical and horizontal integration of instruments, such as legislation, building codes and urban planning
- Lack of linkage between adaptation measures and local knowledge potentials

2 Appropriate Frameworks to Encourage Early Local Responses to Climate Change Are Necessary

There are indications that appropriate frameworks are being developed. In Europe, for instance, the supranational level (the European Commission) is creating support structures for cities, both through more accessible funding for the implementation of adaptation measures and through the widespread creation and dissemination of knowledge. Different government spheres are, likewise, progressively harmonizing their adaptation goals and efforts to boost efficiency. Aligning efforts with the private sector will also be crucial for cities to deliver climate-proof solutions with an efficient use of resources.

Setting the stage for adaptation, however, will not be complete unless a fair participatory process is undertaken at all levels. Locally, stakeholders should identify vulnerabilities and understand that climate change adaptation needs to be integrated into and contribute to sustainable development principles and practices. Indeed, and ironically, the rapidly deteriorating state of ecosystems worldwide – increasingly scarce resources, a changing climate and the demands of a growing population – will likely contribute to a global understanding that the pursuit of sustainable development, economic growth, improved quality of life and an enhanced resilience of natural and man-made landscapes are not – cannot be – conflicting objectives. This may require, admittedly, innovative solutions and a revisited concept of progress.

3 Cities and Towns Will Face Several Challenges When Adapting to Climate Change and Increasing Their Resilience

In addition to insufficient funding and lack of knowledge, non-existent or outdated national legislation can sometimes be a hindrance. The uncertainties associated with climate change science and its projections, the extent to which adaptation measures are necessary, their timing and the depth of potential interventions are additional obstacles to implementation.

An integrated approach to the challenges facing adaptation, sustainable development, quality of life and resilience building is necessary to efficiently implement adaptation measures. This would help to avoid conflicts between measures planned and implemented by different actors, as well as between mitigation and adaptation objectives. An integrated approach also minimizes the risk of adaptation criteria not being included in investment planning and spatial and urban planning.

A reality check shows that even though cities and towns worldwide implement adaptation measures, the practice is, geographically, unevenly spread. Furthermore, adaptation work is frequently evaded, misunderstood or conducted in an inefficient way – without creating synergies between local government departments and processes or with other tiers of government and stakeholder groups. Appropriate frameworks and support from higher levels of governance have the potential to break the local barriers to implementation by making adaptation feasible through funding, as well as by creating a high-level political justification to adaptation interventions even in the face of existing uncertainties.

4 Climate Change Adaptation Is an Exam in Good Governance and Management, Demanding Strong Political Leadership and Commitment

Extreme weather events regularly highlight deficient adaptive capacity within urban systems and management – damage to technical infrastructure and buildings, disruption of municipal and health services, poor social cohesion and emergency management. Political accountability can be strengthened by addressing these issues holistically and in a timely fashion.

This chapter presents examples from across the world that highlight different approaches taken to frame and solve regional and local challenges, based on existing framework conditions, as well as on their capabilities and on the resources dedicated. Among them, the cases of India and Vietnam, for instance, show the struggle to plan and implement urban resilience in a holistic and socially just way; the study of Santiago de Chile discusses how to insert stakeholder input into adaptation planning when faced with increasing sensitivities; the examples of the Philippines, Mexico and South Africa discuss the process of developing and implementing climate change policies; findings from the Reality Check workshop provide an overview of the challenges of integrating climate-related risks in the urban development path of Ho Chi Minh City; while the Norwegian case ascertains that adaptation policies are particularly difficult to introduce because they lack the appeal of mitigation and warns of the risk of potentially conflicting mitigation and adaptation efforts.

The singularity of each case demonstrates that the frameworks, levels of advancement and capabilities of adaptation are considerably different around the globe – and even within countries – and that sound framework structures and an open approach to sharing knowledge will be determining factors in mainstreaming adaptation practices in a most efficient way.

Building Resilience in Asian Cities

Bach Tan Sinh, G.K. Bhat, Marcus Moench, and Steve Gawler

Abstract The vulnerability of urban systems and communities to climate change can be extremely high. Many cities are vulnerable due to their dependence on fragile urban systems, and this is particularly true for the poor and other marginalized groups residing in these cities. Planning for urban resilience must, as a result, address the factors that contribute to system fragility while also ensuring access to such systems by marginalized as well as more socially and economically advantaged communities. While the above conceptual challenge may be clear, practical strategies for building climate resilience by addressing the fragility of systems and addressing the needs of marginalized communities are only beginning to emerge.

This chapter presents the approaches, methods and initial results of resilience planning and practice undertaken by cities in India and Vietnam as part of the Rockefeller Foundation "Asian Cities Climate Change Resilience Network" (ACCCRN). It then draws on some of the initial learnings from this experience and discusses ways of embedding urban climate resilience planning into sustainable development at the local level and into national development planning frameworks.

B.T. Sinh (✉)
National Institute for Science and Technology Policy and Strategic Studies (NISTPASS), Hanoi, Vietnam
e-mail: sinhbt@yahoo.com

G.K. Bhat
TARU Leading Edge, 424 Qutab Plaza, Gurgaon 122 002, India
e-mail: gkbhat@taru.org

M. Moench
Institute for Social and Environmental Transition (ISET), Boulder, CO, USA
e-mail: moenchm@i-s-e-t.org

S. Gawler
ICLEI – Local Governments for Sustainability, Oceania Secretariat, Jakarta, Indonesia
e-mail: steve.gawler@iclei.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_24,

Keywords Climate change resilience • Vulnerability • Urbanization • Shared learning dialogues • City resilience strategy

Abbreviations

CtC	Challenge to Change (International NGO)
GEAG	Gorakhpur Environmental Action Group
ICLEI	International Council for Local Environmental Initiatives
ISET	Institute for Social and Environmental Transition
NISTPASS	National Institute for Science and Technology Policy and Strategy Studies
TARU	TARU Leading Edge

1 The Asian Cities Climate Change Resilience Network (ACCCRN): Building Resilience in Asian Cities

Since 2008, the Rockefeller Foundation has provided support to ten medium-sized Asian cities to develop practical methods and tools to respond to climate change, reduce poverty and manage rapid urbanization through the Asian City Climate Change Resilience Network (ACCCRN). The programme has worked with cities in India, Vietnam, Indonesia and Thailand. This chapter focuses on the experience from India and Vietnam as the programme is the most advanced in these two countries.

The ACCCRN programme was initiated by the Rockefeller Foundation based on a growing recognition of the severe challenges climate change posed for the poor and socially marginalized populations across Asia's rapidly growing cities. Most international agencies working on climate change were focusing on rural areas, but work to address the impacts of climate change on vulnerable urban populations represented a clear and critical gap.

Equally important, there was a clear gap between emerging scientific information at the global level and "actionable" strategies at the local level. While there was considerable work being done at the international level to develop funding options for adaptation, there was little understanding of how to match emerging financing options with local adaptation planning.

The Institute for Social and Environmental Transition (ISET), a key adviser to ACCCRN, proposed engaging with cities using shared learning processes developed under other projects, as a basis for engagement and resilience planning. The core idea was to initiate a progressive process of engagement and analysis at the city level that would bring global scientific information on climate change together with local insights to (a) develop a common understanding of the impacts of climate change on urban systems and populations and (b) identify practical response strategies. The approach was designed to involve a broad base of stakeholders and perspectives at the city level to ensure that the needs of vulnerable groups were addressed, and that the response strategies identified were evidence-based and practical. The process consisted of (1) iterative meetings designed to enable multidirectional information sharing (termed shared learning dialogues) to build understanding and support planning, (2) climate and vulnerability analyses, (3) sector studies on key urban systems and (4) pilot projects to gain implementation experience.

2 Vietnam

The three ACCCRN cities in Vietnam are Da Nang, Can Tho and Quy Nhon. In each city, the local government is leading the project with support from the national and international partners. In Vietnam, the ACCCRN programme covers four phases from scoping (2008) to engagement (2009–2010), implementation (2011–2013) and replication (2009–2013 and beyond).

The key partners in Vietnam are NISTPASS, a national policy and strategy research institute under the Ministry of Science and Technology; Challenge to Change (CtC), an international NGO; and ISET. NISTPASS is the national partner and coordinated the research component, while CtC worked directly with local governments and communities in each city through a number of activities such as community-based vulnerability assessment, awareness-raising trainings and implementation of pilot projects.

In each city, the ACCCRN project was led by the People's Committee, which approved the project and its management structure. The vice chairman of the provincial People's Committee led the Project Steering Committee, comprising leaders of relevant technical departments and local mass organizations.

The Vietnamese ACCCRN Project has recently finished its second phase with capacity building and development of the city's climate change adaptation action plan. The achievements are the results of an extended iterative process involving stakeholder organizations from international, national and local levels. This learning process has provided a number of relevant experiences and lessons on climate change resilience planning in Vietnam.

2.1 Lessons Learned: Vietnam

First, capacity building should focus not only on the technical aspects of climate change but also on the capacity to coordinate, facilitate, consult with and engage multiple stakeholders.

Second, shared learning dialogues were piloted to provide a platform for engagement of stakeholders including not only local authorities, mass organizations and communities but also national policy makers, planners and researchers.

Third, climate change resilience planning is new to most of the stakeholders, and the iterative learning process requires time and resources to build this planning capacity. The lead agency and coordinator of the climate change working group play a crucial role in the resilience planning process. In the beginning, this organization and/or person may not need to be very good in the technical aspects, but they need to have a number of capabilities including (a) a very good understanding of the integrated planning approach, (b) good facilitation skills, (c) good sense of team work, (d) good connection with various local organizations from community to city level and (e) effective communication across city departments.

3 India

Surat, Indore and Gorakhpur were selected for the ACCCRN programme in India. These three cities face different types of challenges, encompassing flooding, water logging, vector-borne diseases, sea level rise and water stress. They also represent a microcosm of the diverse local administration systems of Indian cities.

During Phase II, detailed stakeholder engagements followed by sector studies were carried out. Simultaneously, the dominant hydrometeorological and hydrological risks were assessed with historical data and models. Current vulnerability status across different environment and socio-economic classes were assessed using Geopsy methods to derive citywide vulnerability. Using the critical uncertainty-based techniques, stakeholders came up with the possible city level social and economic scenarios for 2030. These studies formed the basis of the three cities' resilience strategies.

These strategies cover water (water supply and wastewater), natural disasters, housing, energy, land use, transport, poverty, public health, social cohesion and institutional capacity building. Short-, medium- and long-term strategies were identified to address the issues of urbanization, poverty and climate change. Pilot projects to address specific high priority issues were attempted in Phase II.

During the first part of Phase III, high priority interventions have been taken including an end-to-end early warning system for floods in Surat and conjunctive water management for water scarce settlements in Indore, as well as micro-planning to reduce the impacts of floods in Gorakhpur. While building local resilience, these examples are also being used for leveraging policies at national and state level through the formation of a National Consultative Committee represented by policy makers, civil society, academia and industries.

All city-level action is supervised by the city advisory committees formed by the city stakeholders. Technical support is provided by TARU Leading Edge (Surat and Indore) and the Gorakhpur Environmental Action Group (GEAG, Gorakhpur). The implementation process is being managed by city municipalities and local agencies. A number of observations on India's experience follow.

3.1 Lessons Learned: India

The urban local bodies (ULBs) are essentially focused on managing urban services but face manpower and capacity shortage, lack of funds and limited autonomy in decision making. Rapid urbanization and growing poverty are already stressing their financial and staff capacities so that most ULBs are unable to access funds as well as develop urban plans that can include climate change resilience. Paradigm shifts are necessary for transforming these institutions to be able to think beyond the management of current issues. In addition, capacity building of local institutions is key to building resilience.

Iterative engagement with the multiple stakeholders at city, state and national levels is necessary to empower them to conceptualize the urbanization-poverty-climate change issues as an integrated challenge. Continued engagement of ULBs, local industries and civil society organizations is necessary to internalize the resilience framework in city planning.

Climate change is a new subject in India, and the uncertainties in model forecasts require an adaptive planning approach, with an iterative planning-action-analysis cycle. This process needs strong mechanisms to monitor changes in urban growth, economy, poverty and climate. City stakeholders need to build their capacities in all these areas through coordinated action with active involvement of city planners, industry, researchers and practitioners.

4 Reflections from ACCCRN

Experiences with shared learning demonstrate that iteration and interaction are essential. Building a solid understanding among key local actors regarding the implications of climate change requires substantial interaction and continued provision of updated information. This is particularly true when local groups have not been exposed to climate-related issues. Furthermore, approaches need to be tailored to local cultures and contexts, including the unique political context of each city.

Climate change data availability is often very limited or totally inaccessible. In most situations, available data is too general and rarely provides location-specific information at the city level. Cities also often have limited authority to use the best emerging science in policy formulation. Sources for information are often not approved for use either due to the highly political nature of the global debates over responding to climate change or due to the inherent uncertainty and evolving nature of local projections. In many cases, it is also unclear whether or not investments in additional data would have substantial value for resolving uncertainties. Given the uncertainties, difficulties are often encountered in communicating and using climate information. Key trends are often evident particularly with respect to temperature and variability, but other critical information on issues such as changes in precipitation or the nature of storms is often lacking. This said, many trends relate to existing problems – so solutions are not necessarily data dependent.

The ACCCRN experience also highlights the absence of standards and the qualitative nature of most methodologies for determining vulnerability. These limitations make most analyses heavily dependent on the nature, skills and perspectives of the analyst. In addition, the methods used are often narrative based, poorly replicable and often very subjective. Overall, there is a clear need for a more systematic and internally consistent basis for vulnerability analysis. Work by ISET and Ove Arup to jointly develop a framework for understanding and diagnosing urban resilience will provide a basis for addressing this in the future. It understands urban vulnerability as a product of the intersection between fragile systems, marginalized populations, constraining institutions and exposure to climate change.

5 Replication, Looking Forward

Looking forward, the experience with shared learning and resilience planning under ACCCRN provides real opportunities but also highlights severe challenges. There is a growing demand for planning methods to guide actions, and planning processes are also becoming increasingly more systematized. Furthermore, they are generating clear opportunities for cost-effective investment to build resilience and reduce vulnerability. Such investments are, however, not comprehensive. Each may only represent 1% of a total solution. The need to increase overall investment and to aggregate the 1% solutions into comprehensive investment plans is paramount.

This points to the central challenge – can investments in urban climate resilience really address the likely impacts of climate change? Globally, scientific information now suggests that changes of 4°C are likely. This level will profoundly strain all the systems on which urban areas globally depend. Many of these systems, such as food and water supply, cross boundaries and require action at the global, regional and national levels. They are beyond the direct capacity of actors at an urban level to manage. Overall, while the ACCCRN programme demonstrates the critical importance of action at the local city level, this is likely to be insufficient unless it is directly coupled with actions at the higher levels.

6 Conclusion

ICLEI has been engaged to assist to replicate the ACCCRN planning processes in many other cities – to help to capture the learnings from the initial cities and to upscale the "1% solutions" globally. Following are some key principles drawn from the early experience in this project which will guide the replication phase.

First, the adaptation planning process should be streamlined and resource efficient, yet still able to deliver quality climate risk analysis and interventions.

Second, a strongly iterative, cyclical approach should be adopted. Climate planning should not be a one-off undertaking, rather it needs to underpin all city development planning and must be revisited as new data and understandings are obtained. Thus, strong links with broader urban resilience and development planning will be a feature of the replication methodology.

It is also very important to retain a people-centred approach, using the shared learning dialogue model to embed stakeholder participation and leadership throughout the process, supported but not led by scientific investigations.

And finally, there is a need to create stronger links between climate change planning (adaptation and mitigation) and mainstream development planning, culminating in a total climate response for the city and an integrated investment plan suitable for a range of financing options.

A Science-Policy Approach Towards Local Adaptation Planning: The Case of Santiago de Chile

Kerstin Krellenberg

Abstract In Santiago de Chile, the combination of recent urbanization patterns, increasing demand for water, energy and land, and climate change will provide challenges particularly with respect to equitable distribution of different resources and the amplification of existing levels of vulnerability, which are generally not distributed uniformly across urban populations. In response, the international project *ClimateAdaptationSantiago* (CAS), operating at the science-policy interface, seeks to develop adaptation measures according to related vulnerabilities for the Metropolitan Region of Santiago de Chile in the key sectors of energy, water and land use.

Science-related activities include projecting local climate change (with a focus on the urban-regional level), estimating its consequences by explorative scenarios and finally proposing adaptive measures. Acting at the science-policy interface, the project strongly builds on a participatory process with key institutional representatives from a wide variety of different sectors of society (public and private sector, civil society and academia, and multilateral organizations).

This chapter addresses the question of how stakeholder involvement helps (a) to best incorporate perspectives on long-term adaptation into short political agendas and (b) to bridge the sector divide in designing local adaptation measures.

Keywords Science-policy approach • Adaptation measures • Participatory process • Santiago de Chile

K. Krellenberg (✉)
Department of Urban and Environmental Sociology, Helmholtz Centre for Environmental Research – UFZ, Permoser Str. 15, 04318 Leipzig, Germany
e-mail: kerstin.krellenberg@ufz.de

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2, DOI 10.1007/978-94-007-4223-9_25,

1 Santiago de Chile Facing Climate Change: Current Situation and Expected Impacts

Like other large agglomerations in Latin America, Santiago de Chile is the political, administrative and economic centre of the country. The metropolitan region accumulates about 40% of Chile's national population and is home to about six million inhabitants (INE 2002). The cities' expansion continues with an expected population increase of more than eight million people by 2030 (MINVU 2008). Together with an ongoing high concentration of economic power and functional systems, the already high demand for resources is expected to continue to increase in the future.

The Metropolitan Region of Santiago de Chile (MRS) is located in a valley between the central and the costal Andean cordilleras and is subject to a subtropical dry climate with hot summers and winter rainfall. The annual average temperature is 14°C with a mean annual precipitation of 312.5 mm. The warmest months are December–February with an average temperature of 18.9–20.0°C, and the coldest months are June–August with average values of 8.1–9.1°C. The highest precipitation rates are between May and August with an average of 57–85 mm, and the lowest rates occur from November to April with an average between 2 and 14 mm monthly. Climate trends for the MRS according to the last 30 years show increasing temperatures, whereas precipitation amounts have been decreasing (average values of WMO from 1960 to 1991).

Global IPCC (2007) projections as well as scenarios calculated with the regional model PRECIS (Providing Regional Climates for Impact Studies) (CONAMA 2006) are consistent with the historic trends observed, predicting higher medium temperatures and precipitation decrease for the central region of Chile, which includes the MRS. The same holds true for projections according to IPCC's (2007) A2 and B1 scenarios for the time window 2045–2065 that were analyzed for the MRS by a standard, simple downscaling methodology based on the probability distribution of hydro-meteorological variables (Cortés et al. 2012). These downscaling results show rising temperatures, both maximum and minimum, by about 1–2°C. A significant increase in days with extreme high temperatures (above 30°C) is predicted, and most of the meteorological stations within the MRS show a decrease in days with temperatures below 0°C. For precipitation, both scenarios show a decrease for almost every month. Fewer days with precipitation and lower rates are among the expected. This decrease is particularly important for the more 'pessimistic' A2 scenario, for which reductions vary between 10% and 30%. Higher temperatures will bring increasing storm run-off and increased melting during winter and spring, although streamflow in general shows a decrease in magnitude due to lower precipitation rates. For the 2045–2065 period, the MRS will be a dryer, hotter city, with a high number of days with extreme temperatures and increased drought during the winter and summer (Cortés et al. 2012).

Among the main expected impacts of climate changes in the MRS are energy and water issues. The river Maipo, responsible for about 70% of the drinking water of the

MRS, is mainly supplied by winter rainfalls and spring snow melting (MOP/DGA 2007). As higher annual medium temperatures will favour the melting of the glaciers and the snowfields of the high Andeans, and the decrease of precipitation will prolong the dry period, the entire water supply of the urban population is at a considerable risk, the more so as water demand increases due to primarily the population growth (Krellenberg et al. 2010). Bottlenecks in energy supply that are already occurring in some years are expected to be more frequent as nearly 50% of the energy supply is generated by hydroelectric power plants (CEPAL 2009). Furthermore, land use and cover changes that are among the consequences of ongoing urbanization processes will impact climate change and vice versa. Land use and cover change, resulting in a loss of environmental services such as storm water infiltration and heat mitigation, show especially strong linkages to risks related to floods (Ebert et al. 2010) and heat (Romero and Ordenes 2004). Together with expected higher average temperatures and an increase in extreme precipitation events, these changes will enforce seasonal hydro-meteorological hazards in Santiago de Chile.

What is yet not clear, but under investigation, is the current and especially the future socio-spatial distribution of the risks over the MRS and therefore the effects on different population groups. But, expected climate changes will most likely aggravate already apparent risks regarding floods, heat stress, and water and energy bottlenecks. This calls for the development and implementation of adaptation measures.

2 Response Capacities in Santiago de Chile

Santiago de Chile does not yet have an explicit climate action plan on the urban-regional level. The national climate action plan (*Plan de Acción Nacional de Cambio Climático*) elaborated by CONAMA (2008) addresses both mitigation and adaptation issues, but it focuses primarily on mitigation aspects and Clean Development Mechanism (CDM) activities and is clearly organized by individual sectors. Exposed (eco-) systems, sectors and critical infrastructure, including associated economic effects, are taken into consideration. The underlying scenario-based vulnerability assessment of (natural) systems can be described as an 'outcome vulnerability' approach (O'Brien et al. 2007). It takes the adverse effects of climate change into account that increase the 'probability' of dangerous exposure situations of systems and sectors. It considers vulnerability as the 'end point' of a sequence of analyses and follows a top-down perspective. Regarding the effects of global climate change, the IPCC's definition of vulnerability is representative of this approach (IPCC 2007: 883). Adaptive governance responses, following the 'outcome vulnerability', often do not consider social groups and urban infrastructure, which are exposed to climate change impacts (Heinrichs et al. 2012). As a consequence, no explicit urban focus, apart from the coastal cities, is included in the national climate action plan (Heinrichs and Krellenberg 2011; Krellenberg and Heinrichs 2010) that could frame the elaboration of adaptive measures on urban-regional level in the MRS. Accordingly, existing instruments of the MRS in terms of spatial planning do not yet explicitly consider climate change.

Moreover, already without taking the challenge of climate change into consideration, the MRS suffers from administrative fragmentation, asymmetries of power and overlapping democratic constellations (Chuaqui and Valdivieso 2004; Orellana 2009), as it consists of six provinces with a total of 52 independent municipalities, each of which is tasked with a local government (Nuissl et al. 2012). The metropolitan region is administrated by the regional government (*Gobierno Regional Metropolitano de Santiago*) with its highest regional representative (the *Intendente)* appointed by the president of Chile, a regional council (regional councillors are elected by municipal councillors) and the regional ministerial secretariats (SEREMI) that are dominating in terms of public inversion (Chuaqui and Valdivieso 2004). There is an obvious absence of overall guiding instruments to shape sectoral and territorial policies, plans and investments and to monitor their performance over time. In addition, governments prefer short-term action as opposed to long-term planning (Barton and Kopfmüller 2012). According to the clear sector divide and the short-term planning agenda, considerable obstacles to more integrated planning within the existing structures are prevailing. This becomes particularly challenging when designing effective local, long-term adaptation measures that consider existing measures, plans, etc.

In 2010, the former *Comision Nacional de Medioambiente* (CONAMA), which published the National Climate Action Plan, was transformed into the new Ministry of the Environment. Today, the Ministry is in charge of climate change issues, and it is in their responsibility to establish a new action plan from 2012 onwards. On regional level, both the regional government and the SEREMIS are the key institutions in controlling the instruments that are mentioned in the national climate action plan (Barton 2009), and therefore among those to implement a climate adaptation strategy on urban-regional level. This makes both entities among the key stakeholders to be involved in a participatory process regarding the development of climate change adaptation measures.

3 Towards Local Climate Adaptation Planning: A Science-Policy Approach

According to the specific needs of the Metropolitan Region of Santiago de Chile, a coordinated response to climate change on urban-regional level is needed. Taking an aggravation of the already apparent risks regarding floods, heat stress, and water and energy bottlenecks into account, an assessment of the current and future risks and vulnerabilities according to the concept of 'contextual vulnerability' (O'Brien et al. 2007; Kelly and Adger 2000) is among the most important scientific contributions. This concept considers, in comparison to the one of 'outcome vulnerability',

vulnerability as it emerged in the hazard community (e.g. Wisner et al. 2004) and in livelihood and poverty research (Chambers 1989). It takes into account that climate change-related vulnerability adds to existing vulnerabilities. For the Santiago case, the analysis of current vulnerabilities differentiated by socio-economic groups related e.g. to land use changes is part of the vulnerability analysis. New insights, especially relevant for the elaboration of long-term measures, emerge by combining natural and social science knowledge based on (a) the results on expected climate changes (Cortés et al. 2012) and (b) on scenario analysis of different alternative future development paths according to an impact and vulnerability assessment for the year 2050. Based on these results, first proposals for concrete adaptation measures are developed.

Transferring and integrating these scientific results into a science-policy participatory process and combining and exchanging it with the knowledge of local practitioners is challenging but among the essential goals of supporting decision-making (e.g. Roux et al. 2006; Sanchez-Rodriguez 2009). For the Santiago de Chile case, the organization of a series of ten round-table meetings, over a 2-year time period, with key institutional representatives from a wide variety of different sectors and levels of society (public and private sector, civil society and academia and multilateral organizations), is the essential element of the participatory process. This process aims in including different perspectives of representative stakeholders, existing activities (although not explicitly climate change related) and offering a platform for exchange between the above-mentioned levels and sectors. It is important to closely connect climate change-related adaptation measures with existing policy and management as likewise highlighted by other scholars such as Dovers (2009) or Corfee-Morlot et al. (2011). It is expected that the involvement of authorities from public and private sectors, civil society and academia contributes to more robust strategies over multiple governance levels and sectors. Furthermore, the involvement of local decision-makers up from the early beginning can make climate change more tractable for them as specific needs and expectations can be discussed.

The participatory process aims to elaborate, jointly with local stakeholders, adaptation measures set for the Metropolitan Region of Santiago de Chile. In turn, the process is organized in a flexible way that allows for context-specific needs. It can be stated that a well-balanced relation between (1) scientific inputs, (2) open discussions and (3) explicit participatory activities within each round-table meeting is crucial for guaranteeing long-lasting interest of local stakeholders and intensive exchange between science and policy. This holds especially true as stakeholders are getting aware of win-win situations. Additional materials like working papers of scientific results, generic briefing papers of related topics and examples from other cities regarding e.g. climate change action that is made available from the website and/or distributed as hard copies at the round tables make scientific work more explicit for stakeholders.

Participatory activities include both plenum and group work and have the potential to set off the sector divide by furthering the exchange between actors and sectors by face-to-face information and discussion. Taking stakeholder knowledge seriously into account by documenting and circulating the outcomes of each participatory activity certifies their involvement as highly needed and valuable. It is also important to highlight that already midway through the round-table meetings, exchange between different sectors and levels was animated and first joint activities beyond the organized meetings could be identified.

4 Conclusions

The interest of this chapter was to give first tentative answers to the question of how stakeholder involvement helps to (a) best incorporate perspectives on long-term adaptation into short political agendas and (b) to bridge the sector divide in designing local adaptation measures. Based on the state of the art in the Metropolitan Region of Santiago de Chile regarding (1) climate change and impacts, (2) local climate action and the need for changes and (3) the developed science-policy approach for developing climate change adaptation measures, this question was briefly discussed.

Considering the problem constraints between long-term adaptation and short political agendas, those scientific results that focus on the estimation of future development paths and the consequences for risks and vulnerabilities are particularly useful. However, downscaling methodologies and future estimations often imply a high range of uncertainties that should not be ignored but rather made explicit. Nevertheless, working with various scenarios furthers local stakeholders to imagine different development options and to understand the need of short-term reaction for long-term benefits. In the light of frequently changing regional authorities, the elaboration of long-lasting information that includes the dissemination of scientific results in an adequate manner (e.g. in the form of information material, manuals, policy briefs, etc.) is among the most important outcomes of such a science-policy approach. Additionally, trying to link adaptation measures into the overall regional strategies of the regional government and the SEREMIs is among the most important objectives, highlighting the implementation-oriented focus.

Regarding the sector divide, stakeholder involvement from different sectors and multiple levels (national, regional and municipal) in the development of urban-regional adaptation measures is a good starting point for bridging. A scientifically organized participatory process has the potential to bring together different actors and knowledge in a rather ‘neutral’ environment. The benefits are scientifically grounded discussions, ‘new’ interchanging data bases and knowledge transfer within a wide range of institutions as well as a platform for exchange somehow away from ‘political thinking.’ Anyhow, the process itself is not yet a guarantee for a successful implementation. Operationalizing adaptation actions within a policy environment will benefit from the formal definition of criteria for success, metrics for measuring that success and transparent reporting to stakeholders (Moser 2009).

Although some scholars state that a systematic approach to monitoring and evaluating climate change adaptation has yet to emerge (Preston et al. 2011), it is obvious that impacts and vulnerabilities vary between locations and the same holds true for social, economic and administrative capacities. Therefore, there will rarely be a ‘one size fits all’ adaptation policy, and regions will have to find their specific solutions.

References

Barton, J. R. (2009). Adaptación al cambio climático en la planificación de ciudadesregiones. *Revista de Geografía Norte Grande, 43*, 5–30.

Barton, J., & Kopfmüller, J. (2012). Sustainable urban development in Santiago de Chile: Background – concept – challenges. In D. Heinrichs, K. Krellenberg, B. Hansjürgens, & F. Martínez (Eds.), *Risk habitat megacity*. Heidelberg, pp. 65–86.

CEPAL. (2009). *La Economía del Cambio Climático en Chile*. Santiago: Síntesis.

Chambers, R. (1989). Vulnerability, coping and policy. *IDS Bulletin, 20*(2), 1–7.

Chuaqui, T., & Valdivieso, F. (2004). Una ciudad en busca de un gobierno: una propuesta para Santiago. *Revista de Ciencia Política, 24*(1), 104–127.

CONAMA (Comisión Nacional de Medio Ambiente). (2006). *Estudio de la variabilidad climática en Chile para el siglo XXI*. Santiago.

CONAMA (Comisión Nacional de Medio Ambiente). (2008). *Plan de Acción Nacional de Cambio Climático, 2008–2012*. Santiago.

Corfee-Morlot, J., Cochran, I., Hallegatte, S., & Teasdale, P.-J. (2011). Mulitlevel risk governance and urban adaptation policy. *Climatic Change, 104*, 169–197.

Cortés, G., Schaller, S., Rojas, M., Garcia, L., Descalzi, A., Vargas, L., & McPhee, J. (2012). *Assessment of the current climate and expected climate changes in the Metropolitan Region of Santiago de Chile*. UFZ-Discussion Paper (in print).

Dovers, S. (2009). Normalizing adaptation. Editorial. *Global Environmental Change, 19*, 4–6.

Ebert, A., Welz, J., Heinrichs, D., Krellenberg, K., & Hansjürgens, B. (2010). Socio-environmental change and flood risks: The case of Santiago de Chile. *Erdkunde, 64*(4), 303–313.

Heinrichs, D., & Krellenberg, K. (2011). Climate adaptation strategies: Evidence from Latin American city-regions. In K. Otto-Zimmermann (Ed.), *Resilient cities: Cities and adaptation to climate change – Proceedings of the Global Forum 2010, Local sustainability 1*. Dordrecht, Heidelberg, London, New York, pp. 223–230.

Heinrichs, D., Krellenberg, K., & Fragkias, M. (2012). Urban responses to climate change: Theories and governance practice in cities of the Global South. *International Journal of Urban and Regional Research* (forthcoming).

INE (Instituto nacional de estadísticas). (2002). *Censo de Población y Vivienda 2002*. Santiago de Chile.

IPCC. (2007). *Fourth assessment report: Synthesis report*. Geneva: IPCC.

Kelly, P. M., & Adger, W. N. (2000). Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change, 47*, 325–352.

Krellenberg, K., & Heinrichs, D. (2010). Urban Latin America under climate change: Do adaptation strategies of city-regions respond to the challenges? In W. Endlicher & F.-W. Gerstengarbe (Eds.), *Continents under climate change* (Nova Acta Leopoldina, Vol. 112, No. 273–384, Halle, pp. 267–274).

Krellenberg, K., Heinrichs, D., & Barton, J. (2010). Climate change and adaptation strategies in Latin American city regions: The case of Santiago de Chile. In M. Fragkias & C. Griffith (Eds.), *Integrative perspectives on urbanization and climate change* (UGEC viewpoints, Vol. 3, 277, Tempe, pp. 4–7).

MINVU (Ministerio de Vivienda y Urbanismo). (2008). *Propuesta de Modificación del Plan Regulador Metropolitano de Santiago*. Santiago.

MOP/DGA (Ministerio de obras públicas/dirección general de aguas). (2007). *Estimaciones de demanda de agua y proyecciones futures. Zona II*. Santiago: Regiones V a XII y Región Metropolitana.

Moser, S. (2009). Making a difference on the ground: The challenge of demonstrating the effectiveness of decision support. *Climatic Change, 95*, 11–21.

Nuissl, H., Höhnke, C., Lukas, M., Durán, G., & Rodriguez Seeger, C. (2012). Megacity governance: Concepts and challenges. In D. Heinrichs, K. Krellenberg, B. Hansjürgens, & F. Martínez (Eds.), *Risk habitat megacity. The case of Santiago de Chile*. Heidelberg, pp. 87–108.

O'Brien, K., Eriksen, S., Nygaard, L., & Schjolden, A. (2007). Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy, 7*, 73–88.

Orellana, A. (2009). La gobernabilidad metropolitana de Santiago: la dispar relación de poder de los municipios. *EURE, 35*(104), 101–120.

Preston, B. L., Westaway, R. M., & Yuen, E. J. (2011). Climate adaptation planning in practice: An evaluation of adaptation plans from three developed nations. *Mitigation and Adaptation Strategies for Global Change, 16*, 407–438.

Romero, H., & Ordenes, F. (2004). Emerging urbanization in the southern Andes. *Mountain Research and Development, 24*(3), 197–201.

Roux, D., Rogers, K., Biggs, H., Ashton, P., & Sergeant, A. (2006). Bridging the science-management divide: Moving from unidirectional knowledge transfer to knowledge interface and sharing. *Ecology and Society, 11*(1), 4.

Sanchez-Rodriguez, R. (2009). Learning to adapt to climate change in urban areas. A review of recent contributions. *Current Opinion in Environmental Sustainability, 1*, 201–206.

Wisner, B., Blaikie, P., Cannon, T., & Davies, I. (2004). *At risk: Natural hazards, people's vulnerability, and disaster*. New York: Routledge.

Participatory Action Adaptation: Tools for Increasing Climate Change Capacity and Preparedness at the Local Government Level

Lucinda Fairhurst, Priscilla Rowswell, and Faith Chihumbiri

Abstract Climate change is expected to have severe physical, social, environmental and economic impacts on cities worldwide, both directly and indirectly. These impacts are expected to have a disproportionate effect on those living in poverty in developing countries, particularly Africa.

In July 2009, ICLEI Africa Secretariat initiated the Five City Adaptation Network project. Already the project is providing some useful and insightful information on the current understanding and experiences of the threats associated with climate change, adaptation and climatic data resources available in Southern Africa. Due to the variety of respective governance and decision-making processes of the cities, the project utilizes a number of entry points (i.e. different sectors or departments) in order to ensure that the project is aligned to areas that are prioritized by the cities and where projects of similar nature are already underway. The use of these tools has assisted and improved the interaction with the various key stakeholders around the topic of climate change and adaptation whilst moving towards enhancing engagement and holistic decision-making processes covering climatic risks, sectoral linkages and the development of locally appropriate adaptation mechanisms. Through this project, a number of mechanisms and tools have been developed to understand the risks, impacts and vulnerabilities at the local level and to prioritize the climatic variable/s that is/are currently impacting the city services, infrastructure and reliability as service providers (i.e. infrastructure, day-to-day service delivery and livelihoods of the local population). This paper describes some of the tools that have been recently developed by the ICLEI Africa team and are being used in Southern Africa to develop and increase capacity around the terms and complexities pertaining to climate change. These tools will also enable the

L. Fairhurst (✉) • P. Rowswell • F. Chihumbiri
ICLEI – Local Governments for Sustainability, Africa Secretariat, Wale Street, 8800 Cape Town, South Africa
e-mail: lucinda.fairhurst@iclei.org; priscilla.rowswell@iclei.org; faith.chihumbiri@iclei.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_26,

identification of local climatic risks and locally appropriate adaptation options that are likely to increase the resilience of African local governments and communities.

Keywords Adaptation • Southern Africa • Climate change • Key stakeholder • Tool

1 Introduction

Significant uncertainties remain concerning the exact magnitude, rate and geographical impact of climate change. Despite this, there is strong evidence in current literature and climatic measurements to demonstrate that, as a result of increasing greenhouse gas emissions, atmospheric and sea surface temperatures are rising.

Africa covers more than one-fifth of the Earth's total land area and it is the second largest continent, with one billion people as (UNEP 2006). Although it has abundant natural resources, it remains the most underdeveloped continent globally. Extreme poverty, uncoordinated governance, poor access to water, sanitation and health services and malnutrition from inadequate food supplies threaten to slow Africa's progress (Sandbrook 1985, State of African Cities 2010). Despite Africa's negligible contribution to greenhouse gas emissions (IPCC 2007), the average sub-Saharan African will bear a threefold population-based risk of suffering adverse effects of climate change when compared to the global total (Byass 2009). The Stern Report concludes that 'the poorest will be hit earliest and most severely'. In many developing countries, even small amounts of warming will lead to decline in agricultural production because crops are already close to critical temperature thresholds. The human consequences will be most serious and widespread in sub-Saharan Africa, 'where millions more will die from malnutrition, diarrhea, malaria and dengue fever, unless effective control measures are in place' (Stern 2006, 84).

Africa is particularly vulnerable to climate change and associated climate variability as the situation is aggravated by the interactions of 'multiple stresses'. These 'multiple stresses' include endemic poverty, complex governance and institutional dimensions, limited access to capital (including markets, infrastructure and technology), ecosystem degradation and complex disasters and conflicts. In turn, these stresses have contributed to Africa's weak adaptive capacity, leaving the continent most vulnerable to deal with impending changes (IPCC 2007).

2 Sub-Saharan Africa Project: Addressing Climate Change Adaptation

ICLEI Africa's adaptation project entitled 'Sub-Saharan African Cities: A Five-City Network to Pioneer Climate Adaptation through Participatory Research and Local Action' program was initiated in July 2009. This initiative is funded jointly by the

International Development Research Centre (IDRC), Canada, and the Department for International Development (DFID), UK, under a research and capacity-building development program called the Climate Change Adaptation in Africa (CCAA) program. This transboundary initiative aims to address the gaps in knowledge, resource, capacity and networks in five Southern African cities by strengthening their ability to plan for, and adapt to, the impacts associated with climate change.

The project utilizes various entry points within each of the cities (to ensure alignment with the city-specific priorities and local governance processes) for the project, whilst using a number of useful tools and case studies, to highlight the impacts, sectoral linkages and adaptation strategies associated with climate change which are being addressed in the Southern Africa region. Cities participating in this research include Walvis Bay in Namibia, Cape Town in South Africa, Maputo in Mozambique, Dar es Salaam in Tanzania and Port Louis in Mauritius. The projected climatic changes and climate variable trends, specific to the region, are presented and discussed within the five baseline studies (that identify potential climate-variable specific threats to infrastructure and services) for each of the cities in combination with a regional climate systems analysis report. This has been deemed to be an important process that capacitates stakeholders in understanding the links between physical changes in the regional climate system, thus assisting in offering a way to reconcile observed trends and future projected changes where they differ.

Local governments, as the sphere of government closest to their constituents, are required to make decisions and set directions for promoting social, cultural, environmental and economic well-being. Extreme climatic events and variability impact local governments and the day-to-day activities and services that they provide to their communities. Subsequently, climate risk and vulnerability need to be strategically managed to ensure resiliency.

3 Methodology of Climate Change Adaptation: Tools for the African Context

3.1 Introduction to Tools

Throughout the project, a number of mechanisms and tools have been created by ICLEI Africa Secretariat to develop, build upon and strengthen the capacity to adapt to climate change, particularly when it comes to understanding the risks, impacts and vulnerabilities at the local level. Combined, these interactions enable the key local stakeholders to engage in discussions and thus allow for the prioritization and identification of the climatic variable/s that is/are currently impacting the city the most (i.e. infrastructure, day-to-day service delivery and livelihoods of the local population).

Two tools have been developed for this purpose including the Interactive Climate Change and Climate Impact Training Tool (ICCCI Tool) and the Local Interactive Climate Change Risk and Adaptation Prioritization Training Tool (Local RAP Tool). The second of which is separated into two parts respectively: Part I: Risk Prioritization and Part II: Adaptation Mechanism Identification. Both tools assist in providing direction and focus towards increasing adaption capacity, in a relatively short period of time, at the local government level. These participatory action research tools encourage and promote discussion and dialogue across multi-faceted, multi-disciplinary and multi-sectoral stakeholders to engage with each other on and around climate change and adaptation. The methodologies of the two tools are discussed in the next sections.

3.1.1 Interactive Climate Change and Climate Impact Training Tool (ICCCI Tool)

The aim of the ICCCI Tool is to assist key stakeholders at the local level (i.e. representatives of local governments, businesses, communities spanning a wide demographic range, rate payers, NGOs, CBOs etc.) to (a) understand the concept of climate change, (b) become familiar with the terminology used and (c) to comprehend the impacts that are projected to occur in relation to the climatic variables (flash floods, sea level rise, wind speed, etc.). The tool uses pictures and images of the planet Earth and its atmosphere to describe climate change, with a particular focus on the anthropogenic influences that are contributing to greenhouse gas emissions and the phenomena known as global warming (Fig. 1). This is further simplified to the local government jurisdiction. For clarity purposes, local examples are given in conjunction with the tool during capacity-building events (i.e. the changing of the local climates that are often associated with deforestation, etc.) and thus enhancing the discussions pertaining to current scientific projections.

This tool can be used in a number of situations:

1. This tool is a 'capacity and understanding' building tool that can be used by any individual (who has some prior knowledge of climate change) to communicate, educate and increase awareness of climate change in its entirety (at the global and local levels) through understanding of the global processes and that there are in fact no geographical boundaries when considering climate change.
2. In the interests of developing strategies and plans at the local government level and enhancing the adaptive capacity of the local communities through increasing knowledge (even if only to educate them about the potential threats they may be facing).
3. This tool should be used upon entering into interaction with key stakeholders at the local level. Dependent on the audience present, the terminology used can be raised and simplified to enable access and understanding of the complexities surrounding climate change.

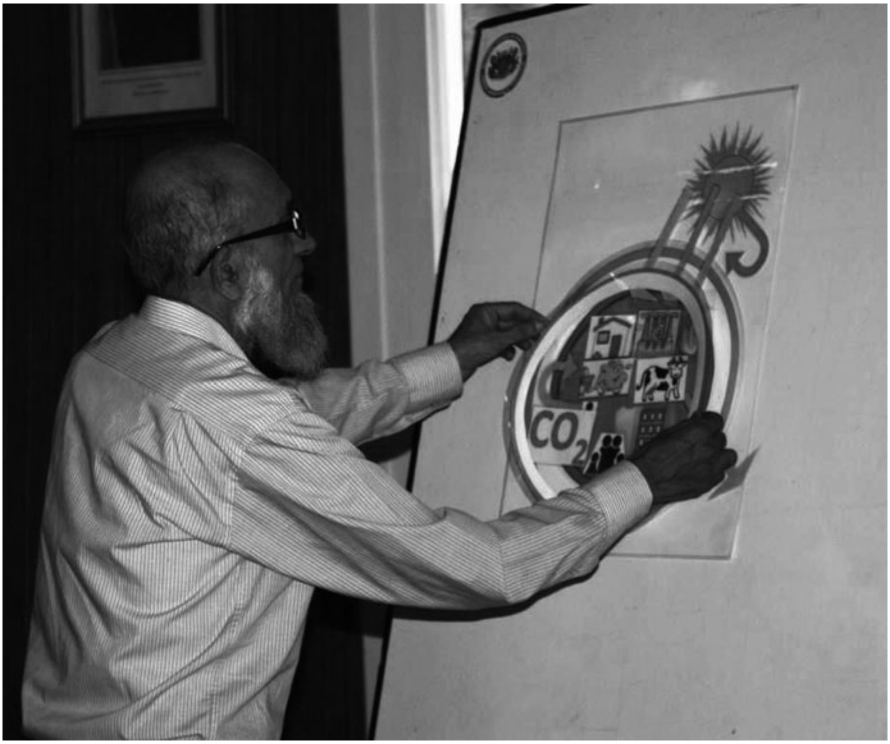


Fig. 1 Local government official from Port Louis Municipal Council, Mauritius, engaging with the climate change capacity-building exercise using the ICLEI Africa ICCCI Tool

3.1.2 Local Interactive Climate Change Risk and Adaptation Prioritization Training Tool (Local RAP Tool)

The aim of this tool is to assist key stakeholders at the local level to prioritize which climatic variables they consider themselves to be the most vulnerable too. A participatory process is then undertaken, whereby adaptation options are shared (in card format and with verbal description), discussed and considered for decisive action. The tool allows for the climatic threat, per climatic variable, to be discussed and unpacked at a very basic level. This is to ensure that all participants are on the same page whilst identifying and deciding upon which of the climatic variables, and their associated threats, are considered to be of priority. Figure 2 illustrates key stakeholder discussing amongst the group the impacts associated with drought, the prioritized variable. Subsequently, the process moves on towards the identification and prioritization of locally specific adaption options.

The first component of this tool assists local governments and other key stakeholders, that fall within their jurisdictions, to prioritize (given the perceived and experienced climatic threats associated) which climate variables, such as sea level

Fig. 2 Key stakeholders from the Temeke Municipal region in Dar es Salaam, Tanzania, discuss and highlight key sectoral impacts in combination with significant events that have previously occurred

rise (permanent and impermanent) and changing rainfall and precipitation patterns, are considered to represent the greatest risk to the present area (see Fig. 3). This part of the tool aims to enhance and encourage interactive discussions around the variables that are considered to be a threat and thus provide direction for the second part of the tool.

The second part of the tool is geared towards driving the initial processes that have been previously presented whilst encouraging open discussion and further interaction. The tool moves towards understanding how climate change variables are likely to manifest themselves in the physical sense (i.e. flooding, drought and sea level rise). The intent, as described by the facilitator, is to encourage forethought towards the identification of suitable and locally appropriate adaptation options whilst considering the local context. Such processes therefore include the identification and prioritization of climate variables (and their associated impacts) which are considered to be exerting the most pressure upon the day-to-day activities of governmental services and infrastructure, the communities and the businesses that fall within the jurisdiction of the local authority.

This part of the tool requires the facilitator to explain and identify, with the aid of the participants, adaptation options that fall into the following categories:

- Community-based adaptation options (i.e. community-owned actions)
- Institutional adaptation options (i.e. institutional arrangements and governance practices)
- Biophysical adaptation options (i.e. the use of natural, soft, biodiverse and ecosystemic measures)
- Infrastructural adaptation options
- And finally, the possibility of preparing a managed retreat

Fig. 3 A Topnaar community member from Walvis Bay, Namibia, explaining to workshop participants, the identified and prioritized climatic variable seen to be exerting the most pressure in the local context, specifically how increasing temperatures are impacting community members

The following two images illustrate this process whereby participants are grouped into smaller interactive discussion groups to discuss and identify the most suitable locally appropriate adaptation options from the above categories that is thought to increase resilience within the given area (Fig. 4). A representative from each discussion group is then required to feedback on the selected adaptation options for the specific prioritized climatic variable, which enables the rest of the participants to intervene and prioritize most necessary steps towards climate resilience (Fig. 5).

These options are then incorporated within the risk/cost/benefit matrices (varying methodologies are used) from where informed decisions and directions can be agreed upon as the next implementation steps.

This tool can be used in a number of situations:

1. To assist local governments and key stakeholders to prioritize areas of focus for action, in terms of climate change (part one). The methodology used ensures

Fig. 4 Illustration of the Tuamoyo community from Temeke, Dar es Salaam, Tanzania, discussing locally appropriate community-based adaptation options for increasing resilience to extreme high temperatures that are already being experienced at the local level

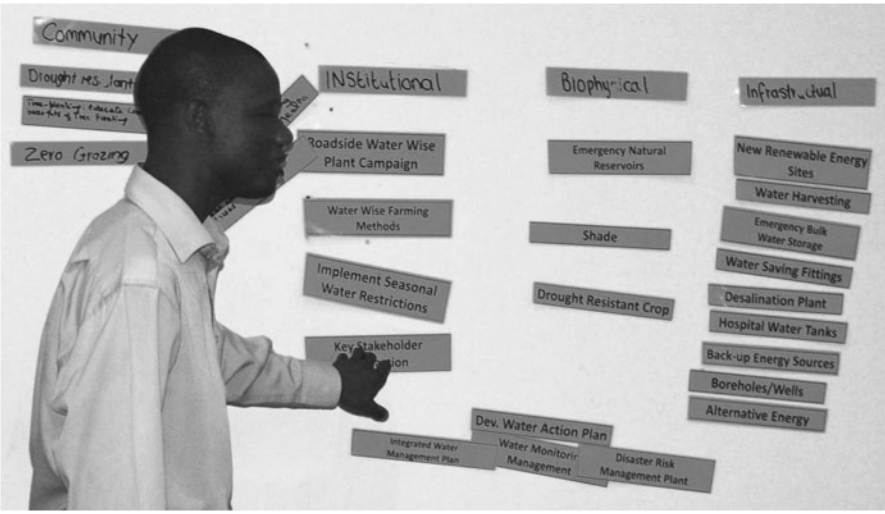


Fig. 5 Locally appropriate adaptation options selected and identified by the key stakeholders within Temeke Municipality, Dar es Salaam, Tanzania. These are considered to increase resilience towards drought within the municipal jurisdiction and are cross-cutting in nature, level and cost as are applicable at the community, institutional, biophysical, infrastructural and managing retreat

that this is an open and transparent process whilst encouraging open dialogue between all involved.

2. The second part of the tool elaborates upon this, provides a number of adaptation options (from a sectoral perspective), catalyses discussions and initiates decisions around which adaptation options are applicable in the given local context. Please note that there may be other options that have already been identified and applied at the local level which should, if appropriate, be included for future use.
3. This tool can be used with variety of stakeholders and should not be used in isolation, as the results from this should then be further analysed and tested for appropriateness using methodologies, such as the cost/risk/benefit matrices, prior to providing direct advice and steps forward.

4 Benefits and Conclusion

The tools were initially developed to increase and enhance capacity and knowledge on climate change and thus increase preparedness through participatory research and local action of African local government officials and key stakeholders. Images, illustrations and the use of local examples when using the tool assist in overcoming language barriers from a broad multilingual African continent. The tools encourage and enhance open interaction and discussion amongst participants, drawing cumulative knowledge pertaining to climatic changes, impacts associated with climate variables and adaptive actions considered most valuable from elderly community members with vast experiences.

The use of the ICCCI and Local RAP Tools described above provides an ideal medium for local multi-stakeholder interactions regardless of age, gender and wealth status, thus enabling ICLEI team members to obtain information from all aspects and dynamics within a participating city. The tools are flexible and can therefore be adapted to address climate vulnerabilities pertinent to a city respective of magnitude and socio-economic factors within the local context. Technical aspects of the tools are easily adjustable, dependent upon the audience and level of participant. The language at which the tool is pitched can be simplified to reach an audience that is unfamiliar with the topic, such as urban communities. More technical language can be used when undertaking these activities with informed/educated key stakeholders, allowing a broader and deeper understanding of the complexities and uncertainties related to climatic variability and climatic projections at the local level. These technical flexibilities allow all participants from a variety of backgrounds to actively participate and to reflect on local experiences from past and current events and any (if appropriate) gradual climatic changes.

Past personal experiences described by individual stakeholders and/or organizations have indicated that the tool encourages the development of thought processes between a variety of stakeholders. Discussions are created when participants present on impacts associated with their prioritized climatic variable. The impacts identified often link to direct and indirect (i.e. knock on affects) impacts that are associated with a single climatic event such as socio-economic, political or environmental facets, which allude to community vulnerability and disrupt the sustainability of livelihoods.

The valuable anecdotal and indigenous knowledge is then captured for consideration during the development and formulation of a tailor-made adaptation framework appropriate in the local context. This will provide necessary steps for increasing adaptive capacity and additionally will lay the groundwork for the participating city and other key stakeholders (i.e. businesses, community members and researchers from a range of disciplines) to implement smart climate actions towards increasing climate resilience.

The tools and workshop aides have been successfully utilized across cities and local governments in Southern Africa in a number of different languages and have consistently proven to be very useful in terms of capacity building and inciting discussions around pertinent climate-related issues in the local context. The tools have also proven to be robust enough so as to ensure climate change can be presented at many different levels without distorting the message or compromising on the valuable outcomes. Use of the tools have also simplified the notion of climate change from an abstract and complex idea to something that is easily accessible and understood by civil society in order for key stakeholders and community members to take ownership of actions towards increasing resilience to climatic events. Stewardship is instilled at all levels (i.e. from community members to decision-makers). These key stakeholders actively contributed towards the formulation of locally appropriate adaptation frameworks through undertaking the tools' step-by-step processes and then are able to pass on good practices to peers and younger generations to sustain and build upon the knowledge leant.

References

Byass, P. (2009). Climate change and population health in Africa: Where are the scientists? *Global Health Action, 2*. Global Health Action 2009. DOI: 10.3402/gha.v2i0.2065.

IPCC (Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R., & Yanda, P.). (2007). Africa. Climate change 2007: Impacts, adaptation and vulnerability. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, & C. E. Hanson (Eds.), *Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change* (pp. 433–467). Cambridge: Cambridge University.

Sandbrook, R. (1985). *The politics of Africa's economic stagnation*. Cambridge: Cambridge University.

State of African Cities. (2010). Thierry Naudin (Ed.), The State of African Cities 2010: Governance, Inequality and Urban Land Markets (pp. 268). UNON/Publishing Services Section/Nairobi, ISO 14001:2004-certified.

Stern, N. (2006, October). *Review on the economics of climate change*. H.M. Treasury, UK. http://www.sternreview.org.uk.

UNEP (Chenji, M., Mafuta, C., & Abdelrheim, A.). (2006). Africa Environment outlook 2: Our Environment, our Wealth. Chapter 3 (pp. 78–118).

Knowledge and Information for Resilient Cities

Birgit Georgi, Aleksandra Kaźmierczak, and Hartmut Fünfgeld

Abstract Climate change is a reality and it will impact human and natural systems despite the worldwide measures to limit greenhouse gas emissions. Adaptation to climate change is therefore an urgent task, and while climate change is a global challenge, adaptation needs to be place based. Adapting to climate change requires a multi-level approach supported by sufficient and suitable information regarding the different stakeholders. Despite existing information gaps, a vast amount of knowledge and information related to climate change has already been generated and made available, yet in practice, only a fraction of this information is used by adaptation policy makers and decision-makers. The skills and capacities of adaptation stakeholders to use existing information are constrained – at the community, local and national government level, among European policymakers, researchers and knowledge providers. Difficulties exist regarding identifying knowledge from a wide range of sources, analysing this information and adapting it to the local context. A collaborative approach, a common language and a continuous collaborative learning between the different stakeholders can help overcome these barriers.

Keywords Adaptation • Cities • Information • Knowledge base • Multi-level governance

---

B. Georgi (✉)
Project Manager, Regional vulnerability and adaptation, European Environment Agency, Kongens Nytorv 6, 1050 Copenhagen, Denmark
e-mail: birgit.georgi@eea.europa.eu

A. Kaźmierczak
School of Environment and Development, University of Manchester, Oxford Road, M13 9PL Manchester, UK
e-mail: aleksandra.kazmierczak@manchester.ac.uk

H. Fünfgeld
Climate Change Adaptation Program, Global Cities Research Institute, RMIT University, GPO Box 2476, Melbourne, VIC 3001, Australia
e-mail: hartmut.fuenfgeld@rmit.edu.au

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_27,

1 Introduction

Climate change is a reality. While mitigation measures may eliminate or reduce climate change in the long-term, adaptation is necessary in order to prepare for and respond to existing and future risks associated with the changing climate. Due to the diversity of local conditions, bottom-up, context-specific approaches to climate change adaptation are often recommended (Biesbroek et al. 2010), and the local administrative level is suggested as optimal for planning and implementing adaptive actions (Alber and Kern 2008). In particular, cities worldwide are at the forefront of climate change adaptation as they inhabit more than half of the global population; in Europe, urban dwellers comprise approximately 75% of the total population, predicted to rise to 80% (and to 90% in certain countries) by 2020 (EEA 2006). Correlating to these figures, the bulk of human socio-economic activity is concentrated in cities, and climate change and its impacts on human social and economic systems, including quality of life, will affect urban areas. Consequently, cities urgently need to act on building their resilience to climate change in order to protect themselves from these potential impacts. To achieve greater resilience, cities need support from both national and regional governments.

A prerequisite of adapting cities to climate change is sufficient knowledge about the expected local impacts, the context-specific vulnerability of cities and the options to adapt. In the context of a multi-level governance approach to climate change adaptation, further knowledge is needed about the interlinkages between different cities, regions and sectors, as well as information regarding the implications of regional-, national- and EU-level climate change policy for the local government sector.

Although a body of knowledge on local climate change adaptation is developing, a number of challenges with regard to such information remain unresolved, including:

– The need to identify what kind of information is already available and what knowledge and information gaps remain with regard to local adaptation.
– Even though some information is readily accessible, it may first need to be 'translated', either to suit a particular local context or to be understood by those making decisions on adaptive actions.
– At an organizational level, capacity constraints remain regarding identifying knowledge from various sources, analysing it and putting it to use in the local context.

2 The Cities' Perspective

Most local governments in Europe are aware that climate change is a pressing issue that requires adaptation measures. For example, in France the national regulation

Grenelle II[1] commits all regional authorities to consider climate change adaptation in their plans (Keskitalo 2010). In many European countries, however, there is still little policy guidance specifically on adaptation, and local adaptive action remains largely a voluntary task for local authorities (Alber and Kern 2008).

A number of cities in Europe, including London, Copenhagen and Rotterdam, have developed climate change adaptation strategies (Carter 2011). However, besides the front runner cities, which deal with adaptation in depth, the majority of European cities still struggle to cope with the task. A recent national-level assessment of UK's progress in preparing for climate change concluded that there is little evidence of tangible and systematic adaptation actions on the ground (Carter 2011; ASC 2010). This may be because local authorities often have a limited understanding of climate change and its impacts at the local scale and see these issues as better resolved at a higher level (Wilson 2006).

Data and information constraints are a common problem. There are notable exceptions of cities that have considerable amount of data and experience in climate change adaptation. In Stuttgart, Germany, the municipality has a special section called 'Urban Climatology' within the Office for Environmental Protection (Kazmierczak and Carter 2010). Moreover, since 1938, the city council has employed meteorologists who have provided the city with extensive data on local climatic conditions. This knowledge and experience allowed to develop the city's Climate Atlas, which in turn supports the planning policies aimed at lowering the surface temperatures and improving the air quality in the city (Kazmierczak and Carter 2010). Despite such pioneering work being undertaken in some cities, the majority of municipalities have limited capacities to apply general meteorological and climatological knowledge and translate it to the local context.

Data constraints were indicated during the European GRaBS (Green and Blue Space Adaptation for Urban Areas and Eco Towns) INTERREG IVc project, which included 14 partners, drawn from eight EU member states, representing a broad spectrum of authorities and climate change challenges, all with varying degrees of strategic policy and experience. The participating cities and regions were asked to develop inventories of the spatial data related to climate risks and vulnerabilities. The differences in availability of data among the different authorities were staggering, as the number of datasets varied between 7 and 67 (Kingston 2011). Whilst some data related to climate hazards and vulnerability of cities has been made available by the GRaBs project at the European level, this resource has not been found particularly relevant for the local authorities. This may be associated with the coarseness, or low resolution, of spatial data at the European level (Fig. 1), which is difficult to scale down to be useful in a spatial planning context (Cavan et al. 2010).

However, the problem often is not that appropriate information does not exist but that cities do not have the adequate resources to retrieve this information or

[1]France. 2010. "Grenelle II: Loi n° 2010-788 du 12 Juillet 2010 portant engagement national pour l'environnement." http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022470434

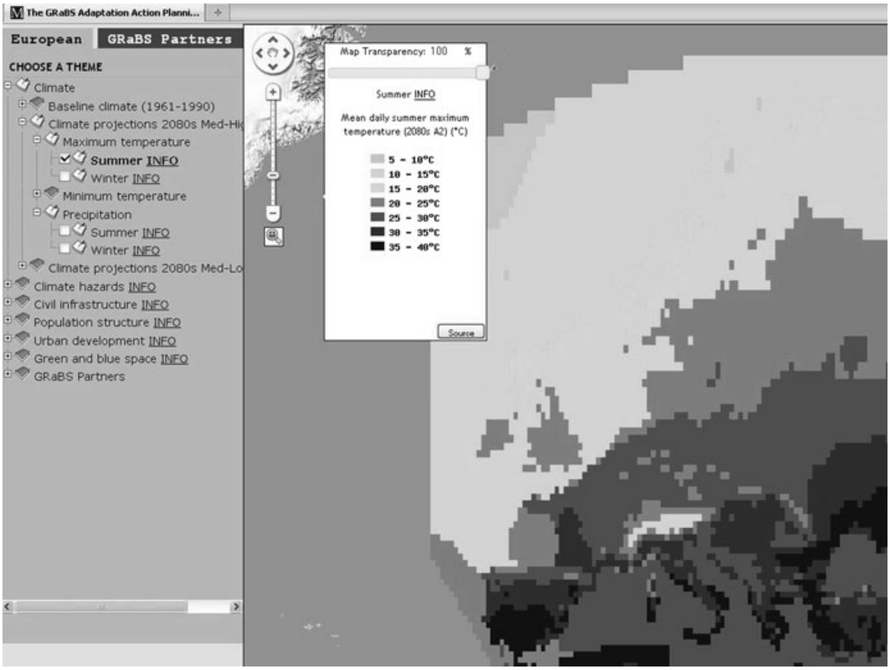


Fig. 1 Screenshot of the GRaBS Risk and Vulnerability Assessment Tool. This map shows the mean summer maximum temperature across Europe for the period 2071–2100 (2080s) under the A2 (medium-high) emissions scenario (*Source*: University of Manchester 2011)

lack understanding regarding which information they need to plan their adaptation actions. In order to deal with information-related capacity constraints, cities first need to increase their awareness regarding the urgency of climate change adaptation. In some cases, extreme weather events, such as the floods in England in 2007 (Pitt 2008) or the 2003 heat wave causing an estimated 80,000 excess deaths across 12 European countries (EC 2008), have created a political window of opportunity for raising awareness on climate change adaptation (Alber and Kern 2008). At the municipal level, these can help to put adaptation at the forefront of the local government agenda; however, the losses caused by such events strongly suggest that other means of raising awareness are needed.

In order to raise the importance of adaptive actions and close the knowledge gaps, some cities have taken the lead by forming direct collaborations with universities and research institutions on climate change adaptation. In the Netherlands, the Knowledge for Climate Research programme is operated by a consortium of government organizations, businesses and research institutes. One of the core projects in this programme is the ‘Climate Proof Cities’, which investigates urban climate change and its impacts, the vulnerability of cities to these impacts and the possible adaptation responses. Close cooperation of cities such as Rotterdam, Amsterdam and The Hague with research institutes aims to optimize the transfer of research findings into policy and practice (Carter 2011).

Another option for cities to expand their knowledge base is to learn from each other's experiences via participation in national and/or international networks. The ICLEI Resilient Cities initiative is probably the best known network of this type. The extensive list of the ICLEI Resilient Cities members illustrates that city networks are not exclusive to pioneer cities but that they can involve cities with varying levels of performance and ambition, and thus facilitate learning (Alber and Kern 2008). In addition, less extensive networks can also be effective. The GRaBS project facilitated the exchange of knowledge and experience through an intensive programme of project meetings and mentoring visits, where the partners would perform the role of either the mentor or the mentee. Another example is Toronto, often considered one of the world's leading cities in adaptation, which has joined the Alliance for Resilient Cities (a network of Canadian cities) and the US Urban Leaders Adaptation Initiative in order to exchange information and ideas with peers in other cities. The city also established its own network (the Toronto Urban Climate Change Network) to support co-operation among governments, universities, colleges and non-governmental organizations on climate change mitigation and adaptation actions and strategies relevant to the City of Toronto (Kazmierczak and Carter 2010).

In addition, cities are increasingly recognizing the value of bottom-up information as complementary to that obtained from research and climate science. Local community knowledge and the involvement of local specialists can be decisive in adaptation processes, including local expertise in areas which cannot be directly labelled as 'climate change knowledge', such as information generated by waste water companies, hobby bird watchers or hospitals. Mobilizing this knowledge by a participatory and gradual approach can be a significant source of knowledge and inspiration in collaborative local adaptation processes (see also Box 1).

Box 1: Practical Examples: Collaborating, Learning and Developing a Common Language for Climate Change Adaptation

A practical approach which combines all three elements mentioned above is co-authoring of publications. Here the different stakeholders learn and benefit from each other's knowledge and develop nearly automatically a common language. In Australia, for example, staff from the Victorian State Government Department of Sustainability and Environment (DSE) have collaborated on the development of a series of internal discussion papers with climate change adaptation researchers from RMIT University in Melbourne, as part of the project 'Framing multi-level and multi-actor adaptation responses in the Victorian context' (Fünfgeld and McEvoy 2011). The discussion papers aim to raise awareness on place-based climate change adaptation planning

(continued)

Box 1: (continued)

and engage staff from across the department in a debate on organization-wide directions for climate change adaptation via a staged stakeholder engagement process. A collaborative research facility, the Victorian Centre for Climate Change Adaptation Research (VCCCAR), was set up with funding from the Victorian State Government to facilitate this type of exchange and collaboration among researchers and policymakers. For further information, visit www.vcccar.org.au.

A European example, the recently completed Interreg IVc project Green and Blue Space Adaptation for Urban Areas and Eco Towns (GRaBS), which involved a consortium of local and regional authorities, research institutes and non-governmental organizations, culminated in the common publication of a special issue of the Town and Country Planning Journal. This publication presented perspectives of different stakeholders and summarized their experiences in the project. During the GRaBs project, also a number of expert papers were produced by different project partners, helping to develop a common understanding. They can be found here: http://www.grabs-eu.org/news.php.

3 The National and European Perspective

There are many ways by which national and European governments and organizations can effectively support the adaptive actions of cities. Cities deliver a range of services to their residents and businesses, including urban planning or community and infrastructure development services. Other decision-making processes (such as legislation), however, are often outside the direct remit of city governments and require collaboration with external parties, including vertical cooperation with governments at other levels (Bulkeley et al. 2009). Developing national programmes that support local initiatives thus becomes important (Alber and Kern 2008). For example, they can provide relevant information via easily accessible locations on the internet. A central online climate information hub run by higher levels of government can save municipalities time that is currently spent retrieving such information from various existing sources and avoid duplication in data gathering.

Currently, the provision of such information hubs differs among European countries. Some countries (e.g. Germany, Denmark, France and United Kingdom) have started to establish sophisticated climate change adaptation portals.[2] These portals include not only climate information, indicators and data but also policy guidance,

[2]For examples of climate change adaptation portals in European, see: KomPass: www.anpassung.net/; Klimatilpasning: www.klimatilpasning.dk/; Observatoire national sur les ef-

decision-making models and planning tools to develop adaptation strategies and action plans. At the other end of the scale, there are countries that still have a long way to go. For example, Portugal has hardly any regional and local climate change data, and the national-level data has proven to be insufficiently detailed for use in local adaptation planning.

Thus, there seems to be a need for the development of a common approach throughout Europe to identify and collect datasets enabling successful planning for adaptation to climate change (Kingston 2011). Currently, there is no official European depository of spatial data and other information relating to climate change adaptation, which would bring together information on climate, cities and populations. The development of the GRaBS Risk and Vulnerability Assessment Tool (see Fig. 1), which aimed to bring together the open-access Europe-wide data relevant to climate risks and vulnerabilities, has revealed that this information is widely dispersed among a number of sources and provided in a variety of formats, which makes it extremely challenging to source, access and process. In addition, some gaps in the availability of data at the European scale were highlighted, in particular in relation to the characteristics of cities and populations, which make them vulnerable to climate change impacts (Cavan et al. 2010).

The challenge to provide appropriate information in one hub has begun to be addressed by the organizations that produce and manage the EU-scale data. A supranational framework for adaptation is already in development at the European level, demonstrated by the European Commission's white paper on adapting to climate change (EC 2009), which forms a foundation for the adaptation strategy plan for 2013. The European Commission is developing an EU Clearinghouse Mechanism on Adaptation, scheduled to go live in March 2012. The Clearinghouse is a web-based IT tool and database on adaptation to climate change, aiming to aid the development and implementation of adaptation strategies. It will provide relevant data and information, such as research projects outputs, on climate change impacts, vulnerabilities and adaptation options and responses. The Clearinghouse will also offer an adaptation support tool, guiding users through the policy cycle for the development of adaptation strategies. Alongside its function as a European-level information depository, the Clearinghouse is designed to promote the international exchange of knowledge and experience, for example, by permitting users to access information generated in other member states and by encouraging joint action through twinning projects. Thus, the Clearinghouse may in particular support those countries with a weaker national and local knowledge base by allowing them to learn about good practices in more advanced regions.

Besides managing information, the national governments and the European Union also support knowledge generation and exchange by funding adaptation research and by providing the institutional and financial support for capacity building at the local level. Further, many of the national and European policies

fets du réchauffement climatique (ONERC): http://www.developpement-durable.gouv.fr/English-presentation,21120.html; UKCIP: www.ukcip.org.uk/

and projects, for example, the funding of infrastructure projects, influence climate change adaptation options available to local decision-makers either directly or indirectly. Such projects need to be designed in a 'climate-proof' manner, which includes ensuring that they do not negatively impact the adaptive capacity of geographic areas, institutions or individuals (e.g. by avoiding constructing new infrastructure in flood retention areas). To this end, it is critical to collect evidence and increase the understanding of decision-makers at all administrative levels regarding the possible repercussions of EU and national-level policies and actions.

4 The Knowledge Providers' Perspective

There is no doubt that improved, high-level information on climatic change is needed to fill current knowledge gaps amongst adaptation decision-makers and practitioners. However, in order to increase their capacity to adapt, more regionally differentiated and context-specific information needs to be gathered. As such, collecting evidence on local and regional climate impacts as well as on feasible, effective adaptation measures are critical for improving adaptation responses (Satterthwaite 2008). This also means improving integration across different spatial scales of climate change information – from the global down to the local level. For many adaptation decision-makers, the large variety of available information has proven difficult to navigate due to time and capacity constraints and due to conflicting messages and the uncertainties intrinsic to climate scenarios. Therefore, local and regional decision-makers can benefit substantially from knowledge providers like universities, research institutes or information agencies feeding their climate change-related information into centrally administered information portals. This would not only help with cutting through the complexity of the information being provided, it could also improve knowledge exchange across organizations and different tiers of government and research.

Strong communication with local governments and other related stakeholders is indispensable to produce targeted and useful information services that can directly feed into adaptation strategies and action plans. This dialogue is often hindered, however, by researchers, science providers and policymakers speaking different languages. Consequently, communication between scientists, decision-makers and stakeholders about the nature of anticipated climatic changes and risks needs to be improved and the key messages tailored to the different audiences involved in adaptation processes. Increasing science communication training and developing reference banks and information repositories on climate change adaptation can be useful steps towards improving communication between researchers and end users and policymakers (Brooks and Adger 2004).

5 Lessons Learned and Conclusion

A change in current practices is required to successfully build a knowledge base for more resilient cities. This involves reaching out to broader stakeholder groups, beyond local decision-makers and climate scientists, and creating spaces for innovative and collaborative ways of problem-solving. Three elements can be considered critical for advancing the knowledge base for resilient cities and ensuring the information generated is useful to decision-makers: embracing a collaborative approach, developing a common language and committing to continuous social and institutional learning:

1. *The role of collaboration between key stakeholders cannot be overstated in climate change adaptation.* Isolated, top-down approaches to knowledge provision are likely to achieve little, as successful adaptation strategies require specific knowledge tailored to the local situation. Any adaptation process will benefit from offering policymakers, knowledge providers, business owners, citizens and communities ample opportunities to talk to each other and exchange knowledge. In particular, active collaboration between decision-makers and knowledge providers ensures that the scientific community can respond to the information needs of cities.
2. *Stakeholders need to develop shared language on climate change adaptation.* Currently, the style of professional languages, the specialized vocabularies and the interpretation of terms used in the context of climate change adaptation differ widely across various stakeholder groups. Without a common language that has a high degree of congruence across stakeholders, it is difficult to understand each other's concerns and come to an agreement. A shared language can be developed gradually through ongoing conversation, debate and mutual respect of stakeholders from various backgrounds.
3. *Continuous social and institutional learning is required.* This concerns both policymakers, who need to work together to learn about climate change impacts and vulnerabilities, and scientists and researchers, who need to improve their understanding of the information needs of the practitioners. In addition, local knowledge and views held by communities and citizens need to be given a place in collaborative adaptation processes. Centralized information portals can substantially support this process of knowledge sharing and social and institutional learning through the exchange of success stories and lessons learned from unsuccessful efforts that require further improvement.

References

Adaptation Sub-Committee (ASC). (2010). *How well prepared is the UK for climate change?* London: Committee on Climate Change Adaptation.

Alber, G., & Kern, K. (2008). *Governing climate change in cities: Modes of urban governance in multi-level systems*. OECD International conference competitive cities and climate change, 2nd annual meeting of the OECD Roundtable Strategy for Urban Development, October 9–10, 2008, Milan.

Biesbroek, G. R., Swart, R. J., Carter, T. R., Cowan, C., Henrichs, T., Mela, H., Morecroft, M. D., & Rey, D. (2010). Europe adapts to climate change: Comparing national adaptation strategies. *Global Environmental Change, 20*(3), 440–450.

Brooks, N., & Adger, N. (2004). Assessing and enhancing adaptive capacity. In B. Lim & E. Spanger-Siegfried (Eds.), *Adaptation policy frameworks for climate change: Developing strategies, policies and measures* (pp. 165–182). Cambridge: United Nations Development Programme, Cambridge University Press.

Bulkeley, H., Schroeder, H., Janda, K., Zhao, J., Armstrong, A., Yi Chu, S., & Ghosh, S. (2009). *Cities and climate change: The role of institutions, governance and urban planning*. Report prepared for the World Bank Urban Symposium on Climate Change. Department of Geography, Durham University, UK and Environmental Change Institute, University of Oxford, UK.

Carter, J. (2011). Climate change adaptation in European cities. *Current Opinion in Environmental Sustainability, 3*(3), 193–198.

Cavan, G., Kingston, R., Lindley, S., Kazmierczak, A., Carter, J., Gong, Y., & Handley, J. (2010). Climate change and urban areas: Development of a climate change risk and vulnerability assessment tool. *Proceeding of the Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors* held at Dauphine Université, Paris, September 2–3, 2010. ISBN 978-1-84219-619-9.

EC European Commission. (2008). *The 2003 European heat wave*. Brussels: Commission of the European Communities. Available at: http://ec.europa.eu/health/phinformation/dissemination/unexpected/unexpected_1_en.htm.

EC European Commission. (2009). *White paper – adapting to climate change: Towards a european framework for action* (COM 147 final). Brussels: Commission of the European Communities.

EEA European Environment Agency. (2006). *Urban sprawl in Europe: The ignored challenge* (EEA-Report 10/2006). Copenhagen: European Environment Agency.

Fünfgeld, H., & McEvoy, D. (2011). *Framing climate change adaptation in policy and practice* (Working Paper 1). Melbourne: Victorian Centre for Climate Change Adaptation Research. http://www.vcccar.org.au/files/vcccar/Framing_project_workingpaper1_190411.pdf. Accessed 22 June 2011.

Kazmierczak, A., & Carter, J. (2010). *Adaptation to climate change using green and blue infrastructure: A database of case studies*. Manchester: University of Manchester. Available at: http://grabs-eu.org/casestudies.php.

Keskitalo, C. (2010). *Developing adaptation policy and practice in Europe: Multi-level governance of climate change*. Dordrecht: Springer.

Kingston, R. (2011). Tooling up for risk and vulnerability assessment. *Town and Country Planning, 80*(6), 264–268.

Pitt, M. (2008). *Learning lessons from the 2007 floods, an independent review by Sir Michael Pitt*. London: Cabinet Office.

Satterthwaite, D. (2008). *Climate change and urbanization: Effects and implications for urban governance*. New York: Department of Economic and Social Affairs, United Nations.

University of Manchester. (2011). *Grabs adaptation action planning toolkit*. Manchester: University of Manchester. http://www.ppgis.manchester.ac.uk/grabs/start.html.

Wilson, E. (2006). Adapting to climate change at the local level: The spatial planning response. *Local Environment, 11*(6), 609–625.

Climate Change Guidelines for Urban Planning in the Basque Country

José María Ezquiaga Dominguez, Javier Barros Guerton, Efrén Feliu, Carlos Castillo, and Agate Goyarrola Ugalde

Abstract The climate change guidelines for urban planning in the Basque Country have been developed by Ihobe on behalf of the (Basque Network for Local Sustainability 2011) (Udalsarea 21) and the Basque Government as a part of the regional public policies regarding climate change mitigation and adaptation. The guidelines are configured as recommendations to municipalities with a special focus on adaptation as Udalsarea 21 has issued previous guidelines for mitigation. Work has included a wide review of initiatives on urban planning for climate change in several countries and sessions with technical staff from different disciplines and levels of government, showing widespread awareness about the problem and a common demand for a clear legal framework at the regional level. The main findings are a strategy to "translate" climate issues to local planning normative elements, and the need in the Basque planning context to "think regionally to act locally", overcoming the administrative boundaries to achieve successful adaptation outcomes in issues like flood control.

Keywords Urban planning • Adaptation • Flood risk • Urban heat island • Sea level rise • Local Agenda 21

J.M. Ezquiaga Dominguez (✉) • J. Barros Guerton
Ezquiaga Arquitectura, Sociedad y Territorio S.L., Amado Nervo 3, 3ºD, 28038 Madrid, Spain
e-mail: jm@ezquiaga.com; jbarros@ezquiaga.com

E. Feliu
Unit of Environment, TECNALIA, C/Geldo, Ed. 700, Parque Tecnológico de Bizkaia, 48160 Derio, Spain
e-mail: efren.feliu@tecnalia.com

C. Castillo • A.G. Ugalde
Basque Government, IHOBE-Sociedad Pública Gestión Ambiental, Alameda de Urquijo, 36, 6ª planta, 48011 Bilbao, Spain
e-mail: carlos.castillo@ihobe.net; agate.goyarrola@ihobe.net

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_28,

1 The Guidelines as a Part of the Basque Climate Change Strategies

1.1 Basque Government-Led Initiatives Regarding Sustainability and Climate Change

The Basque Government places great emphasis on the framework against climate change. It has therefore generated and developed different instruments to foster a low-carbon economy, including the Basque Climate Change Office, the Basque Plan against Climate Change 2008–2012, the Climate Change Bill (currently before parliament) and the new Basque Plan against Climate Change 2020 (being prepared).

As far as adapting to climate change is concerned, two of the four strategic targets of the Basque Plan against Climate Change 2008–2012 specifically tackle adaptation:

– OE3[1]: "minimize risks for natural resources"
– OE4: "minimize risks for human health, the quality of urban habitats and socio-economic systems"

The Basque Plan against Climate Change also includes four action programmes. One of those programmes covers adaptation actions, based on "anticipating climate change to preserve natural eco-systems, protect human health and adapt the socio-economic systems and infrastructures". Ihobe is a publicly owned company whose mission is to support the Basque Government's Ministry for the Environment, Land Planning, Agriculture and Fisheries in enabling environmental policies and spreading the green sustainability culture within the Basque Autonomous Community. Ihobe's main areas of action are climate change, sustainable production, eco-innovation, environmental policy, sustainable consumption, waste and resources management, biodiversity and contaminated land. Currently, Ihobe's main challenge is to contribute to the EcoEuskadi 2020 Sustainable Development Strategy, a social agreement for sustainability that sets out the path to be followed in order to advance towards more sustainable progress.

Ihobe's role in the development of the Basque Government policy regarding climate change includes:

- The K-egokitzen project started in 2007, combining the University of the Basque Country and Tecnalia research centres. Its main objective is to study adaptation strategies, by means of setting up a knowledge pool on the climate change scenarios and their impact on different sectors, such as water resources, infrastructures, urban areas, coasts and rural, land and marine ecosystems. Its mission is to produce a viable climate change adaptation programme for the Basque region.

[1]OE stands for "objetivo estratégico" (strategic target).

- Ihobe is also the Technical Secretary of UDALSAREA 21 – the (Basque Network for Local Sustainability 2011) Basque Network of Municipalities for Sustainability .[2] Set up in 2002, UDALSAREA 21's mission is to "promote the establishment of quality Local Agendas 21 and consolidate the Local Plans of Action as integrated management instruments for the municipal sustainability policies, so that they effectively contribute to environmental improvement and to the quality of life, to foster the role of the municipalities in the sustainable development policies of the Basque Country, and to raise the environmental awareness of Basque society[3]". The Local Sustainability Observatory of the Basque Country is the network's monitoring platform, publishing the Basque Country Local Sustainability Reports. As part of the Udalsarea 21 framework, a methodological guide on preparing local adaptation strategies has been published, along with a guide on incorporating climate change adaptation to the municipal urban approach. The network's actions encompass various actions aimed at raising the local governments' awareness and technical skills regarding innovative approaches to environmental issues. Among the technical tools specifically created by the network, there are software (municipal greenhouse gas emissions calculator), model municipal bylaws against climate change, guidelines for sustainable urban planning (LKS Ingeniería 2005), and methodological guides (a guide on preparing municipal programmes against climate change, along with the two mentioned above), and the dissemination of good practices developed by the members of the network. Ihobe is also active in the international scene contributing to discussion forums, as in the Resilient Cities Global Forum 2010 (Olazabal et al. 2011).

1.2 The Basque Climate Context

The Basque Country is one of the most prosperous regions of Spain. It has a population of 2,160,000 inhabitants and a surface area of 7,234 km^2. The Basque Country can be divided into three regions based on different climatic features:

- Atlantic: moderate temperatures (mild winters and summers), rainy and influenced by the sea
- Transition: influenced by the Mediterranean and oceanic climates
- Mediterranean: dry summers and cold winters

According to the first available results from the models prepared by the Intergovernmental Panel on Climate Change (IPCC), an increase in winter precipitation

---

[2]The Udalsarea 21 Network is made up of the 190 municipalities of the three provinces of the Basque Country; the Basque Government's Ministry for the Environment, Land Planning, Agriculture and Fisheries; the Basque Government's Ministry for Health and Consumers, URA – Basque Water Board and IHOBE – Public Environmental Company.

[3]As stated in Udalsarea 21 Strategic Plan for 2003–2005.

and a drop in the summer precipitation due to climate change is expected at the end of the twenty-first century in the Basque Country, which translates into an annual reduction in precipitation ranging between 15% and 20%. At the end of this century, the extreme maximum temperatures could rise between 1.5°C and 3.5°C in general terms and up to 4.7°C in the city of Vitoria, with longer heat waves in urban areas, and the extreme minimums between 1°C and 3°C. Such temperature increases, together with the variation in precipitation, are expected to affect the human and natural systems. In addition to the changes in climatic variables, the average sea level is expected to rise between 29 and 49 cm; as a result, flood risk will increase in estuaries, and beaches could recede up to 40% in some cases. Water precipitation will decline globally (9% in the winter and spring), and a change in rain patterns will increase fluvial flood risks. The expected impacts are higher temperatures (and heat waves), raised sea levels, evapotranspiration, water stress, fires, floods, erosion and variability in the rainfall system and extreme episodes.

2 The Spatial Planning Context in the Basque Country

The Basque spatial planning context cannot be understood without knowing the land-use dynamics. A large part of the Basque Country is a rugged mountain range separating the Ebro Valley from the Bay of Biscay. But for the surroundings of Vitoria (the regional capital), large plains are scarce and there has been a fierce historical competition among land uses for prime positions in the lower part of the valleys, which are often subject to flood risk (a substantial part of the housing stock was historically built on flood-prone areas, although current regulations are intended to prevent new urban growth in such conditions). Strong industrial development in the later nineteenth and most of the twentieth centuries has led to a dense urban occupation pattern in the valley plains, making it clear that land is a scarce, non-reproducible resource.

The Basque Country has a hierarchical spatial planning system defined in the state and regional land laws.[4] There are two main scales:

– What is commonly understood as regional planning in most countries (planeamiento territorial), intended to set a clear framework for land uses at the regional scale (Directories de Ordination del Territorial, DOT) and, with more detail, at a subregional scale, as the Basque Country is divided into 15 functional areas encompassing several municipalities with strong bounds. There are also specific plans that address territorial issues (transportation, fluvial flood risk, agricultural and forest uses, coastal areas) covering the whole region or parts of it.
– The municipal planning (planeamiento urbanístico) by which each municipality develops a Plan General, setting the land-use rules for its territory.

[4]The Spanish Land Law (2008) sets the basic property and citizen rights. The Basque Regional Planning Law (1990) and Urban Planning Law (2006) define the Planning document's elements and requirements. The Basque environmental framework is a decisive element for planning.

The Basque system shows a very strong link between regional and municipal planning. As opposed to other areas, regional planning in the Basque Country is not limited to defining broad strategical orientations, as it sets quantified goals for municipal residential growth and imposes strong constraints on the planning powers of municipalities. Regarding municipal Plan General, its format is closer to the French “Plan Local d’Urbanisme” than to the British “Local Development Frameworks”; in American terms, it is a full-fledged planning system (as opposed to limited zoning systems) with strict growth control and limits to private development in non-urban areas. The Plan sets detailed instructions for each land plot and flexibility at the time of defining the building project is constrained by the plan both in geometry and use patterns, as opposed to the more open systems in which the “planning application” has greater design freedom.

3 Challenges

The current challenges to ensure proper climate adaptation in urban planning in the Basque Country can be summarized as:

– Reinforcing the incipient collaborative network between policymakers and research teams in the Basque Country to improve prioritization of research needs, and the use of the results. There is a clear need for a one-stop information repository regarding climate change impact forecasts at regional and municipal scale, which could be used in planning documents as an officially endorsed source.
– Articulating a collaborative network among policymakers at different levels and across areas, to start mainstreaming adaptation and coordinate actions. Some issues (and especially those related to flooding, be it seaborne or fluvial) cannot be fully met at the municipal scale, but it was equally clear that no solution can be attained without the municipalities.
– Implementing early adaptation actions, especially at the diverse scales of spatial planning.
– Increasing collaboration with other regions, the Spanish state government and at the European scale to share knowledge.

4 Design of the Guidelines

The production of guidelines for a broad range of activities is one of Ihobe’s main tools for its good practice dissemination actions. Prior to the development of the document described below, Ihobe has published guidelines on sustainable urban planning and sustainable building construction, which has helped to focus the work in this case.

4.1 Targeted Users

The guidelines are designed with three main user groups in mind:

– Municipal architects and engineers: in broad terms, the first are in charge of urban planning, while engineers are in charge of public works and utilities.
– Municipal environmental officers: these can have a wide array of professional degrees and are usually in charge of Local Agenda 21 and environmental quality.
– Technical staff from other sections of the local government and other administrative levels (provinces, Basque government, Spanish government) and technical staff from utilities and urban services companies.

Therefore, users can have varying previous knowledge about urban planning (a complex field in which environmental and social considerations can be checked by the economic impact on public budgets). An initial choice to organize the contents of the guide according to the usual chapters of a municipal Plan General has persisted, as this is the structure in which the proposed climate adaptation strategies have to be enforced. The guidelines cannot be an introduction to the Basque spatial planning system (there are already good books about the issue), making it harder for non-planners to use. However, they try to fill the gaps in approaches in their choice of technical languages and by sets of tables relating to the different concepts.

4.2 Focus on Adaptation

The main initial goal of the guidelines was to define strategies for climate adaptation, as mitigation has been previously developed by Udalsarea 21 in guidelines for municipal emissions inventories.[5] Adaptation being such a wide field, a decision was taken to test the implications for urban planning of three impacts: fluvial-flooding risk, sea level rise and urban heat island. The choice was based on the close relation between these impacts with the field of urban planning. An initial result of the project has been a basic study of the potential implications for Basque municipalities of such impacts, showing the need to increase the climatic resilience of the existing urban areas.

4.3 Sources

The guidelines build on the experience of previous IHOBE publications. The sources used in the document also include a wide array of international documents

[5]In the final version, a more ambitious scheme in which there is also room for mitigation has been adopted, creating two main chapters, each one structured according to the Plan General's contents, but the focus remains stronger on adaptation.

regarding the interactions between spatial planning and climate mitigation, ranging from Dutch approaches to flood risks (such as the Rotterdam Climate Initiative or the Room for the River Programme) to French Climate Plans over to Japanese by-laws regarding urban heat islands or the Stuttgart Climate Booklet. These also include experiences in Spain and the Basque Country, such as the new sustainability by-laws of San Sebastian. The contributions of the members of public administration technical staff consulted for the guide have also been relevant, especially regarding their views on the feasibility of the project.

4.4 Status of the Document

The guidelines are not intended to become a part of the normative Basque planning system.[6] They can be used by each municipality as a toolkit, according to its own climatic context and local priorities, as far as that is possible in each case.

5 Adaptation Guidelines

The planning issues identified regarding climate adaptation are:

– Land classes: the land of each municipality must be divided by the Plan General in rural, urban or urban growth land class. The urban land is delineated as a result of legal criteria (mainly the pre-existence of streets and urban utilities), and the rural land is in many municipalities already partly defined by regional planning or protected areas. The main adaptation issue is a sensible definition in terms of size and location of urban growth land, avoiding climate impacts. There is also a need to ensure watershed conservation programmes in rural land, as a way to protect downstream urban settlements, and to measure erosion progress in coastal shores in order to exclude new building along potential risk stretches by including them in a specific rural land class.
– Use classes[7] and compatibility[8]: critical public facilities (health-care facilities, police stations, potential temporary shelters) should be out of risk areas, even

[6]The Basque Government is studying measures to introduce climate change relate innovations in its spatial planning laws, which could become compulsory for municipalities. As a part of the preparatory studies, see Ezquiaga and Barros (2011).

[7]"Use classes" means here the usual division of uses in land use plans: residential, industrial, offices, public facilities, parking, public open space and so on.

[8]"Use classes compatibility" means here the use assignation to buildings: there is generally a main use (residential, for instance) that often can be joined by ancillary uses (parking, retail, offices) in varying proportions and positions; the ancillary uses are then deemed "compatible" with the main use.

in pre-existing urban areas subject to risk, and evacuation strategies should exist for each at-risk neighbourhood. When considering urban heat island risk areas, a need for climatized spaces in public facilities open to all the population is clear. In terms of compatibility, restrictions should be set for uses in the lower floors of buildings on flood-prone zones, and climate-proofing requirements should be defined for changes of use in pre-existing buildings.

– Urban infrastructure requirements: the guidelines propose the creation of a database of street conditions for the whole municipality, including street materials, building details and potential role as flood barriers, and a study of the sensitivity of water and electricity urban infrastructure to flood. This would lead in each municipality to the inclusion on the Plan General's by-laws of specific requirements for public works. There are specific problems with historical heritage areas in which often some of the elements on which a social consensus for conservation exist conflict with general adaptation issues.[9]
– Building requirements: the growing detail in the state's building code has reduced the size of such requirements in urban planning. Despite that fact, some issues still require a local regulation and are related to climate change adaptation: the choice of materials in façade (raising the issues of albedo), requirements for double-aspect[10] units in new housing (reducing the need for air conditioning in summer) and choice of constructive solutions for climate proofing of pre-existing buildings.

6 Conclusions

The clear awareness that has been detected in the Basque technical staff at all levels of government during the guidelines preparation shows that spatial planning holds a real potential as a climate adaptation tool, but this requires a clear integration of all scales of land-use planning with sectoral planning (water management, emergency planning, public facilities management) and the use of common scenarios and guidelines in public policies. Nevertheless, there is a clear chance for a set of voluntary rules that can be used by municipalities while the Basque Government prepares legal modifications in that sense. The main fields for this kind of local action in the Basque Country are:

[9]A usual comment among municipal staff consulted during the preparation of the guidelines was the need for a protocol to act in cases of historical bridges or structures that deserve historical protection but constitute a clear risk-worsening factor in fluvial flooding. Although diversion channels and other means are technically feasible, their cost is a powerful deterrent, raising the issue of a need for choice criteria. As opposed to mitigation, in which renewable energy generation can help reduce emissions and be financially sustainable, no such thing happens in this case.

[10]Double aspect housing units have openings to opposed façades, allowing for cross-apartment natural ventilation.

– Improving the knowledge about the real conditions of the municipalities, especially about urban issues, in terms of building materials, public utilities and facilities (stock and usage), real uses of the land and buildings and risk factors. This knowledge must be constantly updated, going beyond a mere formality during the planning revision procedures; it is complex, as many data depend on private companies or have to be produced without previous sources. But it is a powerful tool to dynamically adapt public policies to the evolution of climate.
– A stronger link between Local Agenda 21 and urban-planning documents. This proves complex as the scopes of both are clearly different, as well as their legal status regarding private rights, but it is clearly the way to a stronger municipal approach to climate change.
– Defining climate-proof urban growth, locating the regional planning-allocated growth quota in areas that contribute to minimize the urban heat island effect and take into account predicted impacts on the coast and the rivers.
– Climate proofing of existing neighbourhoods in risk areas; this can be more efficient at the municipal scale regarding urban heat islands, as changes in urban greenery, public open spaces, use compatibility schemes and building refurbishment can be implemented without a need for coordination with other instances, but there is also room for actions regarding infrastructure adaptation to the rise of the sea level. Usually, fluvial flooding requires a wider, watershed-oriented approach, but there is room for action regarding the correction of urban drainage problems caused by street design.

The climate change guidelines for urban planning in the Basque Country can be summarized as a first toolkit for municipalities wishing to integrate good climate adaptation practices in their land-use planning, as part of a bigger picture in which eventually all these aspects will be covered by region-wide regulations.

References

A wide array of good practice guides regarding environmental policies and climate change is available at http://www.ihobe.net/Publicaciones

Basque Network for Local Sustainability. (2011). Available at: http://www.udalsarea21.net

Basque Regional Planning Law. (1990). Ley 4/1990 de 31 de mayo, de Ordenación del Territorio del País Vasco. Available at www.euskadi.net

Basque Research Center, BC3, University of the Basque Country, Ihobe (publisher). (2009). *Mapa de Conocimiento de Cambio Climático en la Comunidad Autónoma del País Vasco (A map of the Climate Change Knowledge in the Basque Country Autonomous Region)*. Spanish version available at http://www.ihobe.net/Publicaciones

Basque Urban Planning Law. (2006). Ley 2/2006, de 30 de junio, de Suelo y Urbanismo. Available at www.euskadi.net

Ezquiaga, J. M, Barros, J., & Basque Government Regional Planning Directorate. (2011). *Estrategias de adaptación y mitigación del cambio climático en planificación espacial. Selección y análisis de buenas prácticas y formulación de criterios de aplicación en el planeamiento territorial y urbanístico de la CAPV* [Climate change adaptation and mitigation strategies in spatial planning. Good practice review and implementation policies for the regional and local planning in the Basque Country]. Spanish and Basque versions available at http://www.ingurumena.ejgv.euskadi.net/r49-orokorra/es/contenidos/informacion/cambio_climatico_2011/es_clima/indice.html

Ihobe. (2008). *Basque plan to combat climate change 2008–2012*. English version available at http://www.ihobe.net/Publicaciones

LKS Ingeniería, M+A+S Abogados, Ihobe (Publisher). (2005). *Manual para la redacción de planeamiento urbanístico con criterios de sostenibilidad* [Guidelines for sustainable urban planning]. Spanish version available at http://www.ihobe.net/Publicaciones

Olazabal, M., Feliú, E., Izaola, B., et al. (2011). Local strategies for climate change adaptation: Urban planning criteria for municipalities of the Basque Country, Spain. In K. Otto-Zimmermann (Ed.), *Resilient cities: Cities and adaptation to climate change – proceedings of the global forum 2010*. Dordrecht: Springer

Spanish Land Law. (2008). Real Decreto Legislativo 2/2008, de 20 de junio, por el que se aprueba el Texto Refundido de la Ley de Suelo. Available at www.boe.es

Integrated Roadmapping to Shape Adaptation Processes in Metropolitan Areas

Jens U. Hasse, Martin Birke, and Michael Schwarz

Abstract Adaptation processes in metropolitan areas are notably faced with nescience and uncertainty about future challenges and with various competing stakeholders, vulnerabilities, interests and responsibilities. By using *Integrated Roadmapping*, the region Emscher–Lippe–Ruhr will develop a reference framework for a region-spanning adaptation process that both connects previously isolated topics and continuously coordinates knowledge, activities and goals of local administrations, corporate sector and society.

Keywords Adaptation • Innovation • Network • Roadmapping • Regional processes

1 The *dynaklim*[1] Roadmap for Climate Adaptation in the Region Emscher–Lippe–Ruhr (Germany)

Climate change and climate politics are some of the social-political challenges that have become neuralgic because, neither in public discourse nor in political actions, their apparent complex and sometimes admitted uncertainty are, or can be,

[1]Networking and Research Project *dynaklim* “Dynamic adaptation of regional planning and development processes to the effects of climate change in the Emscher–Lippe region (North Rhine-

J.U. Hasse (✉)
FiW Research Institute for Water and Waste Management, RWTH Aachen University, Kackertstraße 15-17, 52056 Aachen, Germany
e-mail: hasse@fiw.rwth-aachen.de

M. Birke • M. Schwarz
Sozialforschungsstelle Dortmund, ZWE of Technical University Dortmund, Evinger Platz 17, 44339 Dortmund, Germany
e-mail: birke@sfs-dortmund.de

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2, 271
DOI 10.1007/978-94-007-4223-9_29,

Uncertainties and Ambiguities in the Field of Adaptation to Climate Change

Uncertain Consequences of Climate Change

Which consequences of climate change will appear where and to which extent can only be successively and approximately identified and validated.

Long and Distant Planning Horizons

The spectrum of time horizons viewed as necessary extends, depending on the disciplinary or sectoral point of view, to 2020, 2030 through to 2050 or even 2100.

Ambiguous Objectives and Conflicts of Goals

There are as many consequences of climate change as there are objectives so that individual adaptation options and strategies may clash.

Ambiguous Constellation of Heterogeneous Stakeholder Groups and Individual Players

Ambiguous and often hidden sets of interests exist among stakeholders depending on their individual interest in climate adaptation and on whether and how they will be or could be affected. This complicates both the foresighted moderation of conflicts of interests and the foresighted arrangement of cooperation between stakeholders.

sufficiently considered. Dealing with climate change requires a fundamental understanding of its involvement in social systems and its complexity that cannot be reduced and therefore gives academics, politics and society challenges that cannot be overcome with the classic means of problem solving (Lieber and Hasse 2011).

However, the fact that alternatives to the standard political procedure cannot be restricted to a simple 'more participation' illustrates a previously little considered problem in climate politics: how can regions prepare for the unavoidable consequences of climate change in addition to climate protection, initiate policies for climate prevention and develop the necessary adaptation expertise in their sectors, industries and local administrations? Climate adaptation processes which are conceptualized for different planning horizons, continuously updated and

---

Westphalia, Germany)", funded by the German Ministry for Research and Education (BMBF) under the KLIMZUG programme ("Climate change in the regions of the future"), 2009–2014, www.dynaklim.de.

further developed to become sustainable are essentially reliant on communication, participation and cooperation. Still, they also need a well-coordinated and resource-intensive policy mix made up of prognosis, planning, moderation of interests, agenda setting, political implementation and political evaluation (Birke et al. 2011). This chapter will present the *integrated roadmapping* method, one central product of the *dynaklim* project, as a suitable format for such a reflexive-iterative policy cycle and as an instrument of participative regional planning and development. It not only constitutes an appropriate strategy method to deal with uncertainty and complexity but also an innovative tool to build regional and local adaptive capacity and a new mode of *regional adaptive governance*.

dynaklim and Emscher–Lippe at a Glance

The *dynaklim* project focuses on the possible impacts of climate change upon the **regional water cycle** in the Emscher–Lippe region (Ruhr basin) and its likely effects on the local population, economy and environment. The *dynaklim* work programme encompasses **interdisciplinary research** into the impact on the regional water balance and various **pilot application projects** for flexible adaptation on the ground.

By setting up a **sustainable regional network**, a web-based **knowledge management** system and a **region-spanning strategic process** ("Roadmap 2020"), *dynaklim* assists the region to develop into a future-based metropolitan area with distinctly strengthened ability to innovate and to adapt to climate change.

The project region encompasses **52 cities and municipalities**, including major cities like Duisburg, Essen, Bochum and Dortmund. In the region, three regional administrative boards and six chambers of commerce take on various tasks and competencies of (self-)administration. Due to a multitude of socio-economic relations, the project region is closely interlocked with all neighbouring counties, cities and water boards. Approximately **3.8 million people** live in the catchment areas of the Emscher and Lippe rivers, and 5.6 million people in the wider area.

2 Roadmapping as an Innovative Approach in Climate and Regional Policy

Climate adaptation and climate impact precaution and management have been on the international and national political agenda for many years now, but have not been well researched and hardly tested. Just like with climate protection (mitigation), a great level of uncertainty and complexity is to be expected with climate adaptation.

Precautionary and foresighted adaptation of regional planning and development processes to expected climate change impacts can therefore only be successful as a dynamically updated and continuous learning process. The '*dynaklim* Roadmap 2020' integrates forecasts, planning and knowledge instruments, and allows for a regional strategic process that pools individual issues of regional climate adaptation across the sectors, coordinates climate-political aims and action programs of local administrations, businesses and civil society and helps to develop the necessary competencies and innovations for implementation. By doing this, an action-orientated agenda is successively created which provides the necessary strategic orientation framework and implementation schedule for the coordination between the institutions and political committees. 'Guide rails' for future-based, coordinated and integrated regional adaptation policies are developed, which are orientated towards alternative adaptation scenarios and existing overall concepts, and are specified for various fields of action. With these adaptation routes, the direction and focuses of modernization (innovation) are specified and described with respect to their economic, social and ecological opportunities and risks (Birke et al. 2011).

Roadmapping is a process that was developed in the 1980s for future planning, technology prognosis and strategy development for long time horizons. Roadmapping is an attractive strategic planning and design instrument because it promises to extend the perspective and the effectiveness of conventional planning methods and because it allows reflexive and strategic handling of uncertainties and insecurity. Probable or intentional development trends are analysed and compared with possible or desired development routes. Based on this, integrated future strategies, development plans and action programs are developed and translated into (sector- or stakeholder-) specific goals, time requirements, measures and responsibilities. In addition, it also investigates how the plans can be realized and become effective in practice, which resources and expertise are required, which uncertainties, risks and faults can occur and how the implementation process can be organized in clear and practical sequences. The roadmap method therefore continues where strategic master plans, regional planning and action programs stop: it not only analyses and specifies what stakeholders, organizations and institutions should do but also how, by what, when and with which means they can do so.

This effect potential requires that:

- Techniques of future prognosis, strategy development and knowledge management can be interlinked with each other.
- Experts from different fields of knowledge and key stakeholders from the region contribute to the process as insiders, roadmap users and future bearers of continuous development.
- Scenarios and strategies can be translated into achievable innovation processes with clear sequences and specific innovation products.
- The unavoidable controversies and conflicts of interest can be moderated in a way that a problem and consensus-orientated cooperation process is guaranteed.

Effect Attributes of Roadmapping

Collaborative

The whole roadmap process is worked on in all phases and work stages by experts and stakeholders together and equally.

Integrative

Different viewpoints, interests, research dimensions and methods and expectations are problem-orientated and considered systematically so that technological, economic, social and society developments, their interaction and their possible side effects can be analysed and framed.

Process-Oriented

The road map process does not stop at formulating targets and specifications for action, but is orientated towards their participatory implementation and is therefore arranged consistently as an open-ended search and learning process – in its instruments, contents and work phases.

Iterative-Reflexive

Even if the roadmap process is reliant on elaborate working structures, instruments and methods, it is not planned and implemented in a linear, rigid and sequential way, but rather in small stages, by continuously checking its intermediate results and in regular feedback with all the participants.

The special performance of the roadmap method as a strategic, collaborative prognosis, planning and learning process therefore requires more communication, moderation, interdisciplinary and trans-disciplinary elements and requires a corresponding, complex project and process management (Lieber and Hasse 2011). This clearly distinguishes it from standard planning instruments that get by with a less complex planning concept and project management, but – at the same time – are limited to trend analysis and prognosis, the top-down development of goals and strategies and the setting up of action plans derived out of these strategies without the involvement of stakeholders. Working on, implementing and dynamically developing *customized regional strategies for climate adaptation* further does, however, not work without collaborative, participative and trans-disciplinary extra efforts. In terms of both regional and climate policies, the roadmap method proves to be promising because it is able to combine, complement and further develop existing master plans, action programs, activities and transfer experiences of the region.

The roadmap method is conceptualized and tested for the first time in this context by the *dynaklim* network and research project. The *dynaklim* roadmapping offers the chance to apply a multi-scale approach to cope with climate change as proposed by Elinor Ostrom: ‘Given the complexity and changing nature of the problems involved in coping with climate change, there are no “optimal” solutions [. . .]. The advantage of a multi-scale approach is that it encourages experimental efforts at multiple levels, as well as the development of methods for assessing the benefits and costs of particular strategies adopted in one type of ecosystem and comparing these with results obtained in other ecosystems’ (Ostrom 2010).

3 Roadmapping as a Collaborative Networking, Research and Policy Process

The fundamental task of the *dynaklim* network, now with over 50 network partners, is to jointly develop, continuously refine and implement, step-by-step, an adaptation strategy for the project region. The *Roadmap 2020* ‘Regional climate adaptation’ is the central instrument for identifying existing adaptation expertise in the region, generating new expertise as well as creating new cooperation and communication relationships. Previously treated as isolated individual issues, sectoral approaches and stand-alone solutions are bundled, relevant stakeholders integrated and adaptation-relevant targets and measures coordinated among regional stakeholders. Then, implementation priorities are specified in coordination with the responsible stakeholders and finally chronologically structured in order to receive a schedule for implementation.

Methodologically, the *dynaklim* roadmap follows the ‘integrated roadmapping’ approach (Behrendt 2010) developed by the Institute for Future Studies and Technology Assessment (IZT Berlin), which structures the roadmap process in four main phases: (1) definition of the search area and analysis of the field of action (*scoping*), (2) trend prognosis and analysis of need for action (*forecasting*), (3) determination of possible development and adaptation routes based on back projection (*backcasting*) and (4) compilation of findings and the conclusive creation of the roadmap (*roadmapping*) (Fig. 1).

The roadmap process builds on the *dynaklim* network structure and process architecture (Fig. 2) and is jointly controlled by:

- The *dynaklim* research consortium that carries out most of the roadmap work during the initial roadmap period until 2014, coordinated by a ‘roadmap editorial group’.
- The *dynaklim* network partners who act as promoters in their fields of action and actively shape, contribute to and test the roadmap.
- The *dynaklim* platforms in which the roadmap work is prepared, coordinated and evaluated together with, as well as for, all stakeholders for the specific sector.
- The ‘roadmap steering group’ in which *dynaklim* partners and representatives of the region jointly keep up with and facilitate the roadmap process and present it to the regional public.

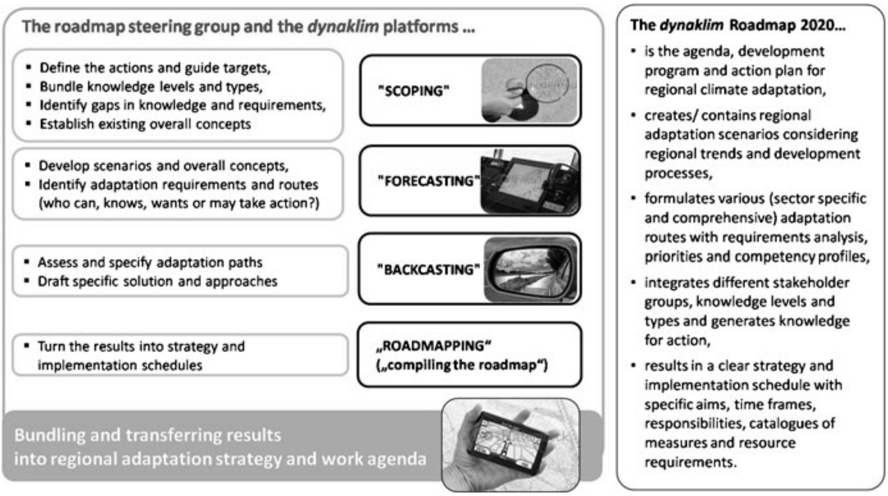


Fig. 1 The four phases of *dynaklim* roadmapping (Birke et al. 2011)

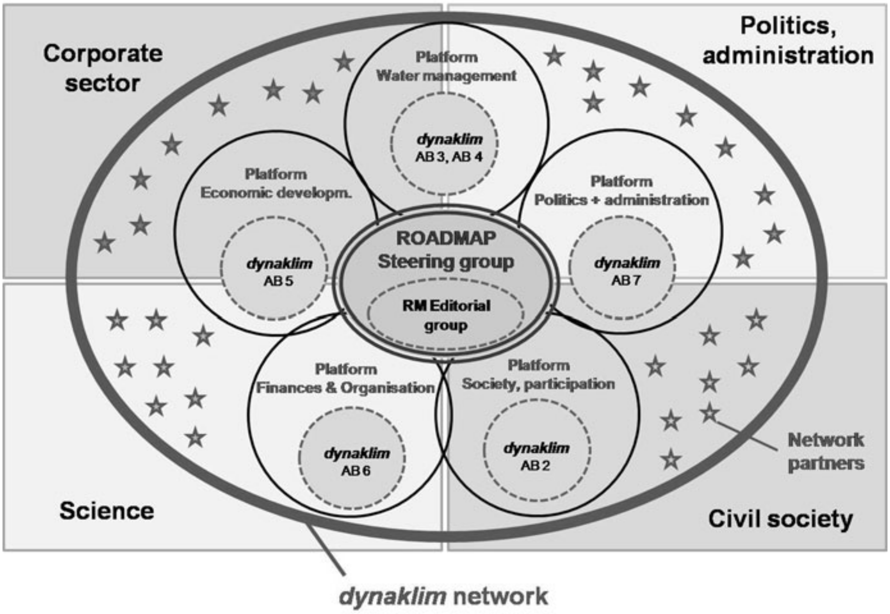


Fig. 2 The *dynaklim* roadmap architecture

- The network's 'cross-linking workshops' which help to facilitate the roadmap process across the platforms and sectors, and discuss and evaluate intermediate results throughout the project.

- The *dynaklim* monitoring and the *dynaklim* knowledge management which also contribute towards coordinating and pooling intermediate results in an intersectoral way.

In Fig. 3, we display the first 5 years of the *dynaklim* roadmap process, which are characterized by continuous compilation, exchange and refinement of information in each ‘roadmapping cycle’. This process is to be based on permanent cooperation between experts from various fields of practice and knowledge, the future users of adaptation measures and various potentially affected parties.

4 Experiences and Lessons Learned at the End of the Second Project Year

The success of the roadmap process essentially depends on how the *dynaklim* network has established itself up to this point, how the *dynaklim* roadmap 2020 is applied and continued in the coming years by the network partners, and how it is perceived by other regional stakeholders as an opportunity for joining a regional dynamic though complex climate adaptation process at low costs. The effectiveness and success of the roadmap work also place high demands on project and network management (Lieber and Hasse 2011) and are reliant on all network partners developing their own practice and project-orientated interest in roadmapping and its issues, methods and intermediate results. As of 2011, more than 50 partners have joined the regional network *dynaklim* with many of these network partners being also partners in various other regional groups and networks.

The majority of *dynaklim* network partners are local administrations (cities, counties and communities) which decided to join the network based on two considerations: (1) the need to find as early as possible adequate answers to future challenges to their responsibilities for services of general interest and (2) the need to find quick, adequate and preferably free access to high-quality knowledge about adaptation to climate change, to experienced partners and to relevant stakeholders from the region. The motivation of regional or state institutions, especially from the environmental, health and urban/regional planning sector, and of civil society groups to participate in the *dynaklim* network seems to be similar to that of local administrations, at least within their particular scope of responsibilities or interests. Most network partners clearly state that the issue of climate adaptation is only one of several other issues and change processes (e.g. climate protection, demographic change or economic/urban/sustainable development) that needs to be dealt with.

In comparison to the aforementioned three groups of stakeholders, the corporate sector for the time being poses a challenge to the networking activities of *dynaklim* and the local or regional business development agencies in the network. Recent surveys and field interviews of *dynaklim* have shown that many companies from the region see higher risks for their locations due to an expected higher probability of damages in the future and that they request more information and knowledge

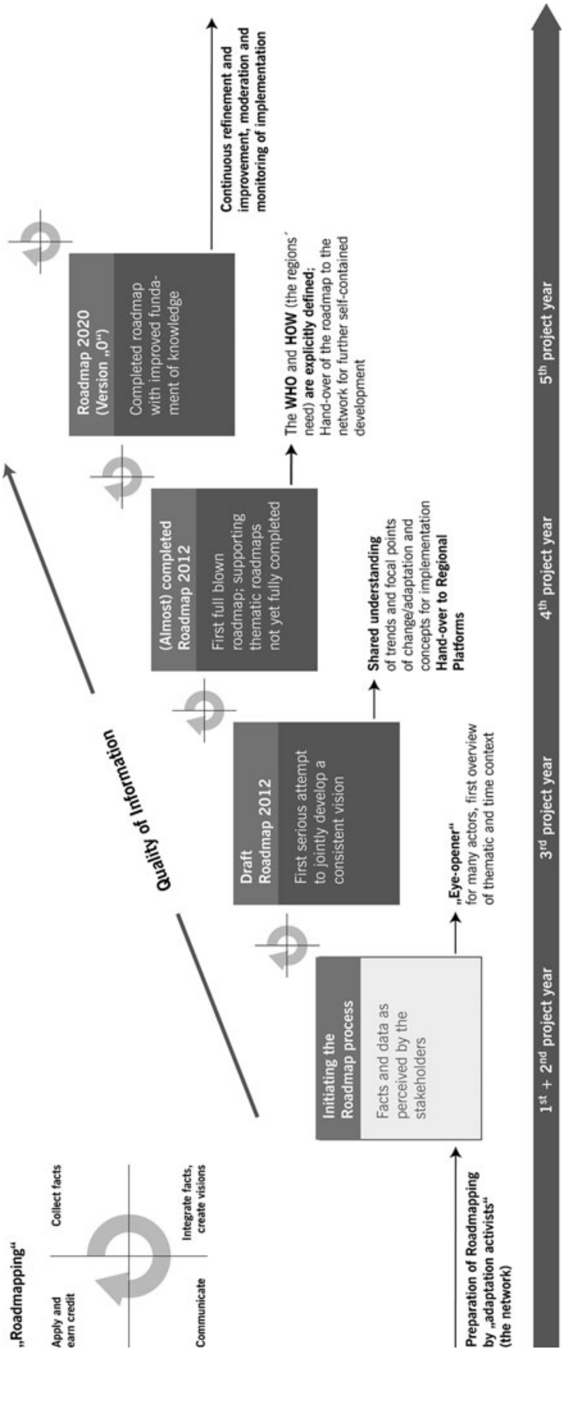


Fig. 3 The *dynaklim* roadmap process (Based on Muller 2008)

about climate risks, adaptation and opportunities. At the same time, their readiness to increase preparedness or adaptation efforts already today does not correlate with these findings, except if they already experienced damages as a consequence of extreme weather events or flooding (Rauscher 2012). Companies in the Emscher–Lippe region also appear to be by and large confident that they will be able to cope with the effects of climate change by mobilizing their individual adaptive capacity that is continuously trained and tested by the markets. It becomes clear that other incentives need to be developed for the region's companies to participate in and, at the same time, benefit from the regional adaptation process in order not to leave them out of the targeted region-spanning discussion and coordination.

Phaal and Probert (2009) found, in reviewing over 70 roadmapping initiatives in Europe, USA and Japan, that a successful roadmap initiative should be clearly linked to broader strategy initiatives. In the Emscher–Lippe–Ruhr region, there is a wealth of experience with regional planning, development programs, overall concepts and with its cooperative and informal designing and legal safeguarding (e.g. Masterplan Emscher-Zukunft, Masterplan Emscher Landschaftspark). It is foreseen that the roadmap process strategically links these experiences to the *dynaklim* goals and activities as well as to other ongoing activities and existing networks in the region. *dynaklim*'s networking activities include the network or competent network partners to become 'adaptation activists' in other regional processes, projects or initiatives, e.g. by carrying the issue of climate adaptation (and knowledge and expertise) into the mandatory process of 'Regional planning Ruhr', or by supporting and participating in regional flagship projects like 'InnovationCity Bottrop'. It has become clear that the promotion of climate adaptation as one of several cross-cutting issues in the region will most likely only be successful by partnering with the relevant networks and strategies in the fields of sustainable development, climate protection or green economy, and by integrating climate adaptation step by step in all relevant policy and administrative processes in the region ('mainstreaming').

dynaklim already enjoys strong support of a number of city mayors and of managing directors of influential regional institutions who got involved, e.g. in the network's advisory council or promote the network and its goals in the public at various occasions. But as a large part of the process of regional institutionalization, integration and full implementation of the *dynaklim* roadmap 'Regional Adaptation Strategy' will only take place after the funding period of the *dynaklim* project (2009–2014), gaining a wider and desirably politically binding support of at least the 53 cities and communities of the region and most of the regional institutions and initiatives within the next 3 years is an important task the *dynaklim* network now needs to focus on. By formulating a vision (a 'future-oriented, foresighted acting and "learning" region') and clear goals for the development of a regional adaptation strategy and by initiating and promoting the related regional roadmap process, *dynaklim* has equipped the region with the necessary tools to act in a coordinated way.

The next steps to gain the necessary political commitment need to be:

- To convince higher-ranking officials from all sectors to get involved in the work of the thematic *dynaklim* platforms and the expert 'delphi'
- To make sure that activities related to climate change and adaptation inside their institution are linked and coordinated with the activities of other network partners
- To facilitate the efforts of local and regional politicians to inform their citizens and local media through their own communication channels about the need to start working on adaptation today, about their participation and role in the regional adaptation process and about the benefit of this process for the region.

5 Conclusions

Roadmapping and the set-up and development of the *dynaklim* network guarantee the generation and use of regional adaptation expertise across disciplines, stakeholder groups and sectors. They both complement each other and are mutually dependent. Linking regional stakeholders in the *dynaklim* network is a prerequisite for successful initiation and implementation of the Roadmap 2020 and for its continuation beyond the period of external funding. In turn, the roadmap offers the network a binding work structure and strategic future orientation.

The consequential paradigm shift from segmented, reactive follow-up care to a proactive, forward-looking and genuinely integrated development of the region is the prerequisite for future sustainable adaptation planning and decision-making by the responsible regional stakeholders (Birke and Schwarz 2005). With the development of the Roadmap 2020 'regional climate adaptation' as a new instrument of *Regional Governance* in the field of regional development, the capability of the Emscher–Lippe–Ruhr region to proactively adapt to climate change effects will be significantly strengthened and can strategically and operatively be applied with positive effects for the innovative capacity and competitiveness of the entire region.

The considerations in the regional discourse about the promotion of another regional 'decade project' focusing on climate change in the metropolitan area Emscher–Lippe–Ruhr offer realistic options for continuing the *dynaklim* roadmap process up until 2020 and beyond, and for transferring the 'integrated' Roadmapping approach as a model for other metropolitan regions throughout the world.

Metropolitan areas can contribute to finding new ways to support large-scale climate policies by creating new forms of cross-sectoral cooperation, collaboration and self-organization at regional and local level. Integrated roadmapping helps to achieve these 'micro-foundations of macro-policies' that will be crucial for solving collective action problems in climate change (Ostrom 2010).

Furthermore, the potential capacity of roadmapping to interlink different policy levels is not yet fully exploited, although it is a well-acquainted and well-used planning and management tool at international and national levels. Updating these roadmap experiences by the new mode of *integrated roadmapping*, on one hand,

and combining those with the new research results on regional roadmapping, on the other hand, will offer great opportunities for a broad and successful implementation of climate change research and policies at all levels.

References

Behrendt, S. (2010). *Integriertes Roadmapping: Nachhaltigkeitsorientierung in Innovationsprozessen des Pervasive Computing*. Berlin: Springer.

Birke, M., & Schwarz, M. (2005). Nachhaltiges Wirtschaften im Spannungsfeld zwischen organisationalem und intermediärem Lernen. In *profile*. Internationale Zeitschrift für Veränderung, Lernen, Dialog, No. 9, pp. 81–85.

Birke, M., Hasse, J. U., Rauscher, N., & Schwarz, M. (2011). Roadmapping als Verfahren der kooperativen Regionalplanung und Klimapolitik. In *profile*. Internationale Zeitschrift für Veränderung, Lernen, Dialog, No. 21, pp. 56–62.

Lieber, M., & Hasse, J. U. (2011). Vom Masterplan zum Change-Prozess - Netzwerk- und Projektmanagement im Klimawandel-Anpassungsprojekt *dynaklim*. In M. Engstler & R. Wagner (Publ.), *Neu denken: Vom Projekt- zum Netzwerkmanagement*, Contributions to the "InterPM" conference, Glashütten/Germany 2011 (pp. 51–70). Heidelberg: dpunkt.verlag.

Muller, G. (2008). Roadmapping (version: 1.0 of 21.02.2008). Downloaded from http://www.gaudisite.nl on 2 Dec 2008.

Ostrom, E. (2010). A multi-scale approach to coping with climate change and other collective action problems. *Solutions, 1*(2), 27–36. Downloaded from http://www.thesolutionsjournal.com/node/565 on 12 Aug 2011.

Phaal, R., & Probert, D. (2009). Technology roadmapping: Facilitating collaborative research strategy. Downloaded from http://www.ifm.eng.cam.ac.uk/ctm/trm/documents/roadmapping_overview.pdf on 9 Aug 2011.

Rauscher, N. (2012). Which objectives are pursued by the region and which adaptation measures (and related costs) is the region ready for? Survey of Sozialforschungsstelle Dortmund (sfs) among citizens and companies (Spring 2011), to be published on www.dynaklim.de.

The Significance of Adaptation Framing in Local and Regional Climate Change Adaptation Initiatives in Australia

Hartmut Fünfgeld, Bob Webb, and Darryn McEvoy

Abstract A number of commonly used approaches have emerged in local climate change adaptation planning, which can be considered as different ways of framing the meaning and purpose of adaptation. The significance of framing in adaptation planning is to date largely unexplored in adaptation research and practice. Yet both social and institutional drivers of adaptation framing can set the course for adaption planning for local or regional governments. This chapter examines the concept and social drivers of explicit and implicit adaptation framing and also draws on the relevant findings from 20 regional and local adaptation projects and initiatives across a wide range of sectors, scales and locations in Australia. The results from this analysis confirm the significance of transparent adaptation framing for effective project scoping. In particular, they point to the likelihood of needing to adjust the project scope throughout the lifespan of an adaptation initiative as the underpinning frames change, and additional climate change implications, as well as non-climatic factors influencing the project, emerge. Building on these findings, future studies into the framing of local adaptation processes can further contribute to both adaptation theory and practice.

H. Fünfgeld (✉)
Climate Change Adaptation Program, Global Cities Research Institute, RMIT University, GPO Box 2476, Melbourne, VIC 3001, Australia
e-mail: hartmut.fuenfgeld@rmit.edu.au

B. Webb
Climate Change Institute and Fenner School of Environment and Society, Australian National University, Canberra, ACT 0200, Australia
e-mail: bob.webb@anu.edu.au

D. McEvoy
Global Cities Research Institute, RMIT University, GPO Box 2476, Melbourne, VIC 3001, Australia
e-mail: darryn.mcevoy@rmit.edu.au

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_30,

Keywords Climate change adaptation • Australia • Local government • Project planning • Framing

1 Introduction

Climate change adaptation processes pose complex challenges to cities, regions and local governments for a number of reasons. First, the goals of adaptation are highly dependent on the local context and need to be negotiated as part of the local decision-making processes. Second, this decision-making is not straightforward as:

- Many climate change impacts and adaptation benefits lie in the (sometimes distant) future.
- The frequency and magnitude of climate change impacts remain uncertain despite increasing ability to scientifically model the climate system.
- The pervasiveness of climate change impacts creates many complex interdependencies.

Due to these factors, adaptation is largely a social and institutional process whereby a range of actors[1] from different levels of government, civil society and the private sector need to engage with each other to agree on and implement a diverse range of adaptation measures. For local authorities, adaptation is therefore a multi-layered, iterative process, involving diverse internal and external stakeholders and collaboration that crosses departmental, jurisdictional and disciplinary boundaries. This process may involve many different interpretations of adaptation. In effect, this chapter argues that both clarity and transparency in climate change adaptation framing are critical for adaptation to be successful as a collaborative process of institutional change. To do this, this chapter brings together selected results from two adaptation research projects carried out in Australia:

1. The project 'framing multi-level and multi-actor adaptation responses in the Victorian context' investigates different ways of framing local adaptation in order to improve clarity, efficiency and effectiveness of local adaptation processes. For the conceptual discussion in this chapter, we draw on research carried out as part of this project.[2]

[1] In this chapter, we use the description 'actors' to cover those with very specific roles and responsibilities in adaptation planning and implementation and 'stakeholders' to cover the broader concept of any individuals or groups significantly impacted by, or involved in, adaptation activities.

[2] The project is funded by the Victorian State Government (Australia) via the Victorian Centre for Climate Change Adaptation Research (VCCCAR). For further information, see www.vcccar.org.au/content/pages/framing-project.

2. A project and related workshop taking stock of existing local and regional adaptation projects around Australia including a synthesis of common issues, enablers and barriers.[3]

We first explore the various dimensions of framing as a sociopolitical concept and its relevance for climate change adaptation processes. We then relate these to the experiences of local and regional adaptation projects in Australia.

2 Framing as a Concept

Planning for the future impacts of climate change is a complex task for most local and regional authorities and one that cuts across traditional boundaries. Such 'emerging organization contexts' (Bouwen 1998) are difficult to establish in existing institutions and organizational structures. Local adaptation initiatives rely on the involvement of an immensely diverse set of people, including local government officials, scientific and other experts, elected politicians, community leaders, business owners and residents. This requires collaborative, cross-disciplinary efforts and governance arrangements.

Due to the diversity of actors and stakeholders involved, different interpretations of the meaning of adaptation coexist, and these often remain implicit. It is argued that actively considering and examining how different actors frame climate change adaptation can help make local adaptation processes more effective (Collins and Ison 2009) and efficient.

In broad terms, framing can be described as a process by which individuals construct and represent meaning to understand a particular event, process or occurrence (Goffman 1974; Gray 2003). Framing occurs whenever individuals with different backgrounds, knowledge and experiences interact to collaborate on an activity. Any information in the public domain is intentionally or intuitively framed in one way or another, and a variety of frames can emerge on any given topic. Framing is an 'unavoidable reality of [. . .] communication processes, especially [in] public affairs and policy' (Nisbet 2009: 15) and hence critical to the direction of any public policy discourse, including climate change adaptation.

Based on this deeply social notion of framing, we can define *frames in collaborative planning processes* as 'organizing principles that enable a particular interpretation of a phenomenon' (de Boer et al. 2010: 502). Frames act as 'sense-making devices' (Weick 1995) that allow members of a group to move towards a shared meaning and sense of purpose for adaptation. In the process of developing an adaptation initiative, frames take on an agenda-setting character, allowing certain questions to be asked while others get silenced (O'Brien et al. 2007).

[3] This project and the related workshop were initiated and facilitated jointly by the Australian National University (ANU) and the National Climate Change Adaptation Research Facility (NCCARF). For a summary of the project workshop, see www.nccarf.edu.au/node/637.

3 Dimensions of Framing in Local Adaptation Planning

3.1 Levels of Framing

We can identify at least three nested levels at which adaptation framing occurs (Table 1). First, at the meta-level, public discourses on climate change adaptation draw on culturally distinct *values and beliefs*, for example, considering the earth and its environment as worth protecting, or maintaining the view that no one, irrespective of social origins or geographic location, should suffer from harm induced by climate change.

Second, adaptation framing can be identified at the *conceptual* level, expressed in theories, concepts and definitions for adaptation processes and outcomes. For example, in local government climate change adaptation planning, typical conceptual frames include viewing climate change adaptation as:

- 'Natural hazard management'
- 'Risk management'
- 'Reducing the vulnerability of disadvantaged groups of society'
- 'Resilience building and sustainable development'

Third, the meta-level and conceptual-level framing translate into the *operational level*, where day-to-day decisions are made and actions taken by referring to distinct frames, depending on local context, situational needs and the roles of key actors. At the operational level, framing is articulated in written and spoken form, for example, in project plans, policy documents, public debates, internal meetings, consultancy reports or in informal chats occurring among staff members. A key example is the process of scoping a climate change adaptation initiative (i.e. determining its objectives, time frame and methodology to be applied within agreed resources).

Both the meta- and conceptual levels of framing address 'why' actors and other stakeholders consider adaptation important (i.e. its meaning and purpose), which then directly influences adaptation framing at the operational level.

At all three levels, the frames can be either explicit (i.e. openly discussed as part of policy or program design) or they can be implicit (i.e. subconsciously represented

Table 1 Three nested levels of adaptation framing

Levels of framing	Determining process of framing	Example
Meta	Referring to value and belief systems	The value that people are entitled to certain human rights and should not suffer unnecessary harm
Conceptual	Theorisation	Defining what vulnerability means in the context of climate change
Operational	Day-to-day scoping, planning, implementation and decision-making	Applying a certain understanding of vulnerability to the assessment of climate change impacts

Source: Adapted from Fünfgeld and McEvoy (2011: 18) without ever being reflected on or openly discussed). In our experience, the latter is more common. However, some explicit framing of adaptation processes typically occurs during the scoping phase of a project, where an adaptation initiative is structured by discussions on goals, expected outcomes, approaches, methodology and resourcing.

3.2 Making Framing More Explicit

Smit et al. (2000) proposed an 'anatomy' of adaptation to systematically specify and differentiate adaptation based on a number of focusing questions. Here we use a slight, but important modification of this approach to indicate how framing (e.g. of an adaptation project) can be made more explicit by actors who address the following questions upfront:

- *Why* individuals or organizations consider it necessary (or not) to engage in adaptation (i.e. what is the meaning and purpose of adaptation)? This question is in addition to those posed by Smit et al. (2000) but, as indicated in Sect. 3.1, is crucial for framing more operational questions.
- *What changes do* individuals or organizations consider important to adapt to (i.e. which climatic and non-climatic stressors are expected to lead to significant local impacts)?
- *What systems* (e.g. human systems, ecosystems, buildings and infrastructure) and which components thereof (e.g. the elderly, the poor, threatened species, public transport infrastructure, etc.) need to adapt?
- *Who* needs to be involved in adaptation, including principal actors, other stakeholders and organizations?
- *How* they envisage adaptation occurring (i.e. what processes and approaches will be used to achieve adaptation outcomes)?

In local adaptation policymaking, a number of personal attributes seem particularly influential in how the above questions might be answered in practice. We refer to these as the 'social drivers of adaptation framing', and a critical examination of these can assist in making framing more explicit.

Firstly, an individual's professional background and their affiliation with an academic discipline or tradition perpetuates particular approaches to project planning and implementation at the municipal scale, such as a predisposition to use either quantitative or qualitative methods and to deem a particular solution as appropriate (e.g. technological, behavioural or institutional solutions). Differences regarding the use of scientific, social and other disciplinary concepts, language, knowledge, skills and practical experience are all influential factors. An example in the context of adaptation is the degree to which individuals are able to understand and interpret climate science information.

Apart from professional background and experience, individuals also bring their personal set of values and beliefs into local adaptation processes. This includes religious and spiritual values, personal history and experiential learning and individual ideas and visions about the future (O'Riordan and Jordan 1999; Tonn et al. 2006; Adger et al. 2009).

Thirdly, much of the framing of adaptation processes is based on the professional and non-professional roles and responsibilities of individuals, including within the local institutional (e.g. municipality) context (O'Riordan and Jordan 1999). Each individual will most likely give preference to those adaptation issues closest to his/her role within the organization they are employed by. Responsibilities for particular dimensions of adaptation processes (e.g. developing an adaptation action plan) may be formalized and made explicit in position descriptions or they may be implicit to the role definition of municipal staff (e.g. managing climate change risks as part of a risk manager's responsibilities).

Fourthly, depending on an individual's role and responsibility, local government staff and decision-makers have different decision-making power, which determines who is expected and permitted to make statements about adaptation, what questions are considered relevant and important for adaptation planning (see above: 'why', 'what', 'what systems', 'who' and 'how') and which answers are deemed appropriate (de Boer et al. 2010).

All of these factors are tied to individuals who, consciously or not, articulate to each other their levels of knowledge, values and beliefs, disciplinary traditions and preferences and priorities derived from their roles and responsibilities. Through this process of social negotiation, individual frames become collective agenda-setting devices that influence the purpose and desired outcome of adaptation processes.

The above drivers of adaptation framing are summarized in Fig. 1. In the following section, we explore how the practical experiences of a number of adaptation projects and initiatives in Australia reflects some of these framing issues, particularly how framing typically evolves during a project.

4 Adaptation Framing in Practice: Some Insights from Australian Projects and Initiatives

There has been an upsurge of adaptation activities in Australia over the last 5 years. In April 2010, the Australian National University (ANU) and the National Climate Change Adaptation Research Facility (NCCARF) brought together 20 representatives from Australian adaptation initiatives at a 2-day workshop held in Glenelg, South Australia. The aim of this workshop was to maximize learning from the current adaption practices and experiences at the local and regional scale of government.

The background and the objectives of the workshop, including participants, inputs and outputs, have been summarized elsewhere (NCCARF and ANU 2011).

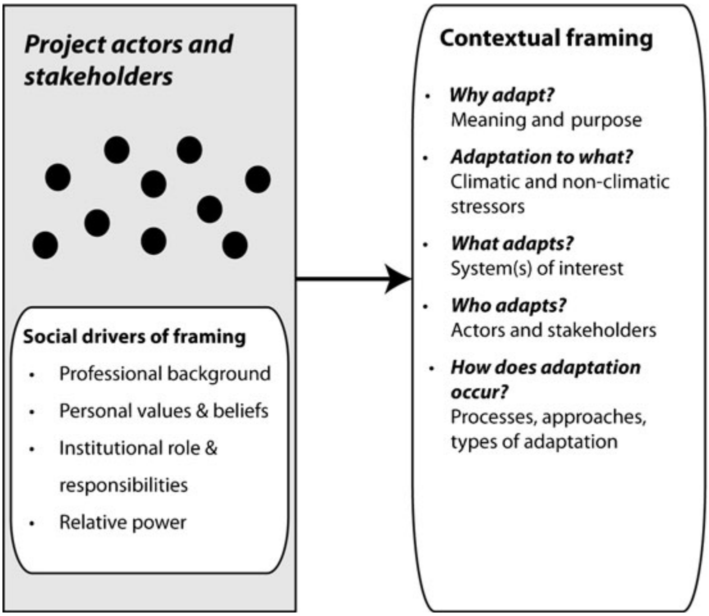


Fig. 1 Social and contextual drivers of framing

The participants included regional and local adaptation project sponsors, practitioners and researchers as well as representatives from all three levels of government (federal, state and local). The projects covered a range of locations, sectors and jurisdictional/institutional arrangements. The common findings, which were validated by all participants in the months following the workshop, therefore appear to be robust across a wide range of contexts. A further analysis has related the workshop's findings to the recent literature on overall adaptation processes and issues (Webb et al. 2011).

The importance of framing of adaptation projects was one of the many issues and themes that emerged from the workshop. In particular, it was concluded that project scoping (which is the key manifestation of framing in the project context) is intrinsically an iterative and dynamic process, as the understanding of the implications of climate change in the local and regional context becomes clearer during the lifespan of the project. Typically, at the outset, framing and related scoping is heavily influenced by the initial 'sponsors' of any adaptation project, but it was common for progressively broader and more integrated scoping to emerge as key interdependencies were identified and response options developed. This requires engagement with a broader range of stakeholders, who in turn become key players in the context of progressive reframing and rescoping. This process is summarized in Fig. 2, which highlights a more dynamic and practical dimension to the more conceptual framework in Fig. 1.

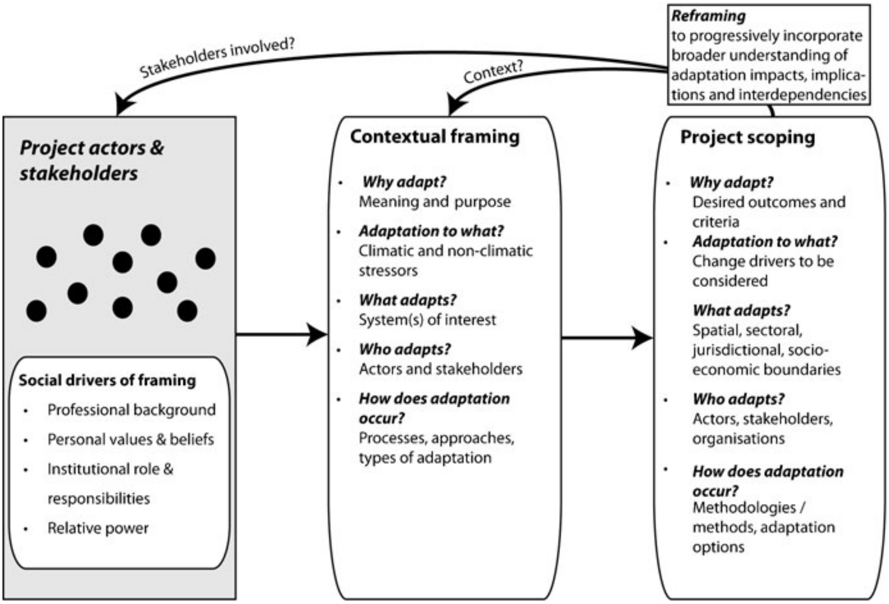


Fig. 2 Iterative framing and scoping of adaptation projects

More specific findings relevant to framing were:

- Investment, at the earliest possible stage, in making framing explicit and allowing for iterative scoping of the project is crucial to improving the chances of subsequent successful outcomes. Given the exploratory nature of many of the adaptation efforts, it was considered inevitable that the scoping of a project would need to evolve dynamically. Insights gained during one project phase frequently required an adjustment of the scoping agreed upon earlier. This highlighted the importance of an adaptive management and governance approach.
- Framing and scoping, and in particular addressing the meaning and purpose of adaptation, will in turn significantly influence desired goals/outcomes, methodological choices, stakeholder engagement and data/knowledge requirements.
- Even though in practice not all issues will be addressed in an individual project, it is valuable to frame an adaptation project in the context of a broader rather than a narrower perspective. This is because of the many interdependencies across both impacts and responses and the fact that, as the project moves towards response option and decision phases, it is increasingly likely (and appropriate) that adaptation responses will be considered by decision-makers in the broader context. Key examples include:

  – Positioning climate change impacts and vulnerabilities in the context of multiple stressors and related strategic objectives, such as mitigation and sustainable regional development.

- Integrated rather than sector specific/highly localized impact and vulnerability assessments (i.e. across sectors, spatial scales and jurisdictions and integrated from key community group perspectives) are highly desirable, though there are a few comprehensive examples of this to date.
- The benefits in covering a regional scale (e.g. a state planning region, a grouping of local governments or the region covered by a natural resource management/regional development authority) rather than just the local scale (e.g. a single municipality). This addresses issues that are generally regional in scale (e.g. water resources, biodiversity, transport and infrastructure) and facilitates more strategic outcomes. It also enables a shared and more cost-effective response, whereas the resources of an individual council can be severely challenged.

However, the workshop also identified some challenges to achieving such 'ideal' framing and scoping:

- In practice, a 'first-pass' framing and related project scoping will be significantly influenced by the initial sponsor's interests and associated institutional arrangements, as well as available resources. It will therefore be necessary to pragmatically balance the most desirable 'integrated' scope (e.g. multiple change drivers, cross sector, spatial coverage) with these practical realities. This means working initially with areas and opportunities where there is strong interest, support and capability and linking the project where possible to existing or emerging policy issues and programs. However, some effort upfront in discussing an initiative's framing will significantly assist if and when the scope needs to be modified as work progresses and new insights and issues emerge.
- Whilst recognizing the many benefits of a broader regional framework (e.g. across several local government areas in the Australian context), often the existing institutional capacities (including structures, authority and governance arrangements) will not easily facilitate regional approaches and decisions. Rarely are there clear corresponding governance and decision-making rights and responsibilities. The workshop highlighted a number of alternative adaptation governance models in Australia, ranging from statutory regional regimes (e.g. South East Queensland) to a variety of 'pragmatic' regional approaches (e.g. using the Natural Resource Management Boards, Regional Organizations of Councils or ad hoc vehicles). It was considered that the statutory regional regimes, such as those in South East Queensland, are likely to have significant advantages especially in identifying and bringing strategic responses into effect.

5 Conclusion

This chapter has proposed that more explicit and transparent framing by those actors who are involved in adaptation efforts would materially enhance outcomes and has summarized some of the focusing questions and approaches that would assist in this. The practical experience from a number of Australian adaptation projects has reinforced this view, and also that framing (at the very least initially) is highly influenced by key sponsors, relationships and existing institutions and is thus very much a 'social' rather than a 'technical' process.

However, the practical experiences also highlight that, especially given the pervasiveness, complexity and interdependencies of climate change impacts and implications:

- It is common for framing and scoping to evolve progressively during the life of an adaptation project.
- A broader rather than narrower scoping is likely to be helpful to good process and outcomes; for example, positioning climate change adaptation alongside other drivers of change and including sufficient spatial and sectoral coverage to ensure major interdependencies are captured.
- Addressing institutional and governance issues are likely to be critical as existing institutional arrangements are unlikely to be well positioned to address more broadly framed options.

This initial attempt to combine adaptation framing considerations with practical experience in an Australian context points to a potentially fruitful field of future research, which can advance both theory and practice. In particular, more explicit attention to the framing drivers and options is likely to significantly enhance the effectiveness of climate change adaptation initiatives. The authors are currently involved in activities to further link these findings with existing adaptation theory, while also working with local and state governments to develop adaptation planning processes that take framing differences into account.

References

Adger, W., Dessai, S., et al. (2009). Are there social limits to adaptation to climate change? *Climatic Change, 93*(3), 335–354.

Bouwen, R. (1998). Relational construction of meaning in emerging organization contexts. *European Journal of Work and Organizational Psychology, 7*(3), 299–319.

Collins, K., & Ison, R. (2009). Jumping off Arnstein's ladder: Social learning as a new policy paradigm for climate change adaptation. *Environmental Policy and Governance, 19*(6), 358–373.

de Boer, J., Wardekker, J. A., et al. (2010). Frame-based guide to situated decision-making on climate change. *Global Environmental Change, 20*(3), 502–510.

Fünfgeld, H., & McEvoy, D. (2011). *Framing climate change adaptation in policy and practice*. Working paper (Vol. 1, pp. 65). Melbourne: Victorian Centre for Climate Change Adaptation Research. www.vcccar.org.au/files/vcccar/Framing_project_workingpaper1_240611_0.pdf. Accessed 20 June 2011.

Goffman, E. (1974). *Frame analysis: An essay on the organization of experience*. Cambridge, MA: Harvard University Press.

Gray, B. (2003). Framing of environmental disputes. In R. Lewicki, B. Gray, & M. Elliott (Eds.), *Making sense of intractable environmental conflicts: Frames and cases* (pp. 11–33). Washington, DC: Island Press.

NCCARF, & ANU. (2011). *Glenelg adaptation planning workshop – April 2010*. Gold Coast and Canberra: National Climate Change Adaptation Research Facility and Australian National University. www.nccarf.edu.au/node/637. Accessed 20 June 2011.

Nisbet, M. C. (2009). Communicating climate change: Why frames matter for public engagement. *Environment, 51*, 12–23.

O'Brien, K. L., Eriksen, S., et al. (2007). Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy, 7*, 73–88.

O'Riordan, T., & Jordan, A. (1999). Institutions, climate change and cultural theory: Towards a common analytical framework. *Global Environmental Change, 9*(2), 81–93.

Smit, B., Burton, I., Klein, R. J. T., & Wandel, J. (2000). An anatomy of adaptation to climate change and variability. *Climatic Change, 45*(1), 223–251.

Tonn, B., Hemrick, A., et al. (2006). Cognitive representations of the future: Survey results. *Futures, 38*(7), 810–829.

Webb, R. J., McKellar, R., & Kay, R. (2011). *Building on Australia's growing climate change experience: A more systematic approach to learning by doing and sharing* (submitted October 2011).

Weick, K. (1995). *Sense making in organizations*. Thousand Oaks: Sage Publications.

Decision-Making Frameworks for Adaptation to Extremes in Two Local Government Areas: Comparing and Contrasting India and Australia

Supriya Mathew, Ann Henderson-Sellers, and Matthew Inman

Abstract Local governments have recognized the need to adapt to climate extremes. Decision-makers at this level thus require a guide to decide on adaptation actions under an unsure future. This chapter explores methods to choose better adaptation options for climate extremes at the local government level, even as uncertainty among climate change projections persists. As such, two local governments in widely different geographic areas are featured – one from a developed nation (Ku-ring-gai, eastern Australia) and another from a rapidly developing nation (Kochi, southern India). The limits of economic evaluations and the significance of qualitative tools under an unsure environment are discussed within the two local contexts. Furthermore, the applicability of recent literature that deals with uncertainty is also studied. For example, some studies choose options that are robust under the best and worst case scenarios, while others choose the 'no regret options' that are justified under all plausible future scenarios. Other criteria for determining adaptation options include the net benefits of the options, urgency of the options, co-benefits of the options and reversibility and flexibility of options. Various evaluation criteria are tested in the two locations to develop a realistic decision-making framework that can rank options for extreme climatic events.

Keywords Climate extremes • Climate adaptation • Local government uncertainty • Decision-making

---

S. Mathew (✉) • A. Henderson-Sellers
Department of Environment and Geography, Macquarie University, Balaclava Road, 2109 Sydney, Australia
e-mail: supriya.mathew@mq.edu.au; ann.henderson-sellers@mq.edu.au

M. Inman
Urban Systems Program, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Riverside Corporate Park, 2113 Sydney, Australia
e-mail: matthew.Inman@csiro.au

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_31,

1 Introduction

Currently, the IPCC (Intergovernmental Panel on Climate Change) fourth assessment reports serve as a comprehensive reference for studies related to global and regional impacts of anthropogenic climate change. These reports show that, even at global scales, uncertainty associated with the frequency and severity of extreme events is large. This uncertainty is further magnified at local scales. Contrary to what is available, there has been immense demand for better climate projections with an emphasis on more certainty among the local decision-makers. This is mainly because analysis of extremes and assessment of proactive options is challenging in an unsure environment. In turn, reliable decisions can only be made by including the entire range of uncertainty, despite the demand for higher confidence in climate projections (Dessai et al. 2009).

Uncertainty about the future climate and its impacts is not the only hindrance in early adaptation actions. Let us assume a situation where the frequency and severity of extreme events are predictable with great confidence. Interestingly, we find that there are other dimensions of uncertainty that are equally important in the decision-making (DM) process, for instance, economic uncertainty or future development uncertainty. Preparations in the form of prevention actions are often linked with high economic costs. High-cost investments require solid justifications mainly economic, which is difficult to attain as uncertainty persists. This is one major reason why local governments prefer reactive responses. A similar approach is obvious, even in international efforts. A report on disasters, published by the World Bank and the United Nations in 2010, points out that about a fifth of the total humanitarian aid between 2000 and 2008 was devoted to disaster relief and response (World Bank and UN 2010).

Thus, it is evident that decisions will have to be made under unsure situations. A guide to DM will reduce the inertia in adaptation action and build local capacity to adapt to extremes. The focus of this chapter is not on community-oriented DM, though we acknowledge its prominence in obtaining adaptation options (through surveys, focus groups, interviews). At some point, the local government will be held responsible to finally decide on a list of options acceptable to the community. We concentrate on this stage of decision-making, where local authorities are left with a portfolio of options. An option can be finalized after assessing its environmental, social and economic benefits and adequacy under existing local government litigations.

This chapter explores a step-by-step guide to choose better adaptation options for extreme events by local governments in a less predictable, complex world. Two contrasting local government areas have been chosen, one from a developed nation (Ku-ring-gai Local Government Area, KLGA, eastern Australia) and another from a rapidly developing nation (Kochi municipal corporation, KMC, southern India). A location in India was deliberately chosen to represent and study the specific challenges faced by developing countries. Climate adaptation decisions within developing countries differ from developed countries because of their limited access to resources and other obvious non-climatic problems such as poverty, unemployment, etc. We have considered bushfires, heat waves for KLGA (see Ku-ring-gai Council 2010) and floods for KMC to work out the decision guide. These case studies confirm that, at the practitioner level, climate uncertainty is only one among many unknowns involved in adaptation DM.

2 Challenges and Directions for Adaptation DM at Local Levels

As mentioned before, the main challenge in DM is the uncertainty surrounding the future. Uncertainty can be expressed:

1. In statistical terms such as a range, for example, expected damage caused by bushfires is between 10 and 15 million dollars.
2. As a range of plausible scenarios, for example, future development paths described by high, medium or low economic development.
3. As recognized uncertainty, which we know exists, but cannot be expressed as real estimates, for example, when two or more experts disagree on, say, the frequency of an extreme.

Thus, a combination of both qualitative and quantitative evaluation tools is required to include various kinds of uncertainty and obtain meaningful and conveyable results to stakeholders (local governments) (Dessai and Sluijs 2007). In this section, we study some reasons for the divergence in the methods used for adaptation DM of extremes at the local government level.

2.1 Geographic Location (Position in Globe, Coastal/Inland)

Geographic locations determine the climate (e.g. climate zones) and hence extremes (tropical cyclones, monsoon rains) specific to a location. KLGA is surrounded by bushlands and hence susceptible to bushfires. So here, we study options for bushfires and extreme heat, as both are to some extent interrelated. On the other hand, KMC is a coastal location affected by the monsoon rains (south-west monsoon and north-east monsoon) and hence prone to floods.

2.2 Socio-economic Determinants of a Place (Current and Future)

An obvious difference between the two local governments is that KMC is part of a rapidly developing nation (India), while KLGA is part of a developed nation (Australia). Socio-economic situation of a place modifies its vulnerability to extremes (Nath and Behera 2011). Most locations within rapidly developing nations will potentially undergo rapid urbanization and population density changes, altering their future exposure to extreme events. Thus, more insight will be required in finalizing future preparatory actions. Current socio-economic stature of locations also governs the internal fund allocations for climate-related projects. Conventionally, projects which offer immediate observable benefits are preferred over projects with uncertain benefits in the future. Experts in KMC suggested that projects with future benefits are often initiated and supported by national or international aids. Majority of the local funding considers immediate community priorities that involve only short-term planning. Thus, there is mismatch between the accepted short-term planning approach (due to immediate priorities and short election tenures) and required long-term planning for climate actions. Our challenge here is to encourage both long- and short-term investments.

2.3 Extreme Events: Analysing the Challenges

The main challenge in analysing extreme events at a local government level is that there are only a few observations, which can be attributed to:

(a) Rare occurrences of the extreme events (usually by definition extreme events are rare)
(b) Local scale of study
(c) Improper record of past observations

Improper or incomplete recording of historical events is a problem more relevant to locations in developing countries. During the KMC field study, an effort to track down information on damage data for years before 2004 proved to be complicated. Data was previously stored in paper files, which were often destroyed after reporting to the relevant state authorities, making damage information at the scale of interest hard to attain. The 2004 tsunami that affected the coastal parts of southern India triggered many institutional and policy changes including setting up of district disaster management units. As a result, records of flood damages following the tsunami are now accessible in electronic format.

Another major problem with extreme event analysis is that definitions of extremes vary. This makes transferring or reproducing decision processes, responses and associated research difficult across locations. Definitions of extreme events can be based on:

1. Type of the event (e.g. flooding cf. bushfire)
2. Impact of the extreme which can be social, economic and environmental damages and the acceptable thresholds for the damage
3. Frequency of the extremes (rarity 1 in 10 years, 1 in 100 years)
4. Availability of damage data and meteorological observations

Heatwaves in KLGA were defined as days where the maximum daily temperature exceeds the 90th percentile of the available observations. The threshold temperature was finalized by considering its possible effect on health of elderly population of KLGA, increased water demand, energy demand and other heat-related damages. Unlike heatwaves, bushfire events were defined based on its potential damages. A bushfire event was counted only if house damages or death of people were reported. Extreme floods in KMC were defined based on the frequency of their occurrences (every 20 years: suggested by the local meteorological experts).

2.3.1 Using Experts to Model Extremes

Analyses of the extremes (both risk assessment and management) demand more information than the few observations available. It is therefore necessary to include other accessible sources of information, for example, expert opinions. Bayesian inference, a method widely accepted in financial risk modelling (e.g. Shevchenko and Wuthrich 2006), combines observations with experts' judgments and can be adopted in this context. Here, expert estimates for the frequency and damage of the events are updated by original data. There are mainly three steps involved in Bayesian inference:

1. Parameters for prior distributions for both frequency and severity (damage caused) are estimated by expert elicitation.
2. The prior distributions are then updated with data available to obtain posterior distributions for frequency and severity.
3. Finally, predictive distributions (future) are drawn from the respective posterior distributions.

The frequency and severity distributions are combined to obtain the total damage. Thus, the method helps to obtain damage information by including both available data and expert opinions as seen in Fig. 1.

2.3.2 Pulling Apart the Notion of Objectivity in Economic Results

Here, we argue that the results of the economic analysis conducted using Bayesian inference are not objective. Firstly, a distribution was assumed to model the frequency and severity of the extremes (e.g. log-normal for severity). Severity can also be modelled by other heavy-tailed distributions such as Pareto distribution and Weibull distribution. This poses a certain degree of uncertainty and subjectivity

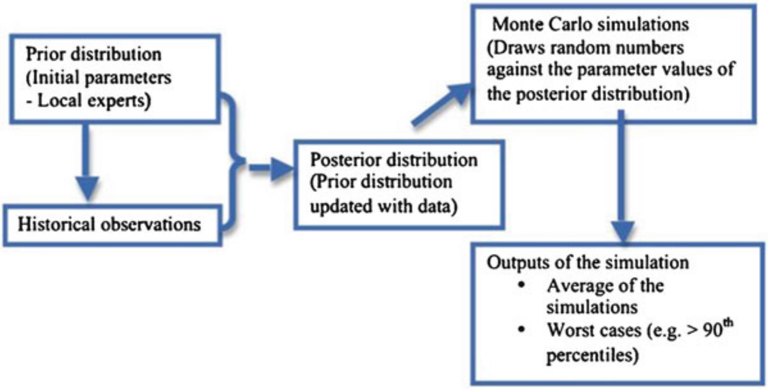


Fig. 1 Block diagram of steps used for modelling frequency and severity of the extreme events

depending on the researchers/experts choice of the distribution. Normally, to estimate parameters of heavy-tailed distributions, a lot of data is required. As discussed before, we solicit experts to derive parameter values and cover for the data scarcity. Thus, reliability of the parameter values is highly linked to the experts' estimation, making it subjective. However, the final damage results obtained by combining frequency and severity are also sensitive to the type of distributions used. Significant variation in the worst case damages (tails of the distribution or >90th percentile) are expected with different severity distributions. In our study, we conducted sensitivity tests to cover the ranges of uncertainties with the three aforementioned heavy-tailed distributions. Thus, severity was modelled with log-normal and Pareto and Weibull distributions. The worst case damages were noted for each distribution and reported to the authorities.

While discussing the steps for Bayesian inference, we excluded the fact that the damages occur over a period of time. Future monetary units have to be converted into equivalent present monetary units using discount rates. The economic results are highly sensitive to discount rate values used. The value of a suitable discount rate has always been under debate (Stern 2006; Nordhaus 2006). The discount rate is usually based on two contrasting arguments:

1. Real interest-based approach – a high discount rate (e.g. 6%) usually reflects the market interest rate.
2. Ethical approach – a low discount rate (nearly zero) derived from the philosophy of intergenerational equality.

Despite the contrasting arguments mentioned above, discount rates for local governments are influenced by factors such as fund availability, political will, community priorities and awareness on climate issues. Thus, in reality a 'pragmatic discount rate' which is appropriate for the local context will be approved. In our research, we rely on sensitivity tests to study if the ranks of the adaptation options change with different discount rates.

2.3.3 Relevance of Qualitative Tools

The previous section confirms that a complicated economic model reduces transparency behind the assumptions made (e.g. type of distribution, data used, expert opinions). Local governments prefer to use economic figures as objective, without considering their ranges, which may not result in a 'right' decision. Till now, we discussed only the directly tangible costs and benefits. There are other equally or more important social and environmental dimensions to the costs and benefits. Some costs and benefits are ethically less convertible to monetary measures. Thus, many economic analyses are partial as they exclude less-tangible impacts and benefits such as quality of life, value of life and conservation of biodiversity. This suggests the need for qualitative tools that can convey the message to local governments, exposing the assumptions made and involve them in every step of the decision process. Cost-benefit analysis could be restricted to study the costs of projects whenever hard options (e.g. infrastructure requiring high investment) are preferred. Risk reduction by hard adaptation options (e.g. fire trails) is better quantifiable than soft adaptation options (e.g. community awareness), which mainly focus on individual behavioural changes. The two case studies show that local governments prefer to implement soft options under uncertainty. This specifically calls for qualitative frameworks and a lot of intuition to assess the options.

2.4 Choice of Adaptation Options: Co-benefits as an Evaluation Criterion

One peculiarity of floods in KMC is that floods occur every year, but at times, the floods can become extreme and cause substantial damage. As the floods are annual, the adaptation options will be continually beneficial and therefore actions are easily justifiable. Options such as harvesting rainwater which is aimed at reducing local floods have additional benefits. These include increased awareness on water conservation which is beneficial during non-rainy or drought periods. Consultation with local level experts in KMC indicates that the choice of options will not be solely for extreme floods if external funds from national governments or international organizations are not available. This makes it pertinent to evaluate the options against their co-benefits which will mean considering other non-climate immediate priorities of the location. Coupling the immediate needs of a community with climate adaptation requirements is one way to act within KMC. In KLGA, co-benefits focus more on both mitigation- and non-extreme-related benefits. For example, most of the options for heatwaves were to reduce the use of carbon-intensive energy by switching to renewable energy. Thus, for both locations, co-benefits can be included as a separate criterion in the evaluation process. In general, the extreme event definitions and their analysis should be derived from the local contexts.

3 Dealing with Uncertainty at Local Government Levels

As a way to deal with uncertainty, options that are robust under all plausible scenarios (best to worst cases) can be selected (Dessai et al. 2009). Robust decisions tend to be rational in an unsure environment, but the method demands flexibility in the choice of options. At the local government level, we cannot expect much flexibility, as the options are predetermined by money constraints and non-extreme benefits. Alternatively, no-/low-regret options such as improving building insulation could be chosen. Thus, options are justified under different plausible future scenarios including the absence of anthropogenic climate change (Eales et al. 2006). In this case, options which perform better are chosen, but they may not necessarily be the best option as there might be residual risks. At the same time, this is an effective way to promote early actions among local governments till they obtain solid justifications and support for their actions. Finally, the conventional method of ranking options against a number of criteria can also be adopted (see Hallegatte 2009; de Bruin et al. 2009). The criteria could be based on:

- The net benefits which include economic, social and environmental benefits.
- The urgency of the options which determines whether an option needs to be immediately implemented.
- The co-benefits of the options which represent benefits other than directly related to adapting to a particular extreme (e.g. mitigation benefits, benefit to another extreme relevant to the location).
- The capacity of options to be updated as new information is obtained (e.g. soft options like awareness programs, early warning systems, infrastructure that can be upgraded). The aim here is to reduce high investment on the wrong options by allowing opportunities to revisit the decisions later. Moreover, short-term planning and the short election terms of local governments also promote choice of flexible, short-term options.

4 Conclusions (Addressing the Problems in Decision-making)

Many rational options are likely to fail, competing against political timelines and non-climate-related priorities, and hence it is necessary to devise realistic solutions. This requires original and innovative thinking towards choice of options and evaluation methods. In our daily life, we prefer to quote economic figures to justify our decisions. At least for climate actions, we need to think beyond mere economic benefits. In many situations, less-tangible environmental and social benefits are large enough to even outweigh the economic benefits. Apart from this, it is also necessary to understand the fact that many economic results are not purely objective, but are based on various assumptions. High-cost decisions like building new infrastructure, where the costs and to some extent benefits are quantifiable could utilize economic modelling. In cases where the benefits and costs are hard to quantify, qualitative tools should be used. This will help to save money and time to a great extent.

The choice of adaptation options at local government levels should help to encourage adaptation initiatives. The usually preferred short-term low-investment options can help to promote actions and reduce risks. Moreover, emphasizing on co-benefits as a criterion in evaluation processes can help to get around uncertainty associated with climate change. These choices are not permanent solutions as there are still chances of residual damages due to an extreme event. Adaptation being an ongoing process, choices can be updated, as more clarity for funds and role of climate change is available in the local government legislatures. In this chapter, we have discussed some of the real challenges and ways to overcome these from a practical point of view.

Acknowledgements I acknowledge support from the Climate Adaptation Flagship within CSIRO (Commonwealth Scientific and Industrial Research Organization) and Macquarie University, Australia. I also thank the Resilient Cities conference organizers, participants who gave me valuable feedback after my presentation and experts at Kochi (India) and Ku-ring-gai (Australia).

References

de Bruin, K., Dellink, R. B., Ruijs, A., Bolwidt, L., van Buuren, A., Graveland, J., de Groot, R. S., Kuikman, P. J., Reinhard, S., Roetter, R. P., Tassone, V. C., Verhagen, A., & van Ierland, E. C. (2009). Adapting to climate change in The Netherlands: An inventory of climate adaptation options and ranking of alternatives. *Climatic Change, 5*, 23–45.

Dessai, S., & van der Sluijs, J. P. (2007). *Uncertainty and climate change adaptation: A scoping study*. A Copernicus Institute and Tyndall Centre Report for the Netherlands Environmental Assessment Agency (MNP). http://geography.exeter.ac.uk/staff/sddownloads/. Accessed online on 17 Mar 2010.

Dessai, S., Hulme, M., Lempert, R., & Pielke, R., Jr. (2009). Climate prediction: A limit to adaptation? In N. W. Adger, I. Lorenzoni, & K. L. O'Brien (Eds.), *Adaptation to climate change threshold, values, governance* (pp. 64–78). Cambridge: Cambridge University Press.

Eales, R., White, O., Owen, J., Kent, H., & Sing, S. (2006). *Climate change mitigation and adaptation implementation plan for the draft south east plan*. Final report. Prepared for the South East Regional Assembly by Collingwood Environmental Planning and Land Use Consultants. http://www.espace-project.org/publications/library/climate_change_implementation_plan-300306-v2.PDF. Accessed online on 13 Jan 2011.

Hallegatte, S. (2009). Strategies to adapt to an uncertain climate change. *Global Environmental Change, 19*, 240–247.

Ku-ring-gai Council. (2010). *Climate change adaptation strategy report*. http://www.kmc.nsw.gov.au/resources/documents/2010_DRAFT_Climate_Change_Adaptation_Strategy.pdf. Accessed online on 13 Apr 2011.

Nath, P. K., & Behera, B. (2011). A critical review of impact of an adaptation to climate change in developed and developing economies. *Environment, Development and Sustainability, 13*, 141–162.

Nordhaus, W. (2006). *The Stern review on the economics of climate change.* National Bureau of Economic Research, Working Paper Series WP12741, December. http://www.nber.org/papers/w12741. Accessed online on 10 July 2010.

Shevchenko, P. V., & Wüthrich, M. V. (2006). The structural modelling of operational risk via Bayesian inference: Combining loss data with expert opinions. *Journal of Operational Risk, 1*, 3–26.

Stern, N. (2006). *The economics of climate change: The Stern review*. Cambridge: Cambridge University Press.

The World Bank, & The United Nations Report. (2010). *Natural hazards, unnatural disasters: The economics of effective prevention*. http://www.gfdrr.org/gfdrr/nhud-home. Accessed online on 13 Jan 2011.

Urban Climate Governance in the Philippines, Mexico and South Africa: National- and State-Level Laws and Policies

Robert Kehew, Mthobeli Kolisa, Christopher Rollo, Alejandro Callejas, and Gotelind Alber

Abstract Faced with the prospects of a changing climate, a small but increasing number of countries have adopted or are developing legal and regulatory frameworks that explicitly address climate change. Moreover, at least some of these laws and policies carve out substantial roles for local governments. The chapter surveys three countries from different regions in the Global South engaged in developing and implementing such laws and policies: the *Philippines* (Asia-Pacific), *Mexico* and more specifically its State of Chiapas (Latin America) and *South Africa* (Africa). The chapter analyses the predominant modes of multilevel urban climate governance (governing by authority, governing through enabling, governing by provision, governing with representation and consultation) that those laws or

---

R. Kehew (✉)
Leader, Climate Change Planning Unit, Urban Planning and Design Branch, UN-HABITAT, PO Box 30030, Nairobi 00100, Kenya
e-mail: robert.kehew@unhabitat.org

M. Kolisa
Department of Municipal Infrastructure and Services, SALGA (South African Local Government Association), 175 Corobay Avenue, Pretoria 0001, South Africa
e-mail: mkolisa@salga.org.za; cthabethe@salga.org.za

C. Rollo
Philippines Country Office, UN-HABITAT, 6819 Ayala Avenue, 1229 Makati City, Philippines
e-mail: chris.rollo@undp.org

A. Callejas
Ministry of Environment and Natural History of the State of Chiapas, 3ra Poniente 148, Segundo Piso, Colonia Centro, Tuxtla Gutierrez, Chiapas, Mexico
e-mail: acallejas@semavihn.chiapas.gob.mx; acallejas@yahoo.com

G. Alber
Sustainable Energy and Climate Policy, Anklamer Str. 38, 10115 Berlin, Germany
e-mail: gotelind@goalber.eu

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_32,

policies embrace. The chapter then offers conclusions including which experiences represent promising practices and other lessons for countries embarking on such processes.

Keywords Adaptation • Governance • Law • Philippines • Mexico • South Africa

1 Introduction

Faced with the prospects of a changing climate, a small but increasing number of proactive countries and states have adopted or are developing legal and regulatory frameworks that explicitly address climate change. Moreover, at least, some of these laws carve out a substantial role for local governments. This is a very recent and still limited development. Alber and Kern (2008) recently concluded that 'provisions in the national legislation that are relevant for local climate policy are rather limited, or fully lacking, in most countries . . . '. As other countries begin to consider such measures, better understanding of these initial experiences may prove useful.

In this chapter, we survey emerging experiences in countries and states from three different regions in the Global South: the *Philippines* (Asia-Pacific), *Mexico* and in particular the *State of Chiapas* (Latin America) and *South Africa* (Africa). More specifically, we examine the predominant modes of multilevel urban climate governance that their respective legal/regulatory frameworks embody. The chapter's emphasis is on governance relations between national- and state-level governments on the one hand and the local government sector on the other. Other governance relations such as between local governments, communities and the private sector, while very important, lie outside the scope of the present analysis. Finally, we offer conclusions including which experiences represent promising practices and other lessons for countries embarking on such processes.

2 Three Countries and Their Climate Change Laws

The three countries surveyed and their climate change laws and policies are as follows (in the order of date of passage of the relevant law or policy).[1]

[1]For copies of laws and policy documents referenced in the chapter, go to www.unhabitat.org/ccci and click on 'reports' and 'policy'. All GDP figures cited below are estimated for 2010, using a purchasing power parity methodology; see www.cia.gov.

2.1 The Philippines

With a population of 89 million, the Philippines has an estimated per capita gross domestic product (GDP) of US$ 3,500. Administratively, the country is organized into several levels of sub-national government, beginning with 17 regions and 78 provinces; the Philippines' 82 cities and 1,525 municipalities are divided into 41,939 barangays. As an archipelago with 36,289 km of coastline, the country is particularly susceptible to typhoons and sea level rise. The Philippines passed their groundbreaking *Climate Change Act* in 2009. Since the passage of that Act, various governmental entities have been involved in its implementation (see Sect. 3.3). In addition to the Climate Change Act of 2009, in 2010, the Philippines also passed a Disaster Risk Reduction and Management Act (not examined at present) that contains some additional features that are relevant to the national and local government responses to climate change.

2.2 Mexico, State of Chiapas

Mexico, a country of 114 million with a GDP per capita of US$ 13,900, is a federal republic comprised of 31 states and 1 federal district. The State of Chiapas has a population of five million people and is one of the poorest states in Mexico. This state has 118 municipalities. Flooding, a major concern in this part of Mexico, could become more severe under future climatic conditions. In late 2010, Chiapas passed its *Law for Adaptation to and Mitigation of Climate Change.* Not coincidentally, Chiapas approved this law around the time of the 16th annual meeting of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) that took place in Cancún, Mexico, from 29 November to 10 December 2010. This event drew the world's – and Mexico's – eyes to the topic of climate change. In fact, another Mexican State, Veracruz, also passed climate change legislation at around the same time (November 2010).

2.3 South Africa

GDP per capita in this republic of 49 million inhabitants is US$ 10,700. Administratively, South Africa is divided into 9 provinces, along with 278 municipalities (8 metropolitan municipalities, 44 district councils and 226 local councils). Much development is concentrated along portions of the country's 3,650 km of coastline, as well as in the inland Gauteng Province. Under future climate change conditions, the coastal population centres will be exposed to more frequent and intense storm surges as well as sea level rise. Gauteng will be subjected to more frequent and intense heavy rains and floods, along with increased heat and humidity; these circumstances may lead to the spread of malaria into this currently malaria-free zone. Several years ago, South Africa embarked upon a broadly consultative effort to develop a coherent climate change policy. In November 2010, as the latest milestone in this process, Cabinet approved the publication of the *National Climate Change Response Green Paper*. The public comment period for this paper closed in February 2011. At present (August 2011), the policy formulation process is still ongoing and has not yet resulted in a final Climate Change Response Policy.

3 Urban Climate Governance in Laws and Policies Reviewed

3.1 Modes of Urban Climate Governance in Multilevel Systems

In discussing urban climate governance in multilevel systems, one can distinguish firstly between horizontal and vertical forms of interaction. In the present context, horizontal interaction refers primarily to the coordination between cities or other local government units. Vertical interaction, the main focus of the present paper, involves relations between different levels of government, including national and local government and any levels in between (e.g. regional, state, provincial).

By focusing on vertical interactions, one can distinguish between several different types of governance relations. Alber and Kern (2008) describe three such modes. At one extreme, *governing byauthority* would occur when national- or state-level legislation *requires* local governments to address climate change in the local policies. At the other ('soft') extreme, *governing through enabling* takes place when national- or state-level governments only *encourage* local-level action (e.g. through the use of non-mandatory guidelines, capacity building or the dissemination of information and best practices). At an intermediate level of engagement between these two extremes is *governing by provision*. This mode goes beyond merely enabling local-level action to providing technical assistance, tools and other services to local authorities and making funding available to help local governments address climate change. Clearly, these three modes can and perhaps should exist side by side: capacity building and fiscal transfers, for example, can help local governments to undertake mandatory actions. Indeed, the provision of adequate additional resources addresses the possible concern of a new 'unfunded mandate' for local government.

The preceding three modes of multilevel governance emphasize top-down relations within a static framework. In addition to these modes, we have identified a fourth vertical relation: *governing with representation and consultation* between the levels of government. Under this modality, the local government sector can become involved in or influence the ongoing development at the national level of policies and strategies in an evolving and dynamic policy, legal and regulatory environment.

3.2 *Urban Climate Governance in Laws/Policies in the Countries Surveyed*

Bearing in mind the framework for multilevel governance presented above, we review the laws passed or policies emerging from the three countries surveyed.

3.2.1 The Philippines

The Philippines' Climate Change Act considers local government units (LGUs) to be 'frontline agencies' in addressing climate change. The Act places particular emphasis on the roles of cities and municipalities in this effort (Sec. 14). The Climate Change Act takes pains to define responsibilities and intergovernmental relations accordingly. It exhibits, in a robust manner, all four of the vertical governance modes noted above.

Firstly, in terms of *governing by authority*, the Act requires municipal and city governments to 'consider climate change adaptation as one of their regular functions'. More specifically, it requires LGUs to prepare and regularly update Local Climate Change Action Plans (Sec. 14). This planning requirement is supported by provisions for *governing by enabling*. The Department of the Interior and Local Government (DILG) and Local Government Academy shall 'facilitate the development and provision of a training program for LGUs in climate change'. The Department of Environment and Natural Resources will establish and maintain a 'climate change information management system and network', while another agency will disseminate relevant information (Sec. 15).

The Climate Change Act also reflects, to a more limited extent, the *governing by provision* modality. It explicitly declares that 'It shall be the responsibility of the national government to extend technical and financial assistance to LGUs for the accomplishment of their Local Climate Change Action Plans' (Sec. 14). However, while it expressly authorizes LGUs to utilize resources from an existing fiscal transfer to implement these plans (Sec. 14), it does not provide for any additional financial resources for this purpose; this circumstance raises the spectre of an 'unfunded mandate' for the additional planning work required. Still, the Act does go on to require government financial institutions to 'provide preferential financial packages for climate change-related projects', including LGUs, presumably for projects once they have been identified via local planning processes (Sec. 15f). With regards to technical assistance, the Act also specifies that 'Provincial governments should provide technical assistance in support of municipal- and city-level initiatives' (Sec. 14).

One noteworthy feature of the Philippine Act is its provision for *governing through representation and consultation*. To guide the government's ongoing climate change response, the Act established a top-level Climate Change Commission, charged with developing and updating a Framework Strategy on Climate Change along with other duties (Sec. 11). This Commission is supported by an Advisory

Board. Of the 20-plus members of this Board, four are from the organized subnational government sector: the presidents of the leagues of provinces, cities, municipalities and barangays (Sec. 5). This provision should provide for valuable feedback about on-the-ground implementation of the Act that can inform further policy development. As a transitory measure, the Act further provides for consultation with stakeholders, including (explicitly) the local government sector, on the implementing rules and regulations of the Act (Sec. 22).

3.2.2 Mexico, State of Chiapas

Compared with the Philippines, Chiapas's Law for Adaptation to and Mitigation of Climate Change places a much greater emphasis on *governing through authority*. Municipalities along with other entities are charged with 'incorporate[ing] policies and strategies that address climate change into their plans and development programs' (Art. 11); they should also formulate climate change policy and take adaptation and mitigation actions (Art. 12). More specifically, the law requires municipalities to 'formulate, approve and administer municipal climate change plans and programs . . ., and to monitor and evaluate their implementation . . .'. Furthermore, the law specifies the priorities that municipalities should reflect in their plans (e.g. to protect population centres and human life) (Arts. 20 and 34). Even more concretely, the law stipulates reductions in urban greenhouse gas emissions in the solid waste and transportation sectors (Art. 9). The law's first sentence stresses the obligatory character of all such provisions (Art. 1).

Chiapas's climate change law reflects to a more limited extent the modalities of *governing through enabling* and *governing by provision*. In both cases, support is to be provided through a yet-to-be-established State Environmental Fund. This fund should help to finance adaptation and mitigation actions, as well as educational programmes (Art. 29). Somewhat troubling, however, is the lack of a dedicated funding source specified for this fund.

The law in Chiapas does not explicitly provide for any local government *representation and consultation* in ongoing state-level decision-making. While it does provide for establishment of a Coordinating Commission, representatives of state-level entities predominate; the local government sector is not represented. Representatives of LGUs and other entities can only attend meetings as non-voting participants upon express invitation from the Commission (Art. 14).

While the focus of the present analysis is on the interactions between state and local government, it is worth noting that the Chiapas Law takes steps to articulate a relation between the federal and state governments in meeting federal commitments to reduce greenhouse gas (GHG) emissions. Indeed, one explicit objective of the law is to orient the state in 'contribute[ing] to . . . compliance with international obligations related to climate change' (Art. 3). More specifically, the Chiapas Secretary of the Environment, Housing and Natural History is charged with 'identify[ing] opportunities and (when appropriate) approving projects to reduce emissions . . . in terms of the Kyoto Protocol . . .' (Art. 21). This provision is all the more striking when one considers that Mexico is not an ‘Annex I’ Party to the UNFCCC and the Kyoto Protocol, with commitments to reduce GHG emissions. However, in June 2009, Mexican President Felipe Calderon committed his country to voluntarily cut, by 2012, its GHG emissions by 50 million tons a year.

One final feature of the Chiapas Law that is worth noting is that, in addition to the preceding provisions for vertical interaction, the law also explicitly provides for *horizontal* coordination between municipalities, including via contracts and agreements, so as to address climate change (Art. 20).

3.2.3 South Africa

As noted above, South Africa has not yet finalized its national climate change policies and laws, but rather is in the middle of a consultative and analytical process to formulate its approach. That being said, the most recent milestone document in that process, the National Climate Change Response Green Paper of 2010, suggests the direction that laws and policies might eventually take with respect to multilevel governance.

The modes of governance promoted by this Green Paper vary substantially by sector. This policy document appears much more willing to adopt the more stringent ‘*governing by authority*’ mode in two sectors where mature technologies exists and have been at least partially proven to work in the South African context. Firstly, in the building sector, the paper calls for ‘regulating commercial building standards with a view to enforce green building construction practices’ (para. 5.9.7). Secondly, in the solid waste management sector, it calls for raising the minimum requirements for landfills (para. 5.9.21). Knowledge as to the technologies and pragmatic actions that can be adopted now may be more widespread in these sectors (e.g. through the capacity-building efforts of the Green Building Council of South Africa, or regarding a landfill Clean Development Mechanism project in Durban) than in other areas. On the other hand, the Green Paper seems to embrace a more cautious ‘*governing by enabling*’ approach in other sectors. For example, it would ‘encourage’ (rather than require) water-sensitive urban design. That this caution is driven by a perceived lack of knowledge is shown by calls in the paper for further research in certain areas (e.g. in the factors that determine urban resilience) (para. 5.9.1).

Likewise, the mode of governance promoted varies somewhat according to the location of the local government in question. In coastal areas, where exposure to climate change impacts is expected to be severe, the Green Paper adopts a more directive mode. In those exposed areas, the responsible governmental bodies will ‘ensure that long-term planning . . . incorporates relevant climate information and [takes] a risk-averse approach to planning’; ‘consider the potential impact of [climate change impacts] on infrastructure development and investment’; ‘protect and rehabilitate natural systems’ such as dunes and ‘develop disaster risk management plans [that] take into account the potential consequences associated with climate change impacts . . . ’ (paras. 5.9.16–19). Requirements are more limited in non-coastal urban areas.

More generally, and more gradually, the paper would require all three spheres of government (including all local governments) to begin to move towards alignment of all policies, laws, regulations and plans within their jurisdiction with the (forthcoming) National Climate Change Response Policy and to achieve that alignment by 2014 (para. 6.1.2). The paper particularly calls for addressing climate change in land use and transportation plans (paras. 5.6.2 and 5.6.9).

In terms of *governing by provision*, the South African paper recognizes the need to provide new tools to implementers including local governments. It provides for the downscaling of models 'to provide climate information at a scale that can be integrated into . . . spatial and development plans' (paras. 5.9.3 and 8.4.8) and the strengthening of decision-making support tools such as a Toolkit for Integrated Planning (para. 5.9.10). However, regarding financial support, the paper is silent on the assignment of new resources to local governments to address additional planning requirements. Despite this, similar to the case of the Philippines, the paper does recognize the need for additional investment resources to address climate change, to be obtained from existing financing institutions and a new Climate Change Fund (paras. 8.1.2 and 8.1.4).

Regarding *governing with representation and consultation*, the Green Paper recognizes the need for vertical mechanisms to ensure ongoing coordination between the spheres of government. It generally calls for that coordination to occur via committees and working groups that already exist. Furthermore, the South African Local Government Association is explicitly recognized as the appropriate body to 'actively participate in the inter-governmental system', as well as to 'ensure the integration of climate . . . actions into Integrated Development Plans' and disseminate information to the public (Sect. 7.4).

3.3 Initial Implementation

Given the recent status of all three initiatives, we can only discuss the initial implementation steps taken in that country with the (relatively speaking) oldest climate change legislation: the Philippines. Here, the DILG (with some support by UN-Habitat) is systematically moving ahead with the implementation of provisions of the 2009 Climate Change Act that affect local-level planning. In 2010 and 2011, based on a pilot experience in Sorsogon City also supported by UN-Habitat,[2] DILG began to address the planning provisions called for by the Climate Change Act. Implementation of this Act is taking place within the context of a multi-year effort to consolidate a disparate group of local-level planning requirements that have accumulated over time into two major planning tools, the Comprehensive Land Use

[2]For more information on the activities of UN-Habitat's Cities and Climate Change Initiative in the Philippines and elsewhere, please visit www.unhabitat.org/ccci.

Plan and the Comprehensive Development Plan. For this reason, the DILG is placing more emphasis on mainstreaming climate change planning into these existing tools than was the original thrust of the Climate Change Act. As of May 2011, all of DILG's regional officers and trainers had completed a training of trainers workshop on this topic. Furthermore, trainers had carried out replication workshops in three cities selected as pilots for mainstreaming climate change concerns into local plans. DILG has scheduled replication of this exercise in more than 50 cities and municipalities for the remaining year.

4 Conclusions and Promising Practices

While it is too early to draw definitive conclusions, review of these experiences suggests several 'promising practices'.[3] Firstly, the Philippines' Climate Change Act reflects a thoughtful approach whereby the 'governing by authority' mode of governance (through which local governments are assigned new responsibilities) is carefully supplemented by provisions that reflect the 'governing through enabling' and 'governing by services' modes, whereby the national government is charged with actively supporting local-level action. While arguably appropriate in virtually all contexts, this sort of design may be particularly relevant in developing countries where local governments of limited capacity may be excessively weighed down by diverse urban management responsibilities, even before adding on new climate change-related duties.

Secondly, establishing explicit consultative mechanisms whereby the local government sector is formally included in the ongoing process of policy formulation, providing for a feedback loop from the field, represents another promising feature of the Philippines' Climate Change Act.

Thirdly, a noteworthy feature of the Chiapas Law is the willingness on the part of a sub-national government (the State of Chiapas) not only to reduce GHG emissions but also to try to explicitly link their efforts to national-level targets and commitments to curb emissions. Since the sub-national government sector exerts at least some level of influence over a substantial portion of the world's GHG emissions, and to date the relation of sub-national- to national-level efforts and commitments has been rarely if ever well-articulated, this measure represents an interesting precedent.

While the three legal and policy documents reviewed above contain a number of promising features, other features raise questions that merit ongoing monitoring

[3] A term utilized by UN-Habitat, in implementation of the Dubai International Award for Best Practices to Improve the Living Environment, to designate new, innovative practices that eventually may mature into 'best practices'.

during implementation. Firstly, in all three countries, the adequacy of provisions for funding to help local governments carry out new planning and investment responsibilities merits close monitoring.

Secondly, the approach being advocated in South Africa whereby coastal municipalities would be assigned with greater responsibilities for addressing climate change than would be non-coastal local governments is of interest. Proponents of this approach could claim that this represents a modulated effort to require those local governments projected to be hardest hit by climate change to pay the most attention to this issue, while increasing to a lesser extent the cumulative burden on other, less impacted local authorities. On the other hand, critics might point to the risks inherent in this approach, whereby some (inland) local authorities such as Gauteng Province that will face climate change impacts may be lulled into a false sense of complacency, or provided with inadequate support for taking action. This issue merits ongoing monitoring during the eventual implementation.

One emerging theme in the ongoing climate change debate is the extent to which local authorities should try to 'mainstream' their climate change response into existing planning processes on the one hand or develop stand-alone climate change plans on the other.[4] As noted above, the emerging South African policy embraces mainstreaming. The Philippines represents an interesting example in this regard: whereas their Climate Change Act calls for stand-alone plans, in practice (and in line with a general trend in the country towards consolidation of planning requirements), the DILG has been promoting a mainstreaming approach.

All three experiences represent groundbreaking efforts to develop climate change laws and policies that define substantial roles for local governments. They merit ongoing tracking as they develop and mature.

References

Alber, G., & Kern, K. (2008). Governing climate change in cities: Modes of urban climate governance in multi-systems. In *Conference on competitive cities and climate change.* Conference on Competitive Cities and Climate Change, sponsored by the Organisation for Economic Co-operation and Development, Milan, Italy, 9-10 October 2008. Unpublished conference paper.

Benzie, M., Alex, H., & Karen, M. (2011). Adaptation in UK cities: Heading in the right direction? ICLEI. In *Resilient cities: Cities and adaptation to climate change: Proceedings of the global forum 2010* (pp. 231–242). Conference on Competitive Cities and Climate Change, sponsored by the Organisation for Economic Co-operation and Development, Milan, Italy, 9-10 October 2008. Unpublished conference paper.

Hartz-Karp, J., & Meister, H.-P. (2011). Creating resilient cities through empowered, deliberative participation. ICLEI. In *Resilient cities: Cities and adaptation to climate change: Proceedings*

[4]For a brief discussion of the pros and cons of the 'mainstreaming' versus 'stand-alone' approaches to addressing climate change via urban management systems, see Benzie et al. (2011). For a pro-'mainstreaming' argument, see Hartz-Karp and Meister (2011); for a pro-'stand-alone' recommendation, see UN-Habitat (2011, p. 147).

of the global forum 2010 (pp. 177–185). Conference on Competitive Cities and Climate Change, sponsored by the Organisation for Economic Co-operation and Development, Milan, Italy, 9-10 October 2008. Unpublished conference paper.

UN-Habitat. (2011). *Global report on human settlements 2011: Cities and climate change*. Conference on Competitive Cities and Climate Change, sponsored by the Organisation for Economic Co-operation and Development, Milan, Italy, 9-10 October 2008. Unpublished conference paper.

Space for Adapting: Reconciling Adaptation and Mitigation in Local Climate Change Plans

Elisabeth M. Hamin and Nicole Gurran

Abstract Amid the complexity of actually planning for adaptation and mitigation in cities, spatial form matters. Denser urban environments generally have lower per capita emissions because they enable transit and more efficient heating. At the same time, a larger green infrastructure can be beneficial to adaptation, as it provides room for urban greening, storm and flood water management, and treatment of other ill-effects of climate change. City plans need to reconcile both goals to be fully climate resilient, but to date, there has not been an empirical evaluation on whether the adaptation policies cities are choosing create conflict with mitigative goals. To address this, we undertake a content analysis of policies in 11 major adaptation plans and explore the implications of these for mitigative potential in the urban form. Overall, we found that many of these policies do not require dedication of new space and likely have little effect on mitigation. For those that require more space, we suggest ways this can be managed to still facilitate mitigation. Examples include repurposing automobile roads into green infrastructure and using coastal retreat and habitat corridors to transfer development to more transit-friendly urban areas. We see a virtuous circle emerging where mitigation and adaptation work together at the city scale to create more desirable cities.

Keywords Land use • Spatial form • Green infrastructure • Municipal policy • Municipal planning

E.M. Hamin (✉)
Department of Landscape Architecture and Regional Planning, University of Massachusetts Amherst, 109 Hills North, Amherst, MA 01003, USA
e-mail: emhamin@larp.umass.edu

N. Gurran
Urban and Regional Planning Program, University of Sydney, Wilkinson Building (G04), 148 City Road, Sydney, Australia
e-mail: ngurran@arch.usyd.edu.au

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_33,

1 Introduction

Urban areas have essential roles to play in both mitigating climate change and in preparing for expected changes. Regarding mitigation, cities are the primary source of greenhouse gas (GHG) emissions, but they also have enormous potential to provide GHG reductions (United Nations Human Settlements Programme, UN-Habitat 2011). In developed countries, part of this potential comes from the greater efficiency of public transit, biking, or walking as compared to auto travel. Hence, situations that encourage effective alternative transportation tend to reduce per capita GHG emissions (Ewing et al. 2008). Denser environments also provide heating efficiency through shared walls and more efficient delivery (Ewing and Rong 2008). The result is that in developed countries city residents tend to have smaller ecological footprints than their suburban counterparts, so cities are both the problem and solution to at least part of the global mitigation challenge (Rees and Wackernagel 2008). Given the pressing need to reduce emissions in all feasible domains (Pacala and Socolow 2004), urban spatial forms that are denser and more transit friendly are important policy goals.

In terms of adaptation, by 2050, it is expected that over 70% of the world's population will be urban (UNFPA 2007). Many of the world's largest cities are located at environmentally sensitive locations—sea coasts, riverbeds, tidal flats—and are likely to experience significant climate impacts (IPCC 2007). Designing and planning the urban form to reduce the harm caused by those climate impacts—in other words, climate adaptation—is essential to protect human populations. But in the built form, effective adaptation often comes from policies that keep more open space in the urban fabric—space to allow storm water to infiltrate, trees to cool the air, species to migrate, and breezes to flow (Pizzaro 2009; Roaf et al. 2005). Adaptation may be easier in less-dense settings.

Following this logic, in previous work, we have argued that in urban areas the challenge is space—how to make cities dense enough for bus/biking/walking, without reducing adaptive capacity (Hamin and Gurran 2008). At that time, few municipalities had completed adaptation plans, so our argument was largely prospective and theoretical. Four years later, there are enough municipal adaptation plans that we can empirically test whether the adaptation policies cities are choosing create conflict with mitigative goals. In this research, we review the policies prescribed in leading adaptation plans, primarily in USA and Australia but also in Europe and South Africa. We selected either complete adaptation plans or substantive chapters in the combined adaptation and mitigations plans. We selected only plans that provided concrete recommendations with some spatial repercussions. Using these criteria, we found 11 plans that could be included in the analysis—see the Appendix for a full list.

2 Adaptation Policies Selected by Cities in the Sample

Table 1 depicts the various adaptation policies that cities are choosing.[1] Water management is the item receiving the most attention. Given that climate change will lead to an intensification of the hydrological cycle in most parts of the world, it is appropriate that water is the top policy concern when it comes to the physical design of our cities. Attention to water can particularly benefit the poor, as low-income households tend to be located in or near the flood zones and the poor tend to have less access to drinking water (Rosenzweig et al. 2011).

When it comes to the spatial character of the implementation choices, a majority of the policies cities are choosing utilize no new space at all, demonstrating that there is quite a bit a city can do to encourage adaptation without requiring dedication of scarce urban space. Actions such as encouraging light-coloured roofs, recommending plant species that will be hardy in emerging climate conditions, and revising engineering and building standards do not directly impact people's property and development rights. Further, it appears that none of these require significant energy to operate and tend to actually encourage more energy-efficient buildings (e.g. green roofs, LEEDs certification). These adaptive actions are either neutral or pro-mitigation.

The approximately 40% of policies that will require the dedication of urban land are more complicated to evaluate for pro- or anti-mitigation effects. With the exception of urban greening, each of these could be used to create or enlarge

Table 1 Policies selected by cities by frequency and spatial implication

Revised engineering standards (e.g., larger storm pipes)	10
Revised design guidelines (LEEDs, building code, etc.)	9
Green roofs and walls	7
Permeable/porous pavement	6
Revised planting lists	4
Public space design for cooling	4
Design for flooding or seawall improvements	4
Albedo lightening	4
Space neutral actions	48
On-site stormwater treatment	8
Zoning changes to limit development in vulnerable areas	7
Expansion of coastal setbacks, natural floodplains and waterways	6
Significant new urban greening/forests	6
Habitat corridors to preserve migration routes	3
Increased urban agriculture and food security	3
Space-absorbing actions	33

$n = 11$ plans, 81 policies, see Appendix for a list of plans and cities

[1]More detail on some of these plans and our analysis is available in Hamin and Gurran (2008) and Hamin (2011).

growth boundaries, encouraging development to occur in existing urban areas or in new but moderately dense nodes that are easy to serve with public transit. Coastal retreat, for instance, can be used to preserve public access to beaches and to preserve habitat, while moving development to denser inland neighbourhoods. In Australia, the quarantining of development rights in low-lying coastal foreshores has become a major concern for homeowners and local authorities, operating within an uncertain regulatory framework (House of Representatives 2009).

The policies could also just push development further out into previously undeveloped areas, encouraging sprawl in the name of adaptation. Urban greening in particular is one of the most challenging policies. Trees are perhaps the single best way to provide air cleansing, urban cooling, and storm water management and may be placed into already-paved areas, creating a huge adaptive win while also sequestering carbon (Currie and Bass 2008). Trees also improve the liveability and desirability of urban areas, and therefore make dense neighbourhoods more popular. But aggressive, large-scale urban greening and urban agriculture initiatives may instead reduce overall densities and create sprawl. The adaptation plans are not specific enough to be able to judge which way these will go.

Despite the challenges mentioned above, there is one particular urban retrofit policy that holds promise in reconciling the need for urban greening with the need to maintain urban densities. In urban retrofit areas, land can be transitioned from automobile-related uses to adaptive uses (Felsen and Dunn 2008). This is already underway in some cities. New York City, which exemplifies competition over urban space, has moved land use from roadway to ecoway. Broadway, one of Manhattan's main roads, has become narrower and greener as two entire lanes have become bicycle lanes and protective seating/infiltration land (Neuman 2008). Chicago, in another example, is renovating its system of urban alleys to become green alleys (City of Chicago n.d.). The plan for North Vancouver calls for every third street to be a green street, supporting on-site storm water management and pedestrian and bike mobility instead of automobile travel (Condon 2010). Less roadway for cars and more for the alternatives—buses, bikes, pedestrians—makes alternative travel more likely (Newman and Kenworthy 1989) and thereby should reduce per capita greenhouse gas emissions. If the 'green streets' are designed with minimal impermeable pavement, more trees, more on-site storm water management potential, we may get cooler, safer, better adapted cities, without making them more spatially dispersed. We gain the benefits of urban greening and create more adapted cities, without sacrificing reductions in greenhouse gas emissions.

These actions seem likely to be more effective when done as part of a systemic, regional approach. An emerging way to frame and characterize this is as green infrastructure (GI)—multipurpose, regionally connected open space that provides some of the same services as traditional 'grey' urban infrastructure, but in a way that is more similar to natural hydrological processes (Gill et al. 2007). Examples of GI include substituting on-site storm water treatments for piped systems, using trees for cooling and air purification rather than air conditioners, etc. This research finds that indeed, cities are choosing green infrastructure for climate adaptation (see Table 2).

Table 2 Green infrastructure

On-site storm water	Permeable/porous pavement	Significant new urban greening/forests	Restoration/expansion of natural floodplains and other waterways	Habitat corridors to preserve migration routes	Increase urban agriculture and food security	Green roofs and walls

Less clearly, but maybe GI				Non-GI responses			
Zoning changes to limit building in vulnerable area	Revised engineering standards (e.g. onsite storm water)	Revised design guidelines (require green roofs etc.)	Design for flooding or seawall improvements	Revised engineering standards (e.g. larger storm pipes)	Revised design guidelines (building code, etc.)	Design for flooding or seawall improvements	Albedo lightening

3 Summary and Conclusions

This is exploratory research and comes with a number of limitations. Our study focused on plans that are web-available in English; it would be helpful to include a more global sample in the next phase of our research. This research reports what policies cities propose, but not what they are actually implementing or how effective those steps are—this is also essential knowledge to improve adaptation practice as it develops. Finally, there is a great need for research to help cities determine how to optimize the adaptive capacity of green infrastructure and other policies listed here for achieving adaptive capacity without interfering with mitigation. Clearly this work is only the beginning.

As we noted at the start, theorists have worried that given a need to prioritize, cities may choose adaptation actions even if they conflict with mitigation. Our research suggests that at least in our sample, this is not occurring, and in fact, cities are prioritizing adaptive actions that are unlikely to interfere with mitigation or may even support it. As the analysis points out, there is a range of options from which cities can choose, and many of the preferred policies do not require new urban space for implementation. We also found that many city policies fit into the general framework of green infrastructure, suggesting that developing more regional, systematic approaches to adaptation will be possible.

When cities need to adopt policies that require dedication of urban space, the analysis suggests that there are four approaches to finding space for adaptation, arranged from likely easier to implement to the more difficult actions:

1. Upgrade existing frontages, sidewalk areas, and parks and backyards that have little tree canopy or storm water infiltration with better planting.
2. Insert larger areas of urban green with care, to encourage nodal and corridor development between dense and transport-efficient neighbourhoods.
3. Repurpose selected roadways to ecolanes designed to make bicycle and pedestrian movement easy, treat storm water, and cool the urban environment through plantings.
4. Extend coastal foreshores or existing floodways to accommodate settlement retreat or relocation and more nuanced approaches to designing for water, transferring development to more appropriate locations.

Each of these shows ways to increase an urban area's adaptive capacity without interfering with mitigation. Taking this one step further, it is apparent that the list of actions that cities propose for adaptation—urban greening, better storm water management, cooling stations, and coastal open space—are actions that make the cities themselves more attractive, more desirable, more liveable. Better cities mean fewer residents opting for the suburbs. More urban residents mean lower per capita GHGs. Adaptation brings liveability, brings urban growth, and brings GHG reductions per capita. Adaptation can not only be reconciled with mitigation, but if done well, it is mitigation.

Appendix: Plans Reviewed

City/region	Year of plan	Pop. density per km	Plan name	Author
Byron and Tweed Shire Councils	2009	64	Climate Change Adaptation Action Plan: Assessing Climate Change Risk and Adaptation Strategy Development in the NSW Northern Rivers Region	GHD Consultants
Cairns Regional Council	2010	251	Positive Change—Climate Change Risks and Opportunities for the Cairns Region; Climate Change Adaptation Action Plan	AECOM Consultants
Chicago	2008	4447	Chicago Climate Action Plan (esp. Chapter 6)	Chicago Climate Task Force
Ethekwini/Durban	2009	3,919	Climate Change Municipal Adaptation Plan: Health and Water	ERM Consultants
Halifax, NS[a]	2007	68	Climatesmart: Climate Change Risk Management Strategy for Halifax Regional Municipality	Halifax Regional Municipality
Keene, NH	2007	240	Adapting to Climate Change: Planning a Resilient Community	City of Keene and ICLEI
King County, WA	2007	315	King County Climate Plan (esp. Chapter 6B)	City Hall, King County, Washington
London	2010	4,807	The Draft Climate Change Adaptation Strategy for London, Public Consultation Draft	Mayor of London
Melbourne	2009	1,566	City of Melbourne Climate Change Adaptation Strategy	City of Melbourne
Rotterdam	2008–2010	2,850	Rotterdam Climate Proof: The Rotterdam Challenge on Water and Climate Adaptation and the follow up 2010 Programme	Rotterdam
Toronto	2008	3,972	Ahead of the Storm … Preparing Toronto for Climate Change	Toronto Environment Office

[a]The Halifax plan is a set of options for treating particular hazards, but these options have been run through a fairly rigorous multistage screening process already and so are similar in specificity and likelihood of implementation to policies listed in other plans

References

City of Chicago. (n.d.). *The Chicago green alley handbook*. Chicago: Department of Transportation.

Condon, P. M. (2010). *Seven rules for sustainable communities: Design strategies for the post-carbon world*. Washington, DC: Island Press.

Currie, B. A., & Bass, B. (2008). Estimates of air pollution mitigation with green plants and green roofs using the UFORE model. *Urban Ecosystems, 11*(4), 409–422.

Ewing, R., & Rong, F. (2008). The impact of urban form on U.S. Residential energy use. *Housing Policy Debate, 19*(1), 1.

Ewing, R., Bartholomew, K., Winkelman, S., Walters, J., & Chen, D. (2008). *Growing cooler: The evidence on urban development and climate change*. Washington, DC: Urban Land Institute.

Felsen, M., & Dunn, S. (2008). Growing water. *Places, 20*(2), 36–41.

Gill, S. E., Handley, J. F., Ennos, A. R., & Pauleit, S. (2007). Adapting cities for climate change: The role of the green infrastructure. *Built Environment, 33*(1), 115–133.

Hamin, E. M. (2011). Integrating adaptation and mitigation in local climate change planning. In G. Ingram & H. Hong (Eds.), *Climate change and land policies*. Cambridge, MA: Lincoln Land Institute Press.

Hamin, E., & Gurran, N. (2008). Urban form and climate change: Balancing adaptation and mitigation in the U.S. and Australia. *Habitat International, 33*, 238–245.

House of Representatives. (2009). *House of representatives standing committee on climate change, water, environment and the arts house of representatives committee report: Managing our coastal zone in a changing climate: The time to act is now*. Canberra: Australian Government.

IPCC. (2007). Climate change 2007: Impacts, adaptation and vulnerability. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, & C. E. Hanson (Eds.), *Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html. Accessed 1 July 2009.

Neuman, W. (2008). Closing on broadway: Two traffic lanes. *New York Times*. http://www.nytimes.com/2008/07/11/nyregion/11broadway.html. Accessed 11 Feb 2010.

Newman, P. W. G., & Kenworthy, J. R. (1989). *Cities and automobile dependence: An international sourcebook*. Aldershot: Gower.

Pacala, S., & Socolow, R. (2004). Stabilization wedges: Solving the climate problem for the next 50 years with current technologies. *Science, 305*(5686), 968–972.

Pizzaro, R. (2009). Urban form and climate change: Towards appropriate development patterns to mitigate and adapt to global warming. In S. Davoudi, J. Crawford, & A. Mehmood (Eds.), *Planning for climate change: Strategies for mitigation and adaptation*. London: Earthscan.

Rees, W., & Wackernagel, M. (2008). Urban ecological footprints: Why cities cannot be sustainable—and why they are a key to sustainability. In J. M. Marzluff, E. Shulenberger, W. Endlicher, M. Alberti, G. Bradley, C. Ryan, U. Simon, & C. ZumBrunnen (Eds.), *Urban ecology*. New York: Springer.

Roaf, S., Crichton, D., & Nicol, F. (2005). *Adapting buildings and cities for climate change*. Oxford: Elsevier.

Rosenzweig, C., Solecki, W., Hammer, S., & Mehrotra, S. (2011). *Climate change and cities: First assessment report of the urban climate change research network*. Cambridge: Cambridge University Press.

UNFPA. (2007). In G. Martine (Ed.), *The state of world population: Unleashing the potential of urban growth*. New York: United Nations.

United Nations Human Settlements Programme (UN-Habitat). (2011). *Cities and climate change: Global report on human settlements 2011*. London: Earthscan.

The Early Experiences of Local Climate Change Adaptation in Norway Compared with That of Local Agenda 21

Carlo Aall

Abstract Norwegian experiences on Local Agenda 21, local climate change mitigation and local climate change adaptation are compared. One conclusion drawn from these experiences is that climate change adaptation lacks the normative impetus for local action that Local Agenda 21 and climate change mitigation have had, thus making it harder to include climate change adaptation in serious policy making. Another conclusion is that climate change adaptation is framed in a way that can be counterproductive to climate change mitigation. By focusing only on the partial effects of changes in local climate conditions and ignoring the possible local effects of climate change in other countries, climate change vulnerability assessments tend to conclude on far less dramatic consequences compared to the general debate on the global effects of climate change. In turn, climate change sceptics may use this information to challenge the conclusion that serious steps need to be taken to avert disaster. The final conclusion is that currently both climate change mitigation and adaptation receive little attention in policymaking at the local, regional and national level.

Keywords Climate change adaptation • Climate change mitigation • Local Agenda 21 • Sustainable development • Norway

1 Introduction

For more than 20 years, a large number of local authorities have been working internationally with the issues of sustainable development, Local Agenda 21 (LA21) and climate change mitigation (CCM). Thus, when discussing the emergence of the

C. Aall (✉)
Western Norway Research Institute, 6150 Sogndal, Norway
e-mail: caa@vestforsk.no

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_34,

new environmental policy issue of climate change adaptation (CCA), it seems fair to draw on these previous experiences. By focusing mainly on experiences from Norway, this chapter will address the following questions: (1) What are the major lessons of working locally with sustainable development, LA21 and CCM? (2) What are the early experiences of working locally with CCA? (3) What lessons can we take from LA21 and CCM to cope with some of the challenges of working locally with CCA?

2 The History of Working Locally with Sustainable Development and LA21 in Norway

In 1988, the national government initiated a high-profile government-financed reform programme at the local level through the 'Environment in the Municipalities Programme' (abbreviated MIK in Norwegian), which took place from 1988 to 1990. The actual reform was introduced by a government white paper on local environment policy in 1991, which among other policy means introduced earmarked funding for applying an environmental officer in each Norwegian municipality lasting from 1990 to 1997. Since then, several research projects have been carried out studying the MIK programme and reform (Jansen 1991; Naustdalslid and Hovik 1994; Hovik and Johnsen 1994).

At first, the MIK reform overshadowed Norway's LA21 efforts, and it was not until 1996 that the first Norwegian municipality (Sogndal) passed a local plan referring explicitly to LA21. However, soon after this, a government programme on promoting LA21came into effect that lasted from 1997 to 2001.

Regarding the policy process, we may sum up the following insights on MIK and LA21:

- Globally, LA21 appears to have been the most successful follow-up of all of the chapters in Agenda 21, at least measured in the 'volume' of activity.
- MIK and LA21 lead to much stakeholder involvement, to a lesser degree, allowing environmental policy to come into grip with 'serious politics'.
- A lack of national support of LA21 in the form of a National Agenda 21 left local authorities 'on their own'.

Regarding policy content, we can sum up the following:

- A lack of substantive success in the sense of seriously contributing to creating 'more' sustainability.
- Mostly 'soft', to a lesser degree 'hard' policy measures were implemented.
- The emergence of 'front-runner municipalities' working also with the more conflicting issues of sustainable development, like sustainable consumption and energy use, running 'in front' of both their fellow municipalities and the national government.

3 The History of Working Locally with CCM in Norway

Local climate policy as a defined policy area was introduced in Norway when the parliament passed the government white paper on the Kyoto protocol in June 1998. The government white paper was followed up by a circular from the Ministry of Environment (MoE) in September 1998, stating that municipalities, in cooperation with the county and regional government authorities, should make local climate plans aiming at reducing greenhouse gas (GHG) emissions and increasing carbon sequestration by afforestation. This steering signal was followed up in 2000 by the MoE, which granted NOK seven million (one million Euro) to a local climate policy programme on promoting local climate planning in Norwegian municipalities and counties. Thirty-seven municipalities and eight counties took part out of a total of 431 municipalities and 19 counties (Aall et al. 2007). In 2007, the government introduced earmarked funding (50.000 NOK) for each municipality to help create local climate and energy handbooks to support these plans, and an online 'one-click' device to produce local GHG emission accounts. In 2009, the MoE set a deadline that all Norwegian municipalities should have adopted a climate and energy plan by 1st of June 2010.

By July 2011, an online assessment presented by the Norwegian Agency on Energy Saving (ENOVA) showed that out of the 431 Norwegian municipalities, 71% have adopted such a plan, 29% are still working on it and 0.7% (3 municipalities) have not picked up on this task. However, the question remains unanswered as to whether something concrete comes out of these extensive planning activities. An assessment of the previous local climate policy programme showed that the outset in the plans on reducing GHG emissions was in some way altered during the implementation stage into energy measures, such as energy savings and providing new renewable energy production facilities (Lindseth and Aall 2004). The situation today is probably the same, whereby climate planning tends to result in energy policy output. The three main national strategies on CCM are (1) buying international climate quotas, (2) funding protection of rainforests in developing countries, and (3) promoting carbon capture and sequestration. This strategy was set out by a government green paper presented by the government-appointed Norwegian Commission on Low Emissions, which assessed the possibilities for reducing Norwegian emissions by 60% by the year 2050 compared with 1990. In the introduction to this report, an important delimitation was made (MoE 2006: 5, my translation): 'A radical shift in the Norwegian way of life in a more climate-friendly direction could deliver major reductions in future GHG emissions. The Commission on Low Emissions has, nevertheless, chosen not to recommend such a strategy, because, among other things, we believe it would be politically impossible to put into effect.' Thus, local authorities are left in limbo. The main strategies as defined in the national climate policy are focusing on areas of policymaking that are outside the domain of local authorities, whereas one of the most important policy domains of local authorities when it comes to reducing GHG emissions – namely, that of GHG emissions linked with private consumption – is specifically ruled out by the national government. Not surprisingly, local action on CCM is therefore often reduced to producing symbols wrapped in local climate planning documents.

The following sums up the main insights regarding the policy process of working locally with CCM:

- Less examples of broad stakeholder involvement, to a larger degree, an in-house planning exercise – but still with limited access to 'serious politics'.
- A soft-policy approach (e.g. requesting and economically and in other ways supporting local CCM planning processes) – but local governments are not included (so far) in economic measures (e.g. Emission Trading Systems), and it is still unclear how 'much' is expected of local authorities.

Regarding policy content in working locally with CCM, the insights are:

- A split policy focus: Reducing production- versus consumption-related emissions. The latter is 'banned' in national CCM policies, but is picked up by some local and regional authorities.
- Also in the case of CCM, we find examples of 'front-runner municipalities' running in front of both their fellow municipalities and the national government.

4 The Early Experiences of Working Locally with CCA in Norway

It seems fair to state that CCA has entered late into the climate policy agenda in Norway (Swart et al. 2009). None of the so far four government white papers on climate policy (1995, 1998, 2001 and 2007) have identified CCA as a relevant task for policymaking in Norway. However, this situation has recently changed. In 2008, a Public Committee on Climate Change Adaptation was established with a mandate to present a government green paper, which was presented in autumn 2010 (MoE 2010). In addition to assessing the climate change vulnerabilities of Norway, a number of policy measures were recommended. This includes integrating CCA in all aspects of public planning, increasing the knowledge basis for CCA, increasing the capacity and competence on CCA in local government, and to catch up with what the government green paper denoted as an 'adaptation deficit', that is, to reduce the lag of money spent on maintenance of physical infrastructure.

How is climate change adaptation understood and conceptualized by local authorities? No studies have been conducted that can answer this question in a good manner. However, participating in a large number of projects involving municipalities, reading examples of local policy documents on CCA, and having direct communication with representatives of municipalities that have placed CCA on their policy agenda allow for making two general reflections on this question.

The *first* reflection is that for the case of CCA, similar to that of environmental policymaking in general, we can distinguish between a local- and global-oriented approach to framing local climate change vulnerabilities:

- Addressing the local effect of changes in local climatic conditions (e.g. local effects of a local flood incident)
- Addressing the local effects of changes in climatic conditions happening on a global scale (e.g. increased global food prices due to decreased global food security, which again is partly caused by climate change)

The first of the two is dominating; the latter is applied only by a limited number of front-runner municipalities.

The *second* reflection on the content of CCA relates to the idea of applying a two-dimensional approach in analysing climate change vulnerabilities. The two dimensions are climate and societal change. Societal change has long been recognized – at least in the academic discourse – as having fundamental importance in determining climate change vulnerability (Tol 1998), and several guiding notes have been produced on how to apply the use of societal scenarios in analysing climate change vulnerabilities, among others, in the United Kingdom (UKCIP 2001) and in Finland (Kaivo-Oja et al. 2004). This approach has also been developed in a Norwegian context and tested by Norwegian municipalities (Groven et al. 2008). But still, climate change vulnerabilities are in most cases analysed on the basis of the one-dimensional approach – even for the case of the United Kingdom which was a pioneering country in promoting this approach towards local authorities.

Experiences from working locally with CCA in Norway illustrate that there are a number of important impasses to overcome in order to achieve an efficient local adaptation to climate change. In a survey from 2007 to all Norwegian municipalities, 90% of the respondents stated that they would like to have clearer guidelines from the national government on CCA (Amundsen et al. 2010). However, a more recent study indicates that when such information and guidance actually do exist, local authorities often do not know about it or where to obtain it. The study in question done by the Office of the Auditor General of Norway in 2010 showed that a majority (56 out of 106) of the municipalities in which maps on geohazards were produced did not know of these maps – even if they had been told so by official emails and the maps had been available free of charge on the national website for geohazard assessments since 2007 (Riksrevisjonen 2010). So perhaps it is the lack of administrative capacity at the local level to make use of existing government information and guidance that is the real problem? Two different studies support this assumption. The first is an assessment of the government-funded programme 'Viable communities'. This is a follow-up of the MIK reform and the national support of LA21, more or less working along the same lines by means of funding local government network activities in support of local knowledge building on sustainable development. A survey done to map hindrances experienced by local actors when trying to promote sustainable development showed that the lack of administrative capacity came up more than any other predefined category of hindrances (Aall et al. 2007). A national survey done by DSB in 2007 corroborates this conclusion (DSB 2007).

The situation for working locally with CCA differs in many ways from that of sustainable development, LA21 and CCM, the most prominent being:

- A total lack of global policy input resembling that of Chapter 28 in Agenda 21
- Until recently, no global networks on local CCA resembling that of the Climate Alliance and the Cities for Climate Protection
- A lack of strong support from environmental NGOs (at least in the case of Norway)

Regarding putting CCA on the policy agenda, the following can be summarized:

- CCA entered late into the Norwegian national policy agenda (green paper on CCA published in autumn 2010).
- The civil protection community has been the main driver in putting CCA on the national policy agenda in Norway, with the Directorate for Civil Protection and Emergency Planning as a key actor.
- CCA entered a little bit earlier on the Norwegian local policy agenda (first front-runner municipality was Flora in 2006) than was the case for the national agenda (a preliminary short version of a national strategy in 2008).
- The research in combination with climate policy and land-use planning community have been the main drivers in putting CCA on the local policy agenda in Norway.

Regarding the CCA policy process, the early insights are as follows:

- Implementation of both soft (e.g. national web portal) and hard (e.g. as from 2010 it has become mandatory to make climate risk assessments as part of local land-use planning) measures.
- Measures on vertical (between national and local levels of government) are more pronounced than horizontal (between sectors at a national level) policy integration.
- Lack of administrative capacity (to some extent, also lack of competence) is viewed by the local authorities as the main hindrance for engaging more actively in CCA.

5 A Learning Potential?

So, what is to be learned from working with sustainable development, LA21 and CCM at the local level that can be of relevance for promoting local authorities to involve more actively in CCA? Below is a list of seven lessons:

1. Outside-in 'soft' policy support

   There is no formal global policy support for local CCA similar to LA21, until recently no supportive global-local government networks on CCA similar to that of CCM, and only reluctant support on CCA from environmental NGOs (at least in Norway).
2. Outside-in 'hard' policy support

   Government support is crucial for achieving results locally in the controversial parts of environmental policy. Whereas government support has been rather weak for the case of LA21 and CCM, there are signs of stronger support on local CCA (at least in Norway).
3. Build local partnerships

   LA21 was much about public participation and stakeholder involvement. So far, local CCA is mainly an in-house planning exercise (at least in Norway).
4. Seek for multiple benefits

   LA21 and local CCM often benefit from multiple benefits (e.g. LA21, improving livelihood conditions and CCM, reducing local air quality). What are the potential multiple benefits for CCA?
5. Sufficient local institutional capacity

   Deregulation and downsizing of public government can seriously hamper the core activities in LA21, CCM and CCA – namely, that of strategic planning and community development – and reduce such activities to in-house processes ('green offices', etc.).
6. Balancing between picking the low- and high-hanging fruits

   Trying to locally pick the high-hanging fruits (global instead of local environmental problems, consumption- instead of production-related GHG emissions) often does not deliver concrete policy outcomes, but triggers important political debates. For CCA, a similar split is between the local effects of local climate change versus local effects of the sum of global climate change.
7. Utilizing the positive role of front-runner municipalities

   LA21 and CCM have numerous examples of front-runner municipalities serving as a 'guiding star' for other municipalities. However, there are also examples of such municipalities serving as a 'lighthouse' in distracting attention from a passive national policy. What will be the case for CCA is still to be seen.

6 Conclusion

Comparing the experiences of sustainable development, LA21 and CCM with that of CCA presupposes that there is a sufficient similarity between these policy areas. There are however reasons to question this precondition. Sustainable development, LA21 and CCM are policy domains of a transformative nature, aiming at transforming society into something very different from that of today. On the other hand, CCA can be seen as a protective policy domain, aiming at protecting today's society from the external threat of climate change. This potentially fundamental conflict may separate 'adaption' from 'mitigation' and by that increase the risks of mal-mitigation (that mitigation can result in producing increased vulnerabilities in society towards climate change) and maladaptation (that adaptation can result in increased GHG emissions). On the other hand, we should question the extent to which prevailing policies on sustainable development, LA21 and CCM in rich industrialized countries like Norway are in fact 'transformative'. A number of studies have concluded that current policy performance on these issues is far from being 'transformative', in the sense of actually transforming towards a sustainable and carbon-free society (Aall and Husabø 2010; Høyer 2010). Thus, being deeply involved in CCA may have also a secondary negative effect, legitimizing the upholding of sustainable development and CCM as 'non-transformative' policy areas. How to change this deadlock situation is one of the most important questions that needs to be addressed in both academic and policy discourses to come. Kok and Coninck (2007) suggest one way out of this situation: that the international conventions on climate change need to be much stronger on adaptation to climate change. A crucial issue should therefore be, in the framework of the next generation of the international conventions on climate change, to identify and describe the danger of mal-mitigation and maladaptation and to develop policy paths to avoid this from happening.

References

Aall, C., & Husabø, I. A. (2010). Is eco-efficiency a sufficient strategy for achieving a sustainable development? The Norwegian Case. *Sustainability, 2*, 3623–3638.

Aall, C., Groven, K., & Lindseth, G. (2007). The scope of action for local climate policy: The case of Norway. *Global Environmental Politics, 7*(2), 83–102.

Amundsen, H., Berglund, F., & Westskog, H. (2010). Overcoming barriers to climate change adaptation – A question of multilevel governance? *Environment and Planning C: Government and Policy, 28*(2), 276–289.

DSB. (2007). *Klimatilpasning 2007. Klimatilpasning i kommuner, fylkeskommuner og blant fylkesmenn*. Rapport. Tønsberg Direktoratet for samfunnssikkerhet og beredskap.

Groven, K., Leivestad, H. H., & Aall, C. (2008). *Naturskade i kommunene*-Sluttrapport fra prosjekt for KS. VF-rapport 4/08. Sogndal: Vestlandsforsking.

Hovik, S., & Johnsen, V. (1994). *Fra forsøk til reform: Evaluering of MIK-programmet*. NIBR Rapport 1994: 23. NIBR, Oslo.

Høyer, K. G. (2010). Seven theses on CO_2-reductionism and its transdisclipinary counteraction. In R. Bhaskar, C. Frank, K. G. Høyer, P. Naess, & J. Parker (Eds.), *Interdisciplinarity and climate change. Transforming knowledge and practice for our global future* (pp. 35–54). London: Routledge.

Jansen, A. (1991). *Reform og resultater. Evaluering av forsøksprogrammet Miljøvern i kommunene*. Oslo: NORAS.

Kaivo-Oja, J., Luukanen, J., & Wilenius, M. (2004). Defining alternative national-scale socio-economic and technological futures up to 2100: SRES scenarios for the case of Finland. *Boreal Environment Research, 9*, 109–125.

Kok, M. T. J., & de Coninck, H. C. (2007). Widening the scope of policies to address climate change: Directions for mainstreaming. *Environmental Science and Policy, 10*(7–8), 587–599.

Lindseth, G., & Aall, C. (2004). *Kommuner og klima. En vanskelig kombinasjon. En spørreundersøkelse om klima og energiplanlegging i norske kommuner og fylkeskommuner*. Rapport 4/04. Oslo: ProSus.

MoE. (2006). *A climate friendly Norway*. An exposition from a Government Committee presented to the Ministry of Environment, Norwegian Official Reports 2006. Oslo: Ministry of the Environment.

MoE. (2010). *NOU 2010:10 Tilpassing til eit klima i endring. Samfunnet si sårbarheit og behov for tilpassing til konsekvensar av klimaendringane*. Oslo: Ministry of Environment.

Naustdalslid, J., & Hovik, S. (red.). (1994). *Lokalt miljøvern*. Oslo: TANO/NIBR.

Riksrevisjonen. (2010). *Riksrevisjonens undersøkelse av myndighetens arbeid med å forebygge flom- og skredfare*. Dokument 3:4 (2009–2010).

Swart, R. J., Biesbroek, G. R., Binnerup, S., Carter, T. R., Cowan, C., Henrichs, T., Loquen, S., et al. (2009). *Europe adapts to climate change: Comparing national adaptation strategies*. Helsinki: Partnership for European Environmental Research (PEER).

Tol, R. S. J. (1998). "Socio-economic scenarios". Version 2.0. In I. Burton, J. F. Feenstra, J. B. Smith, & R. S. J. Tol (Eds.), *UNEP handbook on methods for climate change impact assessment and adaptation studies*. Amsterdam: United Nations Environment Programme and Institute for Environmental Studies, Vrije Universiteit.

UKCIP. (2001). *Socio-economic scenarios for climate change assessment: A guide to their use in the UK Climate Impacts Programme*. Oxford: UK Climate Impacts Programme.

Climate Change Adaptation Plan of Vitoria-Gasteiz, Spain

Marta Olazabal, Efrén Feliu, M. Karmele Herranz-Pascual, Beñat Abajo, Iratxe González-Aparicio, Andrés Simón-Moral, and Andrés Alonso

Abstract According to the International Panel on Climate Change, while majority of the efforts to combat climate change have been centred on mitigation, climate change adaptation is becoming crucial for effective and efficient climate change strategies. This is demonstrated by the growing importance of concepts like vulnerability, adaptive capacity and resilience of socioecological systems in the international political agenda.

Along these lines, several of the climate change initiatives developed in the Basque Country express the need to develop climate change adaptation plans from a proactive and anticipatory perspective in order to minimize the impacts on ecosystems, human health and wellbeing, regional economy and infrastructures. Despite the competitive advantages and economic benefits which can be provided by the implementation of climate change adaptation strategies, many governments have not yet included such measures in their policies and plans. In this regard, the project PACC-Vitoria (Climate Change Adaptation Plan of Vitoria-Gasteiz) was formalized and launched in mid-2010 through a collaboration agreement between the Basque Government, the City Council of Vitoria-Gasteiz and the Unit of Environment of Tecnalia (research centre located in Bilbao, Spain).

Keywords Climate change • Adaptive capacity • Sustainable development • Floods • Vulnerability • Urban plans • Local adaptation • Vitoria-Gasteiz

---

M. Olazabal • E. Feliu (✉) • M.K. Herranz-Pascual • B. Abajo • I. González-Aparicio • A. Simón-Moral
Environment Department, TECNALIA Unit of Environment, C/ Geldo, Ed. 700, Parque Tecnológico de Bizkaia, 48160, Spain
e-mail: marta.olazabal@tecnalia.com; efren.feliu@tecnalia.com; karmele.herranz@tecnalia.com; benat.abajo@tecnalia.com; iratxe.gonzalez@tecnalia.com; andres.simon@tecnalia.com

A. Alonso
Environment Department, Vitoria-Gasteiz City Council, C/ San Prudencio 30, 01005 Vitoria-Gasteiz, Spain
e-mail: aalonso@vitoria-gasteiz.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_35,

1 Introduction

1.1 Social and Biophysical Characteristics of Vitoria-Gasteiz

It was not until the late eighteenth century that Vitoria-Gasteiz experienced a large influx of people moving into the urban area. As such, new quarters were created based on an urban development plan that favoured more parks, recreational areas and a higher standard of living (Table 1).

In the summer, the average maximum temperature in the city is 24.5°C, but temperatures can reach as high as 32°C in certain months. During winter season, the average daytime temperatures hover around 14°C. In the night, the temperatures range from 1°C (50 percentile) to −4°C (10 percentile). During the last 50 years, Vitoria-Gasteiz (and the Basque Country) has experienced a number of extreme events including a cold wave in 1956 and a heatwave in 2003 with precipitation levels of 24.8 l/m^2 (compared to 60 l/m^2 during the summer of 2002) (Fig. 1).

Flooding is also a common problem mostly in the north and the south of the city due to the Zadorra River and the small rivers which cross the city. In turn, extreme events combined with urban expansion have led to several planning actions including the use of wetlands which can buffer extra water in the winter and spring. Indeed, a special plan that aims to improve the current drainage capacity and reduce or eliminate the effects of floods has been developed to defend the town against the floods from the Zadorra River and other streams of the southern area of the city.

1.1.1 Vitoria-Gasteiz Sustainability and Planning Strategies

Vitoria-Gasteiz will hold the title of the European Green Capital in 2012 (EC 2011) with three main pillars: strategic environment projects (Green Belt, etc.), green economy and social involvement.

Indeed, Vitoria-Gasteiz was the first city in the state to adopt the Agenda XXI (1998) and has received several international awards for its actions towards sustainable urban development. The UN selected the Vitoria-Gasteiz's Green Belt as one of the top 100 global actions in the 3rd International Competition of Good Practices.

Table 1 General data (2010) of the city of Vitoria-Gasteiz

239.361 population	234.194 urban 5.167 rural
Surface 277 km^2	35 km^2 urban 61 rural settlements
Density 864,12 inhab./km^2	
Pop. growth rate (last 20 years) 13%	
Population distribution: 8% are foreign; 17% are over 65 years; 12% are under 15 years	

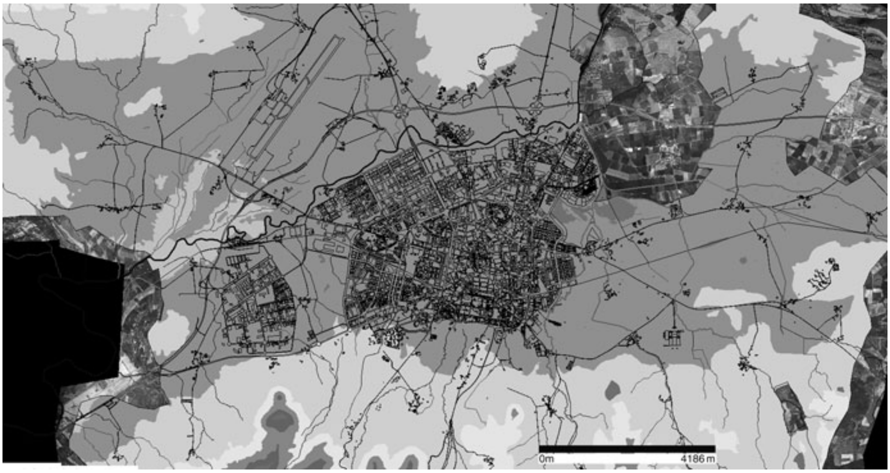


Fig. 1 Vitoria-Gasteiz: water natural drainage network (*Source*: System of Environment Information of Vitoria-Gasteiz. Scale 1:50.000. http://www.vitoria-gasteiz.org/gis/http/website/SIAMi/viewer.htm?MAP=reddrenaje)

Regarding sectoral issues, the Vitoria-Gasteiz PIAA (Plan Integral de Ahorro de Agua – Water Saving Integral Plan), the Local Energy Plan of the Municipality of Vitoria-Gasteiz 2006–2010, the Air Quality Management Strategy Plan 2003–2010 and the Municipal Waste Comprehensive Plan are significant in sustainable development politics addressing both consumption and distribution issues. Vitoria-Gasteiz has also put in place a new generation of urban sustainability indicators in 2011, which comprises of more complex urban indexes and spatial analyses.

Vitoria-Gasteiz has also shown its concern for climate change by signing a number of different European and international agreements such as the Aalborg +10 ratification, the Urban Accords Environment San Francisco, along with its participation in the Spanish Network of Cities for Climate.

In direct relation to urban planning, the Vitoria-Gasteiz 2010 Strategic Plan, the Master Plan XXI and other projects, such as the Sustainable Mobility and Public Area Plan and the Cronos Project, form part of the background to the current development of the Vitoria-Gasteiz 2015 Master Plan.

1.2 Context of the Climate Change Adaptation Plan

In the last few years, the reduction of vulnerability, the maximization of adaptive capacity and resilience have gained importance in the international political agenda, as well as in the initiatives, research, plans and strategies driven by the government of the Basque Country and Vitoria-Gasteiz (Basque Government 2008; Vitoria-Gasteiz City Council 2006). Following these, the Basque Country is making special efforts to support the Basque municipalities to develop adaptation policies and strategies that include urban vulnerability assessments (Olazabal et al. 2011).

Accordingly, an agreement was signed in May 2010 between the Basque Government and Vitoria-Gasteiz to design an adaptation plan. The aim of such an agreement was to:

- Build capacity among the different stakeholders and institutions to adequately respond to climate change impacts
- Align coherently the approach of climate change adaptation initiatives at different scales and administrative levels
- Lead the local implementation of research outputs and methodologies developed at the regional scale
- Raise awareness about the importance of addressing climate change adaptation as part of the local sustainability policies in Basque municipalities

2 Definition of the Plan: Technical Approach

2.1 Some Principles to Manage Adaptation

So far, it is widely accepted that the design of the climate change adaptation plan must encompass the following issues:

- The establishment of mechanisms and instruments to enhance the appropriate social and institutional framework
- The diagnosis of local climate
- The consideration of socio-economic and socio-demographic scenarios
- The quantification of potential impacts, characterizing vulnerability and risks in different urban activity sectors
- The identification of critical impacts, assessing vulnerability and prioritizing response
- Alignment, coordination and mainstreaming of policies
- The identification of knowledge gaps and capacity building opportunities
- Monitoring and evaluation

2.2 Method

Facing the challenge of integrating knowledge and scales, the previously mentioned principles have been specifically complemented in Vitoria-Gasteiz with a participatory philosophy.

The PACC-Vitoria project is structured into four main stages: (1) climatic, socio-economic and socio-demographic temporary trends and scenarios; (2)

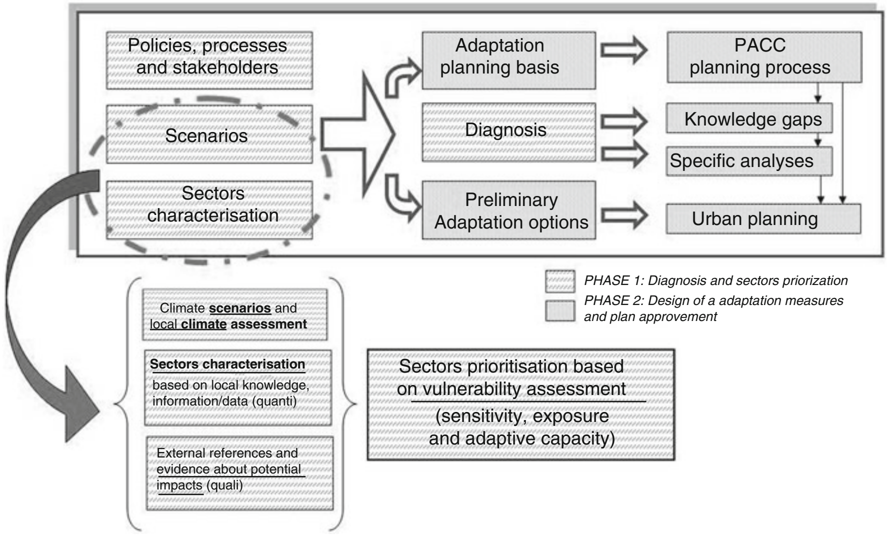


Fig. 2 Plan of adaptation to climate change of the city of Vitoria-Gasteiz: process diagram

characterization of sectors in Vitoria according to their vulnerability to climate change; (3) governance framework for aligning the main local policies and synergies with other processes; and (4) action planning and adaptation in urban development.

As a diagnosis, stages 1 and 2 (phase 1 of the project – see Fig. 2) started back in June 2010 with an open and flexible approach, providing an innovative and pioneering character to the initiative and trying to maximize the synergies with other policies and processes of Vitoria, especially the ones related to sustainability and urban planning. Another key criterion of the process is transparency, and information and knowledge transfer, which aims to encourage participation in the process and to strengthen local adaptation capacity.

In Fig. 2, the two stages (included in both phases 1 and 2 of the project) are clearly labelled by the different shadows. The bottom of the figure provides a detailed explanation of the tasks that are part of the diagnosis of phase 1. Although the "Urban Planning" box is included in phase 2 of the diagram, the utilization of the diagnosis and mid-project results by the urban planning team is currently taking place.

The rest of the paper will describe the advances made in phase 1 of the project. Section 3 will describe briefly the scenarios built for the city of Vitoria-Gasteiz regarding climate, urban thermal performance and precipitation, and Sect. 4 will summarize the work developed until now.

3 Stage 1: Development of Scenarios

3.1 Climate Scenarios for the City of Vitoria-Gasteiz

For this study, six Regional Climate Models (RCM) included in the EU-FP6 ENSEMBLES project are selected (Gonzalez-Aparicio and Hidalgo 2011). The simulations run under the IPCC A1B climate scenario (Nakićenović et al. 2000). The climate change results are shown by means of several standardized climatic indices extracted from the EU-FP5 STARDEX project focused on moderate extreme events. The indices are given as ensemble averages of the selected models.

Following this, the section below summarizes the climatic indexes calculated during the summer and winter seasons (the description of the statistical method used to obtain these data can be found at Gonzalez-Aparicio and Hidalgo 2011).

3.1.1 Summer Season

The number of days with a temperature over 35°C is an index of international reference since it is of high importance to human health, as defined by WMO Expert Team on Climate Change Detection Monitoring and Indices (ETCCDI 2009; Karl et al. 1999; Peterson 2005). During the reference period (1961–1990), the summer season average of the index is 1.9. Analysing the scenario of 2070–2100, we observed that this number is five times more, exceeding 10 days per summer season. In general, these values are two or three times higher in urban than in rural areas.

According to Gonzalez-Aparicio and Hidalgo (2011), heatwave episodes are defined as 6 consecutive days having temperatures higher than the seasonal temperature for the control period plus 5°C. In the city of Vitoria-Gasteiz, such temperature is 29°C.

In this regard, we observed not only a positive trend in the number of days involved in a heatwave, but also a rise in temperatures. Moreover, the length of heatwaves will increase by 18% at the end of this century (2070–2100), with average summer temperatures reaching 33.97°C.

3.1.2 Winter Season

In the city of Vitoria-Gasteiz, the winters will be more moderate with less extreme temperatures. Under the 2030–2060 scenario, it is expected that the ensemble models average will be −1.7°C. At the end of the century (2070–2100), the temperature will increase to −0.6°C. The number of days with a temperature below 0°C will decrease, reaching 8.5 days per winter (30 days in the reference period), as ensemble models average.

Regarding the cold wave episodes, the futures scenarios have a negative tendency, whereby there is a reduction in the duration of the cold waves due to a minimum temperature increase. Indeed, at the end of the century, the minimum temperature during the cold waves will be −5.2°C. The episode frequency is expected to decrease by 20% with respect to the reference period (1961–1990).

In summary, the future temperatures will be higher in the winter and summer. Although this might be favourable in the winter, this will produce discomfort in the summer. Furthermore, based on these projections, it is evident that we need to define adaptation measures to minimize the thermal difference between the urban area and its rural surroundings. In this line, the following section shows the results of the calculations of the urban thermal map for the city of Vitoria-Gasteiz, which will reassert these conclusions.

3.2 Urban Thermal Map

The final aim of this task is to localize high thermal stress areas, which are vulnerable to potential (future) increase in temperatures. Once these areas are identified, they would be the main focus of the adaptation measures.

Having this objective in mind, a 2D representation of temperatures at 2 m over the land surface in the Vitoria city (medium size city) has been performed using the urban parameterization Surfex (Le Moigne et al. 2009) (Fig. 3).

From the results obtained in the city of Vitoria-Gasteiz, some issues need to be highlighted:

- The city of Vitoria-Gasteiz shows an UHI (urban heat island) effect closely reaching 5°C above the temperature of the rural environment. This UHI is higher in the summer than in winter season. The values obtained are similar to the values of other medium-sized European cities.
- The areas where high temperature values are registered during maximum UHI are areas with low vegetation and a low sky view factor.
- Vegetation, wetlands, reservoirs and fountains improve the thermal stress effect, reducing the temperatures during positive UHI effect.
- The UHI is greatest during the night, which is especially dangerous for vulnerable population groups such as the elderly and children during a heatwave episode.

3.3 Rainfall Scenarios

Regarding the rainfall scenarios, we do not have enough data or reference studies to describe the local events of the following 100 years in the city of Vitoria-Gasteiz. As such, we will use regional data collected in the Basque Country as a reference (Mendizabal et al. 2008; Santa-Coloma et al. 2011).

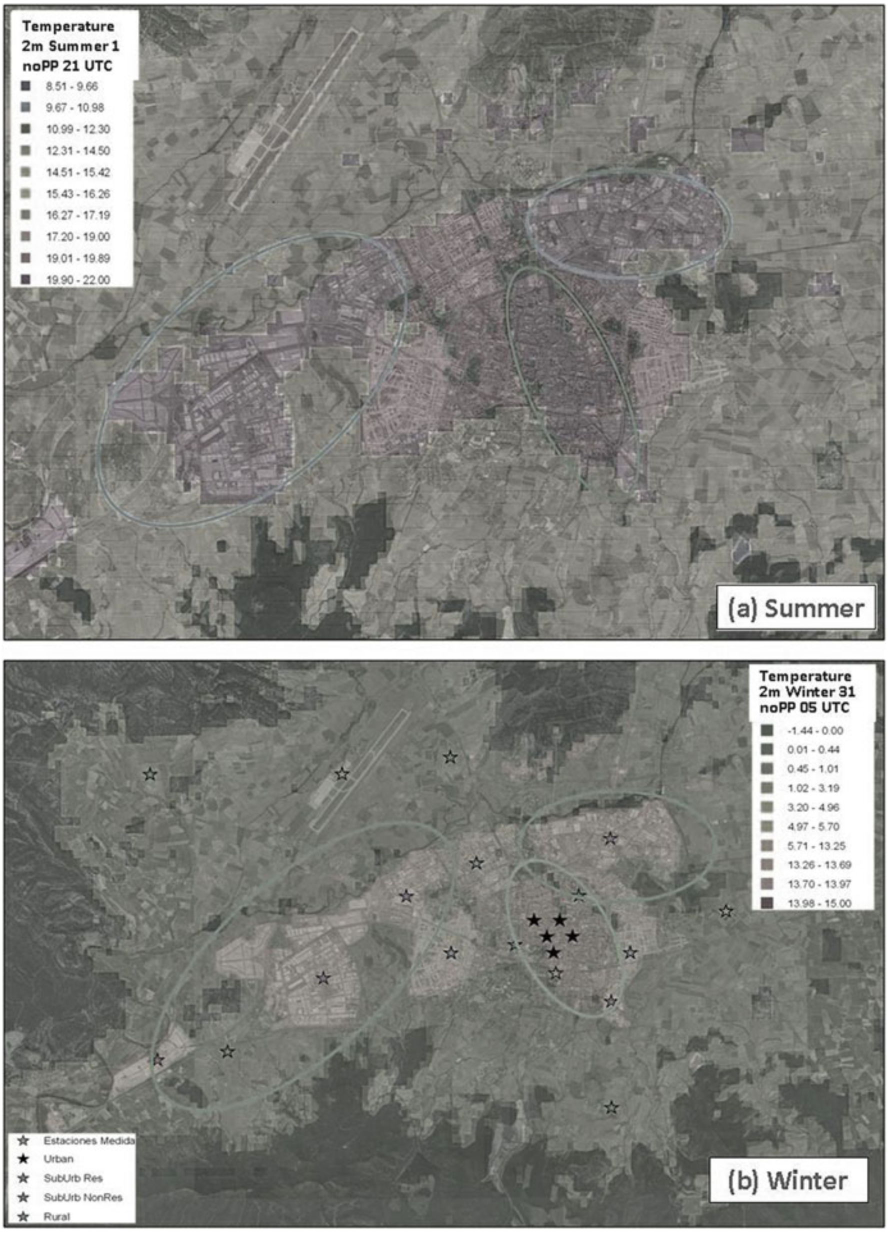


Fig. 3 Urban thermal map: results for (**a**) summer and (**b**) winter seasons

Global and regional models indicate a decrease in precipitation in the Basque Country with an annual decrease from 15% to 20% for the end of the century.

Although there is no clear rainfall pattern, rainfall tends to increase during the winter season from 5% to 20% and decrease during the summer season from 30%

to 50%. An increase of 10% in the daily extreme rainfall is expected to occur for the end of the century (Chust et al. 2011) (under the IPCC scenario A1B about greenhouse gas emissions) (IPCC 2001).

4 Stage 2: Vulnerability Assessment

4.1 A Technical-Participatory Approach

The objective of this stage is to determine which sectors are the most vulnerable to climate change, specifically to the threats identified in the development of scenarios (stage 1). In detail, there are three tasks which must be carried out:

Task 1. Sectors characterization
Task 2. Assignation of values of exposure, sensitivity and capacity of response
Task 3. Vulnerability assessment and sectors prioritization

Regarding the participatory process, the sectors and key infrastructures (task 1) have been defined through a workshop where city council technicians and local stakeholders were invited. Furthermore, online participatory tools are currently being used to assess exposure, sensitivity and capacity of response (task 2). Once this is validated, a vulnerability assessment and a preliminary prioritization will be carried out by the team of researchers at Tecnalia, which will be presented, discussed, modified (if required) and validated by stakeholders and city council technicians.

For all this to work, climate data and scenarios developed in stage 1 will be used. Also, two horizons have been selected in order to do the analysis for 2050 and 2100.

4.2 Task 1: Characterization of Sectors

Using a combination of local, national and regional proposals and the IPCC AR5 sectors outline (IPCC 2011), the final proposal was structured around three main areas and nine different sectors. Accordingly, a list of key elements has been identified for each one of these sectors (see Table 2).

Planning documents and studies have been used to describe each element. These descriptions will form the basis for the vulnerability assessment (tasks 2 and 3, see Sect. 4.3), together with an identification of the particular effects of climate change on each sector and/or key element. In fact, the identification of potential climate change impacts is a result of a deep review of documents and studies from the international to the local level (e.g. Andrey et al. 1999; DEFRA 2011; NRC 2007).

Table 2 Sectors and key elements

Areas	Sectors	Key elements
Natural and rural environment	1. Water resources	Rivers and wetlands (e.g. Zadorra, Salburua, Alegría)
		Aquifer
		Water collection and supply
		Sewage treatment plant "Crispijana"
		Water purification plant "Araka"
	2. Natural resources	Ecological corridors network
		Vitoria Mountains and Bosques-Isla
		Green belt
		Endangered species
	3. Rural environment	Agricultural system: generated goods and services
		Municipal rural areas
Urban environment	4. Urban built environment and public spaces	Historical area
		Green areas and public spaces
		Residential areas
	5. Transport and infrastructures	Bike lanes and pedestrian paths/streets
		Roads and motorways
		Public transport infrastructures
		Airport
		Freight transport infrastructures
		Waste infrastructures
		Energy infrastructures
	6. Economical activities	Industrial parks and activities
		Science park (Miñano)
		Shopping areas, traditional shops and small businesses
		Tourism
Society and governance	7. Society	Culture
		Education
		Social cohesion
		Sports
		Security
	8. Human health	Health infrastructures and buildings
		Social services to the elderly and dependant people
		Urgent services: medical care
	9. Governance	Policies and plans
		Participation
		Coordination

Both qualitative and quantitative data were used, depending on availability, to maximize robustness and certainty of the assessment of the parameters which vulnerability relies on (see the following section).

4.3 Task 2: Assigning Values of Exposure, Sensitivity and Capacity of Response

In order to perform a vulnerability assessment of the sectors and key elements in the city of Vitoria-Gasteiz, we must conduct the following sub-tasks:

1. Identification and description of the key elements to be analysed
2. Description of climatic and non-climatic stressors which can affect the key elements
3. Assessment of exposure, sensitivity and capacity of response of the key elements to the climate change stressors described

These sub-tasks are actually being carried out through the development of the online working sheets (adapted from Snover et al. 2007), which will be distributed to city council representatives and stakeholders. Each one of the participants has been nominated to work on certain fields of his or her expertise.

There is a working sheet per key element. Previously, the research team has done the same work which would be validated through the comparison and addition of information which will be gained through the online work of the participants. Thus, the participants will find blank sheets that they need to fill in. The results (showing tendencies and in a scale of low, medium and high) will be aggregated using different formulas to get a composite indicator of vulnerability:

$$\text{Vulnerability} = (\text{Exposition} + \text{Sensibility}) - \text{Capacity of Response}$$

Finally, the results of task 2 will be used to establish priority planning areas taking into account also the uncertainty embodied in the climate change predictions (scenarios development – stage 1, see Sect. 3) for each key element.

5 Conclusion and Future Steps

Until now, efforts have been allocated in the development of climate scenarios and in the collection of data regarding key elements for sustainability and urban development for the city of Vitoria-Gasteiz.

Among other important issues, a balance of qualitative and quantitative data of each sector during the information compilation of diagnosis phase is essential. Also, the early connection between the diagnosis and the urban planning processes within the city is seen as an excellent input for the development of effective and successful adaptation measures.

Following the prioritization of sectors, the definition of actions along a participatory process must be undertaken. The identification of adaptation measures must follow some principles:

1. To define a process of anticipatory and flexible adaptation (no regret measures).
2. To address adaptation-mitigation synergies and trade-offs.

3. It is crucial to early articulate the processes and procedures of adaptation and urban planning. For this reason, it would be profitable to purposely create public institutions with that responsibility or to give such responsibilities to existing ones (water or energy management institutions, planning bodies, etc., at regional or local level) (Blanco et al. 2009).
4. To support local adaptation through local and regional coordination of policies and also to provide external expertise on local knowledge.
5. To encourage and support community action that reduces risk (for instance, good disaster preparedness).

Nowadays, taking action towards adaptation to climate change means taking advantage of the situation, and this adaptation must be preceded by a strong mitigation plan so that we can address the cause of the problem and not to exacerbate its effects. On the contrary, our opportunity to adapt will be limited by the rapid pace of climate change (Satterthwaite et al. 2007; Snover et al. 2007).

Urban policies must enhance and search for synergies with the global policies on climate change on issues such as the reduction of energy demand, emissions, water consumption and waste generation. Indeed, this objective must be pursued both by environmental and socio-economic policies in a context of social equity regarding availability and accessibility of resources and services.

The studies presented here acknowledge that an urban planning and management which considers potential climatic impacts and vulnerability of the built environment will help to jointly meet the economic and environmental priorities (Kamal-Chaoui et al. 2009) and to build more competitive territories and cities.

References

Andrey, J., Mills, B., Jones, B., et al. (1999). *Adaptation to climate change in the Canadian transportation sector*; report submitted to Natural Resources Canada, Adaptation Liaison Office, Ottawa. Online: http://adaptation.nrcan.gc.ca/perspective/transport_3_e.php.

Basque Government. (2008). Basque plan to combat climate change - Plan Vasco de Lucha contra el Cambio Climático (PVLCC) 2008–2012. In IHOBE Sociedad Pública de Gestión Medioambiental (Ed.), *Basque Government – Gobierno Vasco*. http://www.ingurumena.ejgv.euskadi.net/r49-11293/es/contenidos/plan_programa_proyecto/plan_cambio_climatico/es_cc/adjuntos/pvlcc.pdf. Accessed 15 June 2011.

Blanco, H., Alberti, M., Forsyth, A., et al. (2009). Hot, congested, crowded and diverse: Emerging research agendas in planning. *Progress in Planning, 71*(4), 153–205.

Chust, G., Borja, A., Caballero, A., et al. (2011). Climate change on the coast and pelagic environment in the south-eastern Bay of Biscay. *Climate Research, 48*, 307–332.

DEFRA. (2011). *Climate resilient infrastructure: Preparing for a changing climate*. London: Secretary of State for Environment, Food and Rural Affairs by Command of Her Majesty. http://www.defra.gov.uk/publications/files/climate-resilient-infrastructure-full.pdf. Accessed 14 July 2011.

EC. (2011). *European green cities, winner 2012: Vitoria-Gasteiz*. http://ec.europa.eu/environment/europeangreencapital/winning-cities/2012-vitoria-gasteiz/index.html. Accessed 24 Oct 2011.

ETCCDI. (2009). *CCl/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices (ETCCDI).*http://cccma.seos.uvic.ca/ETCCDMI/. Accessed 24 Oct 2011.

Gonzalez-Aparicio, I., & Hidalgo, J. (2011). Dynamically-based future daily and seasonal temperature scenarios analysis for the northern of Iberian Peninsula. *International Journal of Climatology.* DOI: 10.1002/joc.2397.

IPCC. (2001). IPCC Third Assessment Report. *Climate change: Impacts, adaptation and vulnerability*. The Hague: IPCC. http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/. Accessed 17 June 2011.

IPCC. (2011). *Agreed reference material for the IPCC Fifth Assessment Report (AR5)*. http://www.ipcc.ch/pdf/ar5/ar5-outline-compilation.pdf. Accessed 20 June 2011.

Le Moigne, P., Boone, A., Calvet, J.-C., et al. (2009). *SURFEX scientific documentation*. Groupe de météorologie à moyenne échelle, note de centre, 87, 211. http://www.cnrm.meteo.fr/surfex/.

Kamal-Chaoui, L., & Alexis, R. (eds.) (2009). *Competitive Cities and Climate Change*, OECD Regional Development Working Papers No. 2, 2009, OECD publishing.

Karl, T. R., Nicholls, N., & Ghazi, A. (1999). CLIVAR/GCOS/WMO workshop on indices and indicators for climate extremes: Workshop summary. *Climatic Change, 42*, 3–7.

Mendizabal, M., Chust, G., Pinto, M., et al. (2008). *K-Egokitzen: proyecto de investigación sobre Cambio Climático: Impacto y Adaptación*. In Comunicaciones de CONAMA9 Congreso Nacional del Medio Ambiente, Madrid.

Nakićenović, N., Alcamo, J., Davis, G., et al. (2000). *Special report on emissions scenarios: A special report of working group III of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

NRC. (2007). *Government roles in climate change adaptation for urban infrastructure*. Natural Resources Canada. http://adaptation.nrcan.gc.ca/projdb/pdf/182b_e.pdf. Accessed 12 July 2011.

Olazabal, M., Feliú, E., Izaola, B., et al. (2011). Local strategies for climate change adaptation: Urban planning criteria for municipalities of the Basque Country, Spain. In K. Otto-Zimmermann (Ed.), *Resilient cities: Cities and adaptation to climate change – Proceedings of the global forum 2010*. Dordrecht: Springer.

Peterson, T. C. (2005). Climate change indices. *WMO Bulletin, 54*(2), 83–86.

Santa-Coloma, O., Mendizábal, M., & Feliu, E., et al. (2010). *Efectos del cambio climático en el País Vasco y estrategias de adaptación.* Congreso Nacional del Medio Ambiente, CONAMA10, Madrid. http://www.conama10.es/conama10/download/files/CT%202010/1335416321.pdf.

Satterthwaite, D., Huq, S., Pelling, M., et al. (2007). *Adapting to climate change in urban areas: The possibilities and constraints in low and middle income nations*. Human settlements working paper series. Climate change and cities. London: IIED.

Snover, A. K., Whitely Binder, L., Lopez, J., et al. (2007). *Preparing for climate change: A guidebook for local, regional, and state governments*. In association with and published by ICLEI – Local Governments for Sustainability, Oakland.

Vitoria-Gasteiz City Council. (2006). *Strategy of Vitoria Gasteiz to prevent climate change – Estrategia de Vitoria-Gasteiz para la Prevención del Cambio Climático 2006–2012*. http://www.vitoria-gasteiz.org/wb021/http/contenidosEstaticos/adjuntos/5088.pdf. Accessed 15 June 2011.

Integrated Climate Action: Linking Mitigation and Adaptation to Make Indonesian Cities Resilient

Purnomo Sidi

Abstract Setting different targets for mitigation and adaptation between central and city government generates a different focus on climate change implementation for each level of government in Indonesia. Nevertheless, both mitigation and adaptation share an obvious common denominator, climate change, and are connected to each other on the operational level. As a result, linking mitigation and adaptation in an integrated climate action plan (adaptive management) is the best way to make Indonesian cities more resilient.

Some training sessions and workshops have already taken place for implementing an integrated climate action plan. As an output, city governments can generate an Integrated City Climate Change Strategy (ICCCS) – a cross-sectoral guideline for supporting the establishment of city policies and measures related to climate change.

Although linking mitigation and adaptation can generate mutual benefits, the difference and potential conflict between the two approaches have also been well documented. To avoid this harmful link, city governments need to be aware of the indications of maladaptation and mal-mitigation at the start of program implementation. Moreover, close coordination between city and neighbourhood districts is the most important way to prevent a harmful link between mitigation and adaptation at the city level.

Keywords Integrated strategy • Harmful links • Maladaptation • Mal-mitigation • Mutual benefits

---

P. Sidi (✉)
PAKLIM – GIZ, Jl. Setiabudi 201, 50263 Semarang, Indonesia
e-mail: purnomo.sidi@giz.de; purnomo.sidi@paklim.or.id

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_36,

Abbreviations

BAPPENAS	Badan Perencanaan Pembangunan Nasional
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
ICA	Integrated Climate Action (ICA) approach
ICLEI	International Council for Local Environmental Initiatives
ICCCS	Integrated City Climate Change Strategy
ICCSR	Indonesia Climate Change Sectoral Roadmap
LED	Light-emitting diode

1 Introduction

Indonesia's geographical location makes it one of the most vulnerable countries to the impacts of climate change and disasters. Most of Indonesian cities are located in coastal areas, subject to sea level rise, La Niña and El Niño, and are also on the Ring of Fire, subject to earthquakes and volcanoes. Indonesia is also the fourth most populous country in the world, putting great pressure on sustainable consumption and energy use.

At the September 2009 G-20 summit, the president of Indonesia voluntarily committed the country to an ambitious roadmap for reducing greenhouse gas (GHG) emissions by 26% against the business-as-usual estimate of emissions in 2020, the first large developing country to do so. As a result, the national development planning board (BAPPENAS) established the Indonesia Climate Change Sectoral Roadmap (ICCSR) in March 2010 to set strategic priorities in both mitigation and adaptation programs.

However, the negative impacts of climate change are already directly affecting the achievement of city objectives and threatening the safety of the community. Thus, city governments tend to focus mainly on adaptation measures, responding to flooding, sea level rise, La Niña and El Niño. Community awareness is also pushing city governments to establish solutions and actions to raise the cities' adaptive capacity.

Even though city governments tend to focus mainly on adaptation measures, linking mitigation and adaptation measures is critical for building the city's overall resilience. Thus, the main challenge for every city government in Indonesia is how to continually increase adaptive capacity and decrease greenhouse gas emissions until 2020. Adaptive management tools are a vital step in answering this challenge.

2 Adaptive Management Tools: Integrated Climate Action (ICA) Approach

The implementation of adaptive management tools for city government is a must; however, it is difficult to embed this tool into city government systems as there are several prerequisites that underlie the uptake of this tool. Firstly, it has to easily accommodate both mitigation and adaptation measures. Secondly, it has to be easily understood and followed by all sectors. Lastly, it has to be based on city government's day-to-day activities.

PAKLIM GIZ and ICLEI Oceania (2008) entered into a Cooperation Agreement in 2009 to develop an Integrated Climate Action (ICA) approach to meet these requirements. Four pilot cities in Central Java (Pekalongan, Yogyakarta, Surakarta and Salatiga) and four in East Java (Malang, Probolinggo, Pasuruan and Mojokerto) have committed to implement this approach since 2010 (see Fig. 1). Later on, two partner cities (Semarang and Blitar) will also join and the improved ICA methodology will be disseminated into other cities in Indonesia.

Due to the demographic and geographic variation, each pilot city will respond to the impacts of climate change differently. Pekalongan, for instance, has been directly influenced by sea level rise and Surakarta has been influenced by precipitation change (flood and inundation). Contrary, one community in Yogyakarta is still struggling with vector-borne diseases (Dengue and Cikunguya), while another community in Salatiga is struggling with temperature increases and drought.

Because of the varying governing procedures and climate change challenges in the different cities, the ICA approach has to be a simple, yet flexible tool to generate climate change programs based on each city's own working base and budget.

The ICA approach, drawing on established ICLEI mitigation and adaptation approaches, is actually designed for all Indonesian cities and is being piloted in Central Java and East Java (see Fig. 2).

Basically, ICA consists of five phases. Every phase has achievable activities, benefits and targets. As a process, it works sequentially, with continuing cyclic repetitions. The first phase, Establish the Context, will assist the city government to understand climate change in general. Phase 2, Prioritize Areas for Action and Set Goals, assists to prioritize relevant climate action plans predominantly through self-financing mechanisms. Phase 3 leads to a clear, integrated working plan for all sectors in city government system. The Monitoring and Reporting phase facilitates self-appraisal of those working plans and targets. And finally, the Review and Re-strategize phase leads to reassessment of baseline data, assumptions and actions.

3 Phased Mitigation and Adaptation Learning for ICA

At the begining, PAKLIM GIZ and the pilot cities had formulated an official sequence of learning process which was not only derived from ICA Phases but also it had the same pattern as city government's day-to-day activities. The learning

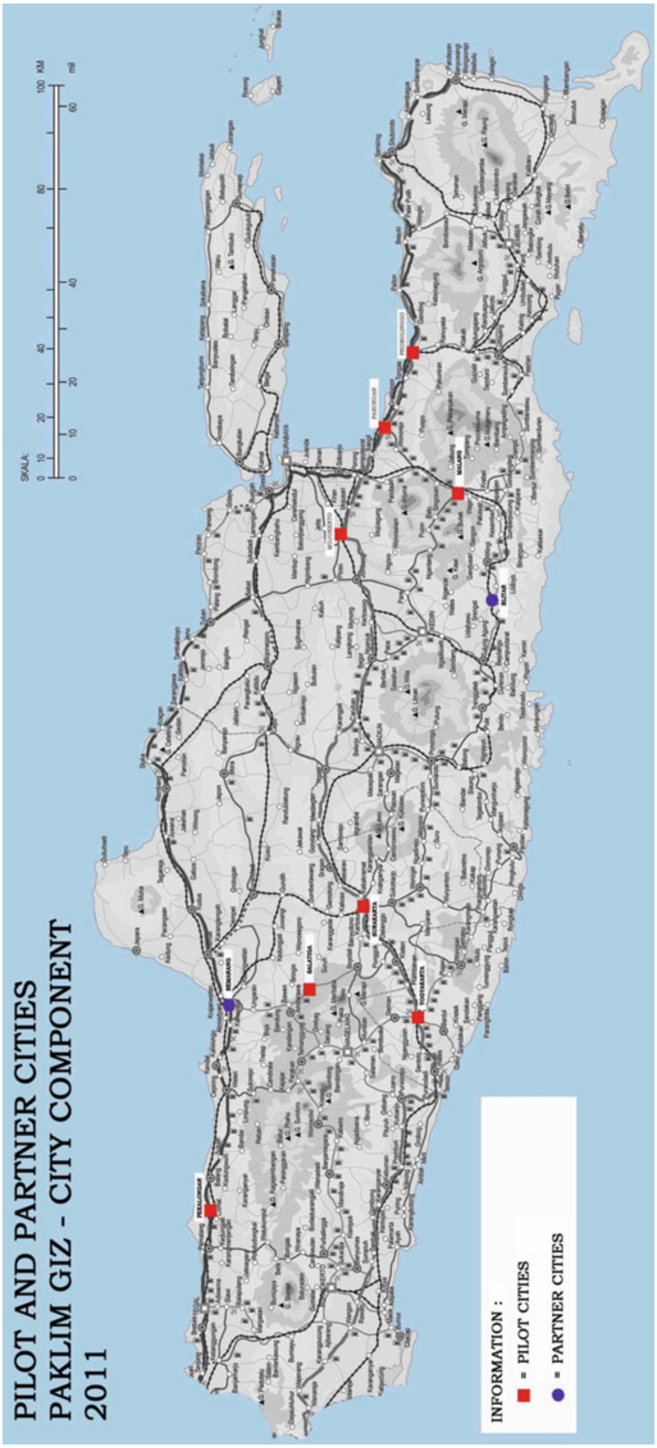


Fig. 1 PAKLIM GIZ pilot and partner cities in Central Java and East Java – Indonesia

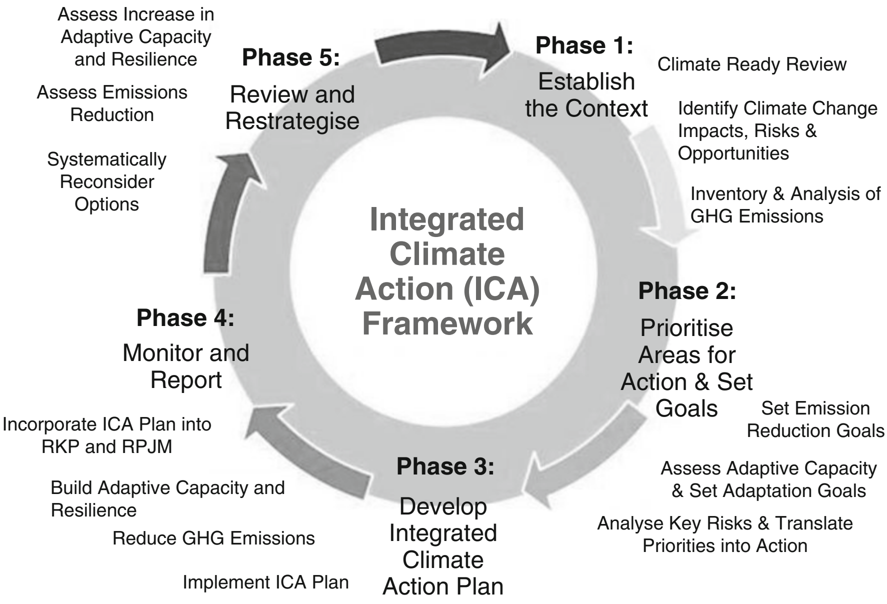


Fig. 2 Integrated Climate Action (ICA) Approach

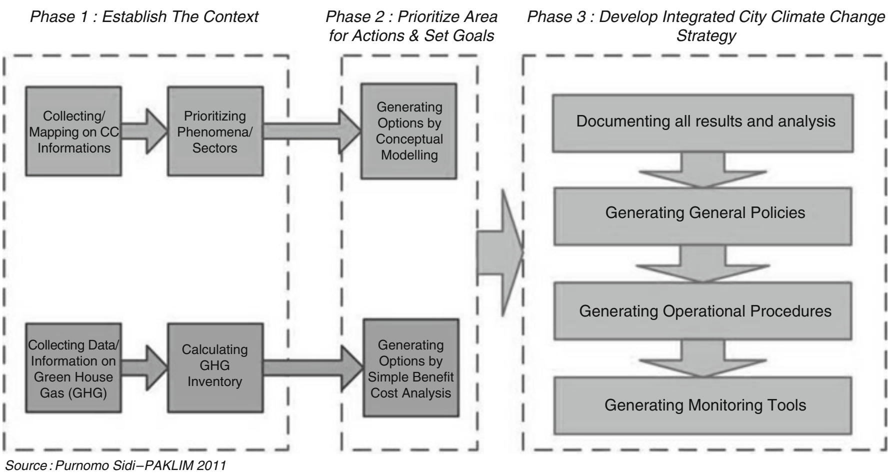


Fig. 3 Phased mitigation and adaptation learning for ICA

process has to be followed by the pilot cities with a clear verification of activities and outputs for both mitigation and adaptation. At the time of writing, most of the pilot cities have reached Phased 3 of mitigation and adaptation learning for ICA (see Fig. 3).

A particular challenge of the ICA is the difference of methodologies and procedures between mitigation and adaptation measures, and this needs to be planned for from the beginning. It is also important to decide at the start whether the two processes will occur in parallel, or one after the other. To enhance cross-learning between mitigation and adaptation, it was decided to follow a parallel, step-by-step approach.

By employing training activities and workshops which link mitigation and adaptation, the city government will have a clear understanding of implementing both mitigation and adaptation measures at the operational level – how to calculate GHG inventory and risk profiles, develop options for action and prioritization, develop a comprehensive action plan and integrate this into the work plan for every city agency. As a significant outcome, city government can develop an Integrated City Climate Change Strategy (ICCCS) for compiling all related documents and results into an official guideline.

4 Developing an Integrated City Climate Change Strategy (ICCCS)

The Integrated City Climate Change Strategy is a living cross-sectoral guideline for supporting the establishment of city policies and actions related to climate change. This guideline will be used not only for supporting city government on measurement, reporting and verification (MRV) but also for insuring all activities function independently.

The ICCCS consists of three major elements. First, a strategy to raise awareness of both mitigation and adaptation based on future impact projections was initiated. This builds on a strong base of collected data/information. It incorporates city development planning, city regulations and an estimation of climate change impacts on the city's vision and mission. It works predominantly at the policy level.

Second, a strategy to combine adaptation and mitigation will be devised in the upcoming years. This strategy will be designed to build some relevant adaptation and mitigation options, to screen these options and to create action plans. Combining adaptation and mitigation options is an important yet challenging process. Unpredictable aspects such as political intervention and inter-sectoral competitiveness between agencies can generate results that differ from what had been initially determined. On the other hand, the linking of adaptation and mitigation options will generate not only mutual benefits but also prevent unintended maladaptation and mal-mitigation.

Third, a strategy to integrate cross-sectoral actions at the operational level is required. This is based on 'downscaling' planned actions into the work plans of each city agency. Looking for operational synergies, avoiding 'burden shifting' and continuous improvement in communication and coordination between city agencies are critical elements of this strategy.

The hardest challenge while developing ICCCS is to be aware of the harmful links between action plans and strategies in both mitigation and adaptation. The awareness of maladaptation and mal-mitigation will be the next step to be considered.

5 Avoiding Maladaptation and Mal-mitigation

Typically, mitigation action plans will generate possible actions to minimize greenhouse gas emissions, while adaptation action plans will generate potential actions to increase adaptive capacity. For example, if a city government undertakes energy efficiency by replacing all streetlight lamps with LED, then the city government has taken a significant action to reduce GHGs. And if the city government undertakes planting mangroves in coastal areas to protect the community from negative impacts of sea level rise, a significant action has been taken to raise the adaptive capacity.

Ideally, however, action plans which tackle both mitigation and adaptation together are the best solutions to deal with climate change. Waste management and mass rapid transport programs, for instance, are strategies which can solve both mitigation and adaptation impacts. By implementing a waste management program, the city has a great opportunity to not only solve the problem of flooding triggered by precipitation change and blocked waterways, but also to solve the problem of electricity by using captured gas (methane). As another example, by implementing a massive rapid transit program, the city has a great opportunity to not only solve the problem of energy efficiency and traffic jams, but also to minimize the multiplier effect of vehicle exhaust (carbon monoxide) which can increase air temperatures and add to GHG emissions.

While local climate action plans should accommodate both mitigation and adaptation approaches, there are cases where adaptation practices conflict with mitigation. As mentioned before, a mutual benefit can be realized when action to reduce GHGs can also indirectly raise the adaptive capacity and vice versa. On the other hand, a harmful link between mitigation and adaptation is generated when action to reduce GHGs instead reduces adaptive capacity.

Maladaptation occurs when increasing adaptive capacity generates more GHG emissions. To build a massive sea wall to protect people from the negative impacts of sea level rise, for instance, can generate more GHG emissions through the construction and embedded energy costs, particularly if this wall is also supported by 24-h water pumping. Mal-mitigation occurs when minimizing of GHG emissions reduces adaptive capacity. To implement a car-free program to minimize GHG emissions, for instance, can reduce the adaptive capacity of city commuters if there is insufficient mass transit.

The potential flow of shifting risks/consequences from mitigation to adaptation and vice versa is illustrated in Fig. 4.

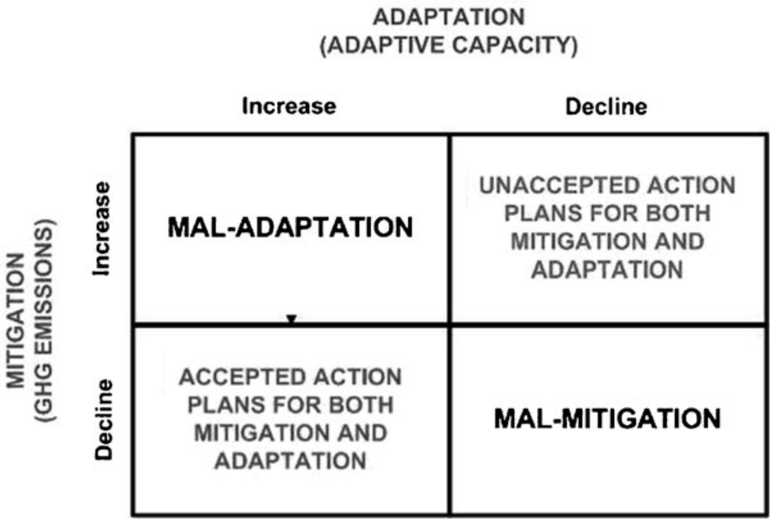


Fig. 4 Mal-Adaptation and Mal-Mitigation

Mal-mitigation may also occur when there is shifting of the burden of GHG emissions from the city to neighbouring areas. To build a ring road, for instance, can decrease GHG emissions within the city administrative area, but it will increase GHG emissions in nearby districts.

However, when integrating mitigation and adaptation measures into local action plans and strategies, there are two challenges that make it difficult to avoid maladaptation and mal-mitigation. First, there is an unfair competition among agencies and a strong political pressure from local parliament. In Indonesia, this typically occurs due to the lack of leadership and coordination from the top level management. Second, there is a lack of technical capacity and technology. This is a result of a lack of cooperation between the city government and the academic community. In short, government projects have not been supported and checked by the scientific community. As such, continuous checking of all climate change action plans and strategies should take place in the monitoring phase. In this phase, academic experts should actively support city government to provide monitoring and evaluation tools.

6 Closing Remarks

Climate change is a cross-sectoral issue, and it requires for Indonesian city governments to link both mitigation and adaptation to make cities more resilient. At this time, the links between mitigation and adaptation are not well understood in Indonesia, and it is important to perform future analysis to avoid harmful links.

As such, it is our hope that the ICA process and ICCCS guideline will support city governments to develop well-balanced climate action plans, and this may also assist provinces and the national government to improve climate change policies.

References

Badan Perencanaan Pembangunan Nasional. (2010, March). *Indonesian Climate Change Sectoral Roadmap (ICCSR)*.

ICLEI Oceania. (2008). *Cities for climate protection Australia adaption initiative*; Local Government Climate Change Adaptation Toolkit.

Enhancing the Climate Change Adaptation Capabilities of Local Governments in Korea: Supporting Programs for Local Adaptation Plan

Jiyoung Shin, Junghee Kim, KyungHyun Kim, Eunyoung Kim, Jungwon Lee, Seong Woo Jeon, and Yong-Ha Park

Abstract In August 2010, the Korean government enacted the National Climate Change Adaptation Master Plan under the Framework Act on Low Carbon, Green Growth (LCGG). Prior to this, the Ministry of Environment (MOE), which is in charge of the national adaptation strategy, launched the Korea Adaptation Centre for Climate Change (KACCC) in July 2009. The MOE and KACCC have also introduced programs to support local governments' adaptation action plans. However, each of the 16 local governments is still required to develop their own action plan to cope with climate change. For example, in 2010, two pilot projects concerning local-scale climate change adaptation planning and climate change adaptation guidelines for local governments were completed. Through such assistance, local governments are developing their own 5-year plans based on the national adaptation strategy.

Keywords Adaptation • Climate change • Local governments • Action plan

1 Introduction

Increased awareness of the rise in global average temperatures and the increased incidence of extreme events have led to the implementation and development of new policies and practices to help cope with climate change (Kennedy et al. 2010; Dovers 2009). Because climate change adaptation goes far beyond the mandate of any one government agency and requires nationwide strategy and action, it is inextricably

J. Shin (✉) • J. Kim • K. Kim • E. Kim • J. Lee • S.W. Jeon • Y.-H. Park
Korea Adaptation Center for Climate Change, Korea Environment Institute (KEI), 290 Junheungno, Eunpyeong-Gu, 122-706 Seoul, Republic of Korea
e-mail: sjirang@kei.re.kr; junghee84.kim@gmail.com; khkim@kei.re.kr; eykim@kei.re.kr; jwlee@kei.re.kr; swjeon@kei.re.kr; yhpark@kei.re.kr

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_37,

linked with stakeholders, private and public sectors, science and academia and community residents. The integration and harmonization of such sectors will lead to successful adaptation.

Between 1912 and 2008, the average temperature of Korea's six major cities rose by 1.7°C (NIMR 2009). In addition, by 2050, the average temperature in Korea is predicted to increase by a minimum of 2°C (NIMR 2009).

There is a growing recognition that urban areas will be profoundly affected by climate change; therefore, local governments must find ways to adapt (AGO 2007). In response, in 2010, the Korean government established the National Climate Change Adaptation Master Plan (2011–2015) and embarked on the development of a framework for local adaptation.

This chapter outlines how the national adaptation framework for systematic programs for local adaptation action was established.

2 Local Adaptation Action Plan

2.1 Definition of Local Adaptation Action Plan

A local adaptation action plan is a practical and proactive plan in order to help local governments improve their resiliency to climate change impacts. Since adaptation planning is not exclusive to urban areas but rather takes place in the context of both central and local governance (Adger et al. 2005), local adaptation action plans in Korea should be harmonized with the National Adaptation Master Plan and be incorporated into existing local policies and programs.

2.2 Rationale for a Local Adaptation Action Plan

In April 2010, the Framework Act on Low Carbon, Green Growth (Republic of Korea 2010) was enacted to establish the legal and institutional bases for aligning national and local adaptation policies. In accordance with Article 48 of the Framework Act, the National Climate Change Adaptation Master Plan (2011–2015) was published in October 2010 by the Ministry of Environment, along with 70 experts and 13 government departments. It was the first statutory initiative for the purpose of climate change adaptation to take place at the national level in Korea. According to Article 38 of the Enforcement Decree of the Framework Act on Low Carbon, Green Growth, central administrative agencies and local governments will have established and implemented their own action plans by 2011. Moreover, under Article 38, the National Climate Change Adaptation Master Plan and the local adaptation action plans are to be reformed every 5 years (Fig. 1).

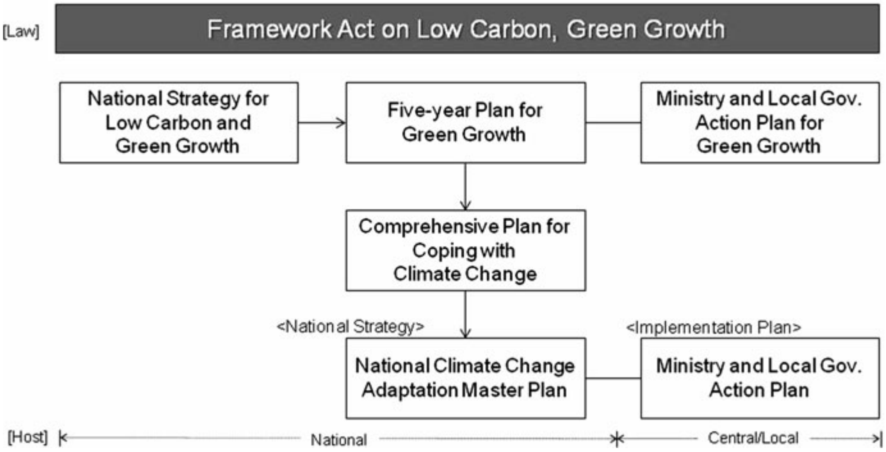


Fig. 1 Climate Change Adaptation Policy Framework (KEI 2010a)

Figure 1 presents the Climate Change Adaptation Policy Framework in Korea. The Framework Act on Low Carbon, Green Growth ensures that legislations, policies and programs are modified to consider climate change adaptation in Korea. Under this act, the National Strategy for Green Growth and the Five-Year Plan for Green Growth were adopted to implement the national vision of green growth more effectively. In particular, the Five-Year Plan for Green Growth started to deal with climate change adaptation, and the Comprehensive Plan for Coping with Climate Change took concrete adaptation and mitigation measures, thereby leading to the National Climate Change Adaptation Master Plan. Based on this master plan, the Korean government plans to carry out 87 projects in ten fields – e.g. health, disaster management and water management. Moreover, 16 local governments and 13 administrative agencies are now preparing for specific countermeasures for adapting to climate change.

3 National Framework for Systematic Programs of Local Adaptation Action Plan

By implementing the Korean Adaptation Centre for Climate Change (KACCC) in July 2009, the Ministry of Environment has been playing a pivotal role in establishing policies and programs dealing with climate change adaptation. In 2010, the KACCC developed a robust framework to provide local practitioners and experts with information and to help government officials and politicians with their decision-making.

Table 1 National framework for systematic programs of local adaptation action plan

	Guiding and consulting	Delivering information	Communicating
Phase one (2010)	Local adaptation planning guidebook	Adaptation option case study	Workshop
	Pilot project	Adaptation policy inventory	Adaptation website
			International seminars
Phase two (2011)	Consulting local adaptation planning	Climate change scenario (Korean meteorological agency)	Workshop
			Expert forum
	Climate change impacts and vulnerability assessment manual		Seminar
			Online community
Phase three (2012–)	Performance evaluation for action plan	Inventory renewal	Workshop
			Expert forum
	Continual consulting		Seminar
			Online community

This framework comprises of three phases and the program renders three types of support: guiding and consulting, delivering information and communicating. Table 1 depicts the framework for systematic programs of local adaptation action plan.

As can be seen from Table 1, the initial phase of the framework raises local governments' awareness on climate change adaptation and strengthens the basis of local adaptation planning. To achieve this, guidebooks for developing local adaptation action plans were provided to 16 local governments, and a pilot study on Seoul and Incheon was carried out by the Korean Adaptation Centre for Climate Change (KACCC).

The second phase of the plan is scheduled for 2011; a wide range of pragmatic support is provided. For example, the national expert panel on climate change adaptation, appointed by the Ministry of Environment, is now helping local practitioners and experts take climate change impacts and adaptation options into full consideration. To assist in projecting future climate trends on a local scale, the Korean Meteorological Agency now affords the latest projected climate change scenarios at 10- and 15-km resolutions. Efforts are underway to downscale to 1-km resolution from additional modelled scenarios, with results expected by December 2011. For the purpose of examining the current and future conditions to determine the degree by which a system is susceptible to and its capability to cope with potential impacts of climate change, the National Institute of Environmental Research is developing climate vulnerability assessment tools and sharing the results with local practitioners and experts.

In the last phase (2012), the local action plan will be appraised on the basis of its commitments. Accordingly, a new model for the performance evaluation of the local adaptation action plan will be devised. In each phase, workshops, seminars and forums will be held to communicate with practitioners, experts and residents who are responsible for adapting to climate change.

The following is a detailed explanation of the pilot projects and the local adaptation planning guidebook performed in phase one for the year 2010 (KEI 2010a). The pilot project in Seoul focused on the health and hazard sector, which is most likely to pose a great risk owing to the city's high urbanization ratio and population density (KEI 2010b). In Incheon, located at the seaside, adaptation planning focused on the marine ecosystem and the marine disaster sector (KEI 2010c). Such an adaptation plan was established as follows: (1) select a target area, (2) analyze the current state and future climate predictions, (3) select the key impacts and the sector/s most vulnerable to climate change, (4) assess impacts and vulnerability, (5) select vulnerable area and vulnerable class to future climate and (6) establish a climate change adaptation plan. Through these pilot projects, local governments evaluated their capability of climate change adaptation in their districts.

Local governments can take away three key lessons for successful adaptation planning from these pilot projects. Firstly, it is essential for local governments to collaborate and strengthen their partnerships across local experts, communities and local government officers in order to reach a local consensus on local adaptation policies and programs. Since adaptation takes place at the community level (where the consequences are felt the strongest), adapting to a changing climate is a shared responsibility across all level of government and is reliant on many sectors, organizations and communities (Adger et al. 2005). Secondly, due to the uncertainty inherent in climate change projections, successful adaptation requires the best available science and reliable data. In turn, the effectiveness of proactive adaptation is based mainly on the precision of local climate change and impact projections (Füssel 2007). Lastly, there is a need for local governments to review and complement the existing adaptation policies and programs while reflecting on the unique characteristics of their own areas.

The guidebook was designed primarily for local government officers and practitioners who are in charge of climate change adaptation. The guidebook entailed the general process for local adaptation planning: (1) establish the context, (2) establish an adaptation task-force team, (3) formulate the adaptation action plan, (4) legislate local adaptation policies and implementation plans, and (5) implement, monitor and evaluate. In addition, the guidebook provided the detailed process of formulating an adaptation action plan in ten fields including two pilot projects. This was a five-step process: (1) identify the climate change issues, (2) review and synthesize existing information on vulnerability and adaptation, (3) assess impacts and vulnerability, (4) set the adaptation goal, and (5) indentify and formulate adaptation plan. So far, the guidebook is accessible online and offline for local government officials, thereby strengthening and building local governments adaptation capability.

4 Conclusion

Given that local areas are currently at a relatively high degree of risk from the impacts of climate change, adaptation to climate change at the local level has become a critical issue in Korea. Therefore, with the aim of improving urban climate change resilience and supporting local governments in establishing local adaptation action plans, the Korean government constructed the national framework for systematic programs of local adaptation action plan. This framework has three main roles in establishing local adaptation action plans. First, national governance helps local governments to establish their local adaptation action plan effectively and efficiently. On the ground, adaptation is a continuous process; therefore central government must act for local governments to connect experts and provide ongoing science and research support. Second, this national framework can encourage local governments to set up a local action plan that is consistent with the vision and goals of a national strategy. Third, based on the close cooperation between the central and local government, the national framework for systematic programs of local adaptation action plan can contribute to holistic and reliable decision-making on adaptation issues. Since adapting to climate change is a complex issue including a variety of fields, it goes far beyond the mandate of any one local government. As a result, central government and ministries need to collaborate with local governments. Also, driving partnerships between local governments, the national framework facilitates benchmarking for local adaptation issues.

In February 2012, local adaptation action plans for 16 administrative areas will be established for the purpose of enhancing their resilience to climate change. Going forward, it will be essential that the national framework for systematic programs of local adaptation action plan is reviewed and developed into a more detailed framework for local councils and communities.

References

Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scale. *Global Environmental Change, 15*, 77–86.

Australian Greenhouse Office (AGO). (2007). *Adaptation options for local government*. Canberra: Department of the Environment and Heritage.

Dovers, S. (2009). Normalizing adaptation. *Global Environmental Change, 19*(1), 4–6.

Füssel, H. M. (2007). Adaptation planning for climate change: Concepts, assessment approaches, and key lessons. *Sustainable Science, 2*, 265–275.

Kennedy, A. B., Gravois, U., Zachry, B., Luettich, R., Whipple, T., Weaver, R., Reynolds-Fleming, J., Chen, Q. J., & Avissar, R. (2010). Rapidly installed temporary gauging for hurricane waves and surge, and application to Hurricane Gustav. *Continental Shelf Research, 30*(16), 1742–1752. doi:10.1016/j.csr.2010.07.013.

Korea Environment Institute (KEI). (2010a). *Development of local climate change adaptation manual(I)*. The Ministry of Environment. Report number 5(1).

Korea Environment Institute (KEI). (2010b). *Assessment of climate impacts and establishment of adaptation action plan in Seoul*. The Ministry of Environment. Report number 5(2).

Korea Environment Institute (KEI). (2010c). *Assessment of climate impacts and establishment of adaptation action plan in Incheon*. The Ministry of Environment. Report number 5(3).
National Climate Change Adaptation Master Plan (2011–2015). (2010). (SI 2010/1).
National Institute of Meteorological Research. (2009). *Understanding climate change II: Climate change in Korea, Seoul*.
Republic of Korea. (2010). *The framework act on low carbon, green growth*. Seoul: The Prime Minister's Office.

Reality Check: Ho Chi Minh City, Vietnam

Adrien Labaeye, Jeb Brugmann, Nguyen Van Phuoc, Bao Thanh, Ly Khanh Tam Thao, Nguyen Anh Tuan, Harry Storch, and Ulrike Schinkel

Abstract At the Resilient Cities 2011 congress, the case of Ho Chi Minh City was presented and discussed by participants during the Reality Check Workshop. The current paper provides a comprehensive overview on the challenge of integrating climate-related risks in the urban development trajectory of the city as well as a short summary of the discussion that took place in the workshop.

Keywords Ho Chi Minh City • Adaptation • Climate change • Exposure assessment • Urban land-use planning

---

A. Labaeye
ICLEI – Local Governments for Sustainability, World Secretariat, Kaiser-Friedrich-Str.7, 53113 Bonn, Germany
e-mail: resilient.cities@iclei.org

J. Brugmann
Founder of ICLEI, The Next Practice, Bonn, Germany
e-mail: resilient.cities@iclei.org

N. Van Phuoc
Department of Natural Resources and Environment, Ho Chi Minh City People's Committee, 63 Ly Tu Trong, District 1, Ho Chi Minh City, Viet Nam
e-mail: phuocnguyenvan22@yahoo.com.vn

B. Thanh
Sub-Institute of Hydrology, Meteorology and Environment of South Viet Nam, 19 Nguyen Thi Minh Khai, District 1, Ho Chi Minh City, Viet Nam
e-mail: bao.thanh@hcm.fpt.vn

L.K.T. Thao
Division of General Planning Management, Department of Planning and Architecture, Ho Chi Minh City People's Committee, 168 Pasteur Street, District 1, Ho Chi Minh City, Viet Nam
e-mail: thaolkt@tphcm.gov.vn

N.A. Tuan
Research and Training Division, Architectural Research Center, Department of Planning and Architecture, Ho Chi Minh City People's Committee, 168 Pasteur Street, District 1, Ho Chi Minh City, Viet Nam
e-mail: tuankts@gmail.com

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_38,

1 Setting the Scene

The southern Vietnamese city of Ho Chi Minh City represents one of the most dynamic examples of urban development and a megacity in the making. The city is precariously located on the banks of the Saigon River, 60 km from the South China Sea and northeast of the Mekong Delta, in anestuarine area of Dong Nai River system. In a short space of time, the city has grown into Vietnam's largest and most populous settlement, becoming an important port city for Southeast Asia and beyond and contributing a dominant share to the national economy. The official population of the city as of 2010 was 7.4 million, spread over a total administrative area of 2,095 km^2 (GSO 2011). However, if the estimated two million migrants and individuals residing on a non-residential and seasonal basis are included, the actual population may well be closer to more than nine million. The city is currently undergoing further urbanization to such an extent that by 2020 official estimates forecast a population of approximately ten million.

H. Storch (✉)
Department of Environmental Planning, Brandenburg University of Technology Cottbus, Erich-Weinert-Str. 1, 03046 Cottbus, Germany
e-mail: harry.storch@tu-cottbus.de

U. Schinkel
Department of Urban Planning and Spatial Design, Brandenburg University of Technology Cottbus, Konrad-Wachsmann-Allee 4, 03046 Cottbus, Germany
e-mail: ulrike.schinkel@tu-cottbus.de

Originally founded on relatively higher grounds, the city has densified through the infilling of open spaces or the redevelopment of existing buildings. However, of greater concern is the rapid expansion into lower-lying and former wetland surroundings, primarily at the expense of urban greenscape and valuable multi-functional natural areas. The city is currently incised by a dense network of rivers and canals of around 8,000 km in length, which account for 16% of the total area. These waterways are affected by a semi-diurnal tide that peaks in September and October. This period is usually coincident with annual rainfall peaks, resulting in a significant percentage of the city's neighbourhoods regularly experiencing floods due to a combination of tides, heavy monsoon rains and storm surge floods. The dimensions of this flooding are, however, constantly changing due to the ongoing rapid urbanization.

2 National Target Program to Respond to Climate Change

The Ministry of Natural Resources and Environment (MONRE) in Hanoi has been commissioned by the prime minister as the main agency responsible for addressing climate change and therefore is the primary agency for climate-related activities within Vietnam. The Ministry developed the 'National Target Program to Respond to Climate Change' (NTP) (The Socialist Republic of Vietnam 2008) which was officially approved on December 2, 2008, under the initiation of the Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN) in Hanoi. The NTP is currently being implemented in the timeframe 2011–2015. The goal is to raise the awareness of climate change issues and facilitate the mainstreaming of climate change adaptation into administrative bodies and policy development. The IMHEN is a subdivision of the MONRE. It includes a sub-institute in HCMC, the Sub-Institute of Hydrology, Meteorology and Environment of South Vietnam (SIHYMETE), with a regional competence for South Vietnam, including the HCMC mega-urban region. The IMHEN in Hanoi and the SIHYMETE in HCMC are explicitly responsible for the coordination of major international research activities in the field of adaptation to climate change within Vietnam.

Alongside international support, the IMHEN is also responsible for the statistical downscaling and reporting of global climate models. As a result, climate change and sea level scenarios for Vietnam have been developed and published by MONRE in July 2009, albeit at a very coarse scale as the spatial resolution is insufficient for the consideration of local level changes. Here, IMHEN recognizes the importance of local knowledge but importantly well-founded downscaled information to address uncertainties at the local level. The scenarios are upgraded, and the second version of climate change and sea level scenarios for Vietnam is to be published soon. While to further raise awareness and disseminate information among key decision-makers, civil servants and inhabitants, the institute and sub-institute utilizes the measures and tools as described within the NTP itself.

According to MONRE (2009), the future impacts of climate change on South Vietnam using IPPC high-emission scenarios have been predicted as:

- *Sea level rise*: Averaged presumed sea level rise by 2050 will be 30 cm, rising to 80 cm in 2100. While worst case scenarios are 33 cm by 2050 and 100 cm in 2100. According to many international reviews on the potential impacts of sea level rise, Vietnam ranks highly among the most affected countries.
- *Temperature*: Predicted to be 1.4–2.6°C higher in 2100, relative to 1980–1999 levels.
- *Precipitation*: An overall 2% increase is envisaged from high-emission scenario by the year 2100, while during the rainy season, a 9% increase is envisaged; during the dry season, a decrease of 10% is foreseen.

Vietnam has a long history of coping with natural disasters and mitigating their effects in many ways. However, the country must recognize that some impacts of global climate change are unavoidable, and as such, there is an urgent need at present to start adapting the mega-urban regions to the current impacts of extreme weather events and the predicted impacts of climate change with which they are likely to be confronted in the future. With more than half of Vietnam's population now living in low elevation zones, coastal urban settlements are becoming increasingly vulnerable.

3 Ho Chi Minh City's Action Plan on Climate Change

Ho Chi Minh City currently faces major challenges in terms of infrastructure development, provision of public transport, flood prevention and provision of other public services due to its ongoing rapid growth. These challenges will be amplified given the projected changes in climate and population over the coming decades (ADB 2010). As part of the National Target Program, Ho Chi Minh City alongside other provinces in Vietnam is currently in the process of developing an Action Plan on Climate Change that shall define adaptive responses to safeguard the city's development. The adaptation strategy is at a preliminary stage and is addressing both mitigation and adaptation. One important component is the assessment of the local pattern of climate change. This helps in identifying vulnerabilities and informing the development of a methodology for the adaptation planning.

Within Ho Chi Minh City, the Department of Natural Resources and Environment (DONRE), the regional department of MONRE, is responsible for the preparation of the Ho Chi Minh City land-use strategy and action plan, reviewing and commenting on all other sectoral and spatial plans for the city with regard to their environmental sustainability, their effectiveness in meeting climate change adaptation requirements and their consistency with the overall city land-use plan. Finally, the department is also responsible for the application of strategic environmental assessments (SEA) and environmental impact assessments (EIA) to the process of establishing development plans and project proposals.

As a fast-growing delta city, Ho Chi Minh City has long recognized the importance of integrating climate change mitigation and adaptation into the city's policies. Currently, research is being undertaken to examine the effects of climate change on the city to arrive at sustainable solutions. Existing policies and strategic documents, such as the Socioeconomic Development Plan for 2025, are currently being revised and updated to integrate climate change adaptation into the planning process. In order to coordinate and integrate all activities related to climate change, HCMC has established the so-called Ho Chi Minh City Climate Change Steering Committee. The Director of the DONRE has been appointed as Vice Chair of the Ho Chi Minh Climate Change Steering Committee whose responsibility is to coordinate the different functional agencies in implementing more specialized plans and projects, for instance, in water resource management in relation to climate change. The focus is on policies that respond to climate change appropriately and effectively to work towards sustainable development. As such the aim is to improve the coordination between city agencies, while DONRE consults other departments, scientists and experts to improve its climate change adaptation programs before putting them into operation.

Further areas of work for DONRE and the Ho Chi Minh Climate Change Steering Committee involve expanding public transport, limiting personal vehicle use, saving lighting energy, recycling programs and addressing pollution within the city. Saving energy in public lighting is seen as an important target. DONRE is working with the Department of Transport to seek solutions to save power in public lighting. Vietnam's electricity supply is sourced mainly from fossil fuels and hydrothermal projects. Cutting down on the use of such sources could make great contributions to environmental protection and prevent further climate change. Recycling is also among the city's top concerns. Recycling waste will help save land needed for garbage burial, thus boosting the efficiency of land use and environmental protection. To facilitate the recycling programs, schemes to classify waste more efficiently need to be developed. DONRE has deployed recycling programs in most districts, and a series of garbage recycling plants have been put into operation.

At the same time, Ho Chi Minh City is enhancing domestic and international training for its staff members on climate change and adaptation to improve the city's management capacity. Along with institutional arrangements, Ho Chi Minh City is undertaking and planning concrete measures to adapt to climate change. In order to reduce the vulnerability of future urban areas, which will be mainly developed on low-lying marshlands for example, a policy was decreed in 2008 that requires all new developments to be elevated up to 2.5 m above mean sea level.

4 Ho Chi Minh City's Urban Development Strategy

HCMC's average annual population growth during the past decade is estimated at 3.5% (Le Van Thanh 2007; Dapice et al. 2010). This development trend is still continuing, leading to a high development pressure. The prevailing economic and population growth has resulted in increasing traffic volumes; the number of motorbikes and cars has significantly increased during the past years; in the first half of the year 2010, the number of cars registered increased to 433,000, while the number of motorbikes surpassed the number of 4.7 million (Phi Vinh Tuong 2011:331). This trend has led to an overcharging of the existing traffic network, causing frequent traffic congestion and limiting the attractiveness for investment.

The development pressure has led to the establishment of new residential areas, such as Phu My Hung Urban and Thu Thiem, and to the shift of manufacturing and industrial estates out of the city centre. Due to advanced construction technology, additional construction land can be provided on wetlands south of the city centre in District 7 and Nha Be, but construction activity in wetlands decreases the city's natural capacity to cope with frequent flooding events. In order to support investment and economic growth, a large proportion of the city government's budget has been allocated for infrastructure provision: predominantly for the development of industrial estates and the upgrading of ports, airports and road and railway networks (Phi Vinh Tuong 2011:322). The challenge of traffic congestion has forced the city authorities to develop an innovative transportation system, integrating four expressways and six metro-rail transit (MRT) lines (Dapice et al. 2010).

The urban development is mainly focused on the industrial sector; as the current master plan for HCMC indicates, it is guided towards the south; in Hiep Phuoc, a new port has been planned and already partly put into practice. Other development corridors are planned towards north, along the National Road No. 22 and the

Trans-Asia-Highwayfrom Hoc Mon, Cu Chi to Tay Ninh and along the National Road No. 13 to Binh Duong province; towards south-west to the Mekong Delta; and towards east to Ba Ria – Vung Tau. In order to respond to the high development pressure, a number of satellite towns are planned; three in the eastern outskirts of HCMC, such as Dong Nai City, Binh Duong City and Ba Ria – Vung Tau City, as well as 12 other independent and satellite towns (Phi Vinh Tuong 2011).

In this constellation, HCMC is going to represent the new business centre, while Binh Duong will be the human resource centre and the location of universities and hospitals of international standards; Dong Nai will provide estates for higher value added manufacturing industries and Ba Ria – Vung Tau for logistic services.

5 Urban Growth and Climate-Related Impacts

Across Ho Chi Minh City, about 160 km^2 (32% of the total currently built-up area of 500 km^2) is exposed to flooding at the current max-tide level of 1.5 m above mean sea level. However, current exposure is concentrated in a few hot-spot areas. Most of the areas with the highest exposure to flooding are recent urban development projects carried out in the last 10 years (2000–2010), located in low-lying areas. By implementing the land-use plans for the years 2010 up to 2025 and thus increasing the total built-up area to 750 km^2 (an increase of 50%), the total built-up area exposed may grow more than twofold to around 360 km^2 for the current max-tide level (Fig. 1). The combined scenario, linking the implementation of the land-use plans up to 2025 with a rising sea level of 1 m, reveals that two thirds of the total estimated exposure of the built-up area in Ho Chi Minh City results from the planned urban expansion into low-lying areas, which are widely known to be flood-prone at current max-tide level.

The current Ho Chi Minh City development strategy, focusing development towards the sea in a south-easterly direction, can be seen in Fig. 1. It should be highlighted that the seaward directing of urban development into low-lying

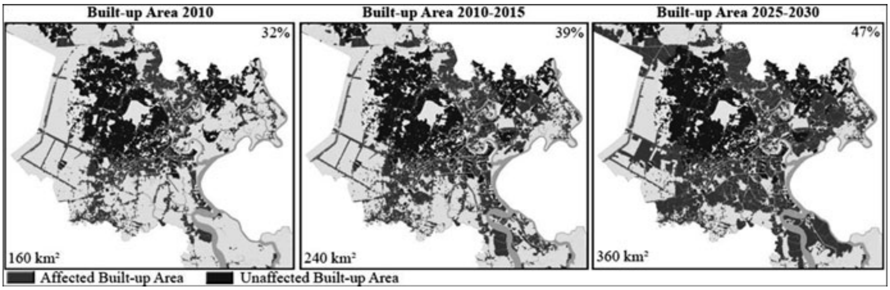


Fig. 1 Inundation risks for the current max-tide water level of 1.5 m AMSL for HCMC's urban development scenarios up to 2025/30 (*Source*: Storch and Downes 2011)

risk-prone areas began in the year 2000. This was encouraged, in particular, by the development of the Hiep Phuoc port project in the southern Nha Be district. The aim has been to move port activities towards the sea to receive much larger container ships and create space for inner city renewal of the old port areas. However, the degradation of low-lying wetlands will increase and lead to the creation of more hardscape features and the loss of space for water, including natural detention and retention areas, which ultimately will exacerbate the surface water flood risks significantly. It is envisaged that these new developments will face enormous difficulties to effectively incorporate and adapt to the effects of both the climatic and non-climatic drivers of future risk.

6 Urban Development and Climate Change Adaptation Strategies

The current master plan 2025 for HCMC, approved in March 2008 by the People's Committee of HCMC, does not particularly integrate climate change adaptation strategies. The Department for Planning and Architecture (DPA) distinguishes between *good land conditions*, located in areas higher than 2 m above mean sea level, and *bad land conditions*, located in low-lying areas. For *good land conditions*, the model project of the eco-belt has been designed, integrating residential areas, parks, universities and artificial lakes, while a cluster has been developed for the *bad land conditions*, placing schools and other social infrastructure amenities into the centre but leaving enough space for infiltration, retention areas and flood plains. From this perspective, opportunities are seen in wetland areas where recreational parks can be planned to protect productive landscapes. The Can Gio bio-reserve is an example for the city authority's efforts to preserve flood plains, enrich ecological values, reduce environmental degradation from urbanization pressure and protect urban central areas from environmental hazards.

While the top-down planning system does not yet focus on climate change adaptation, local level initiatives, such as the innovative approach of community-based adaptation (CBA), may significantly strengthen the resilience of the local population to climate change impacts. These local level approaches cannot substitute holistic adaptation efforts, but they can significantly complement the top-down planning approach by providing local level capacity and knowledge while providing low-tech and behavioural adaptation strategies tailored to the local risk exposure.

In this regard, the *Architectural Center*, as a part of the Department for Planning and Architecture (DPA), has also undertaken research on community living patterns for peripheral areas of HCMC. Living patterns in southern areas are designed to have small gardens for agricultural production and appropriate areas for lakes and fish ponds which are productive and retain water run-off. Aquaculture has been encouraged to sustain living and ecological patterns.

7 Challenging Status Quo, Exploring New Solutions

Research has suggested that planned urban development in HCMC is currently aggravating flood vulnerabilities and potentially causing more harm than the impacts of local climate change (Storch and Downes 2011). While in most developing countries informal settlement patterns are a major factor behind vulnerability, this is less an issue in HCMC. The peculiar circumstances have complex roots that make the city both unique and particularly vulnerable. In part it is explained by the history and dynamics of its development. The Reality Check Workshops' discussion at Resilient Cities 2011 suggested that the municipal boundaries tend to direct infrastructure development towards the sea, away from the jurisdiction of neighbouring municipalities. Also, large infrastructure investments, supported by international funders and decided at the national level, have concentrated development in the southern part of the city – an especially risk-prone area.

The concentration of future exposure to sea level rise in rapidly growing cities in Southeast Asia, such as in Ho Chi Minh City, emphasizes the urgent need to take steps to integrate the considerations of climate change into land-use planning, urban development strategies and flood risk management. Any delay to develop and integrate effective adaptation strategies into the spatial planning system would inevitably have not just citywide but also regional or even nationwide economic consequences.

Solutions are not straightforward. Drainage works are already underway to limit the impact of regular flooding. The recent creation of a steering committee was commended by Resilient Cities' participants as it allows the city to coordinate climate action across departments. Going further, participants suggested greater integration of flood prevention and other natural hazards risk assessments in the master plan. But redefining the urban development master plan for the year 2015 is a complex process that involves numerous actors and requires a final approval by the central government. Awareness of the challenge, based on sound climate data downscaled to the local level and vulnerability assessments, is an important step towards change.

References

Asian Development Bank (ADB). (2010). *Ho Chi Minh City – Adaptation to climate change: Summary report*. Mandaluyong City.

Dapice, D., Gomez-Ibanez, J. A., & Nguyen Xuan Thanh. (2010). *Ho Chi Minh City: The challenges of growth*. Vietnam: United Nations Development Programme, Harvard Kennedy School – ASH Center for Democratic Governance and Innovation, HCMC.

General Statistics Office of Vietnam (GSO). (2011). *Population and population density in 2009 by province*. Vietnam. Retrieved July, 2011, from http://www.gso.gov.vn/default_en.aspx?tabid=467&idmid=3&ItemID=9882

Le Van Thanh. (2007). *Economic development, urbanization and environmental changes in Ho Chi Minh City, Vietnam: Relations and policies*. PRIPODE workshop on urban population, development and environment dynamics in developing countries, June 11–13, 2007, Nairobi.

Ministry of Natural Resources and Environment (MONRE). (2009). *Climate change, sea level rise scenarios for Vietnam* (p. 33). Hanoi: Ministry of Natural Resources and Environment.

Phi Vinh Tuong. (2011). Development of special economic zones, industrial estates, ports, metropolis and alternative roads in the greater Ho Chi Minh City area. In M. Ishida (Ed.), *Intra- and inter-city connectivity in the Mekong region*. BRC research report no. 6, Bangkok Research Center, IDE-JETRO, Bangkok. http://www.ide.go.jp/English/Publish/Download/Brc/pdf/06_chapter7.pdf. Retrieved July 2011.

Storch, H., & Downes, N. K. (2011). A scenario-based approach to assess Ho Chi Minh City's urban development strategies against the impact of climate change. *Cities*, *28*((6) Special issue: low carbon cities), 517–526.

The Socialist Republic of Vietnam. (2008). *Decision on approval of the National Target Program to respond to climate change*. Unofficial translation, Hanoi. Retrieved September, 2011, from http://www.ngocentre.org.vn/files/docs/Decision_158_on_approval_of_NTP-1.pdf

Part V
Financing the Resilient City

Introduction: Financing the Resilient City

Richard Simpson

The finance challenge for building urban resilience and adapting to climate change is daunting, but the costs of doing nothing are even dimmer. As cities grow, they concentrate more people and assets, and with this, greater risk of economic loss. The costs of a single storm event on a city's infrastructure and urban services can exceed US$ 1 billion. Of the estimated global adaptation costs of US$ 80–100 billion per year, 80% will need to be spent in urban areas alone (World Bank 2010). At the same time, international climate finance is failing to provide anywhere near such quantities.

The international climate adaptation funds will always constitute only a small fraction of the overall amount to be spent on urban development over the next decades. As the urban capacity doubles in the next 40 years from 3.5 billion people living in urban areas in 2010 to 6.3 billion by 2050, the financial momentum to build urban resilience lies with urban development. For example, India alone is likely to invest US$ 300 billion in urban infrastructure over the next 20 years (Asia Economics Analyst 2007). As such, capital spent on urban development needs to be spent in a way that it takes long-term resilience into account, while the relatively small amount of top-down international climate funds need to be used effectively.

In response to this challenge, a mandate was given at the Resilient Cities 2010 Congress for ICLEI to further explore the question of how a bottom-up financing of a resilient city should look like (or more specifically, at the outset ICLEI, asked how the international climate finance could be inverted). A Think Tank on Financing the Resilient City was convened in February 2011 with the resulting report: *Financing the Resilient City: A demand driven approach to development, disaster risk reduction, and climate adaptation: An ICLEI White Paper*, which is presented here in a shorter contribution. Questions of financing have increasingly

R. Simpson (✉)
ICLEI – Local Governments for Sustainability, World Secretariat, Kaiser-Friedrich-Str. 7, 53113 Bonn, Germany
e-mail: urban.research@iclei.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_39,

risen on the global and local agenda as demonstrated by the discussions that took place at the Resilient Cities 2011 Congress in response to the identified need to tackle the financing challenge.

Jeb Brugmann's strategic vision highlights that financing local climate action and resilience building should and could be more creative. The great quantities of capital for urban development can be utilized and directed in a way that they contribute towards building urban resilience once resilience projects and programs are identified. Financing can be more creative by developing new financing mechanisms and tapping into both public and private local, regional and national resources. Urban resilience, when understood as an area-based performance enhancement mechanism, can increase the value of the entire area. International finance can play a key role in providing the necessary catalytic effects by building local capacity to identify, plan, leverage finance and implement the right actions.

Philipp Monaghan calls for cities to be more "business savvy". Cities have resources at their disposal which they can mobilize, but they may need to become more "business savvy" in the way they go about it. At the same time, Ulrich Mans's contribution forces us to think of the broader understanding of resilience in terms of policies geared at job growth, food, water and energy security. In examining the policies and incentives for green industries in India, Mans and Gueze et al. show that the private sector can also contribute to building urban resilience.

Even though optimizing opportunities exist, this should not disguise some key challenges cities, even those among the most developed and economically mature, are confronted with when financing climate change adaptation. Lykke Leonardsen, from the City of Copenhagen, details some of these challenges from a senior city practitioner's viewpoint. The risk to the city is real and large. The city has estimated the price of adapting Copenhagen to the future climate at approximately 1.5 billion EUR (approximately US$ 2 billion). This stands in contrast to the cost of a single storm event in July 2011 at around 300–600 million EUR (~US$ 400–800 million) in loss and damages. She reinforces that a paradigm shift is needed in the way we look at cities. The comparison between traditional measures, such as additional dams or drainage, and the more creative adaptation measures that integrate certain planning initiatives provides a fresh way of assessing the costs and benefits, as well as new challenges.

Although the highly developed cities of mature market countries have still many questions to address, cities in the developing world or emerging market countries are confronted with even greater challenges: beginning with a lack of basic infrastructure, urban poverty and informal settlements to rapid change and growth without the required capacity. Monika Wiebusch's contribution from the KfW provides important reflections on the role of donors. She enforces that the current relative amount for adaptation from the overall KfW Entwicklungsbank allocation is comparably little, while there are compelling reasons why the international funds are typically directed through the national institutions and not directly accessible to cities.

The finance chapter seeks to further stimulate the debate and exchange on financing the resilient city. Leveraging financial investments to build urban resilience is an urgent, current and future challenge. Projects within the overall resilience building frameworks need to be identified and brokered in ways that attract various financial sources. It is a highly complex and differentiated matter. It will be unique according to each city's financial, human, social, manufactured and natural capital, as well as those endowed by state and national governments. It is a challenge to find a common language, to build cooperation and to identify innovative ways for accounting sheets to prove that resilience projects are bankable. The following contributions scratch at the surface of an important debate for further research, policy, practice and action. They highlight some of the different perspectives, opportunities and challenges.

References

Asia Economics Analyst. (2007). Issue no: 07/13, July 6, 2007, Goldman Sachs Economic Research.

World Bank. (2010). Website at http://climatechange.worldbank.org/content/new-report-seescities-central-climate-action, referencing to the report by Daniel Hoornweg et al. *Cities and climate change: An urgent agenda*. Washington, DC: The World Bank.

A Demand-Driven Approach to Development, Disaster Risk Reduction, and Climate Adaptation

Jeb Brugmann

Abstract This chapter briefly presents a strategic framework for effective deployment and leveraging of limited available climate adaptation funds. This chapter summarizes the full report 'Financing the Resilient City: A Demand Driven Approach to Development, Disaster Risk Reduction, and Climate Adaptation – An ICLEI White Paper' prepared in response to a concurrence among experts at the Resilient Cities 2010 congress and launched at the Resilient Cities 2011 congress in Bonn, Germany.

Keywords Climate change adaptation • Demand-driven approach • Disaster risk reduction • Adaptation funds

1 Introduction

It has been estimated that up to 80% of the expected US$ 80–100 billion per year in climate change adaptation costs is to be borne by urban areas. Current international pledges for adaptation funding fall far short of this figure. At the same time, during the period between 2005 and 2020, it is estimated that some US$ 46 trillion will be expended on fixed assets in China's cities alone. Worldwide expenditures and investments in urban fixed assets could well be in the magnitude of 300 times the available adaptation funds during the critical decades of climate adaptation. If limited climate adaptation funds are not deployed so as to leverage this vast financial momentum behind global urban development towards more resilient city building, then the effectiveness of international adaptation efforts will be very substantially

J. Brugmann (✉)
Founder of ICLEI, The Next Practice, Bonn, Germany
e-mail: resilient.cities@iclei.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_40,

reduced. At the same time, adaptation and resilience buildings are inherently a local challenge, reflecting the unique risk factors in specific places. Adaptation funds also need to be responsive to this reality.

2 Urban Risk and Urban Performance

Urban areas are built to provide economic utility and social, political, and economic advantages to their residents and owners. Cities are built – and people, companies, and governments invest in them – *to perform.* The overall performance of an urban area is achieved through the design and development of urban locations and systems as units of specialized kinds of performance. Within the context of fixed urban asset expenditures, the meaning and relevance of 'resilience' is the reliability and efficiency of the performance of an asset or urban location/district under a range of likely environmental and economic conditions.

The seriousness of climate-related risks for urban regions and nations has been very well documented and demonstrated in recent weather-related urban disasters. These risks substantially undermine the performance of affected urban areas, and of fixed asset investments in them. There are two primary types of risk. Catastrophic risks arise from vulnerabilities to extreme environmental events such as flooding, violent winds, temperature extremes, and increasing sea levels. In addition, however, the performance of urban areas and assets is more frequently undermined by the poor planning, design and location of urban areas, and infrastructures as systems, such that areas only reliably provide their full utility, amenities, and advantages within a narrow range of economic and environmental conditions. These risks can be called systemic risks, arising from poor development of urban areas as resilient systems for specific kinds of performance.

Such s*ystemic risks* create sustained losses due to highly inefficient energy, water, food supply, and health-care systems, arising from poor maintenance, old technology, and poor demand side and life cycle management. Such systemic underperformance results in urban requirements for considerably greater financial and resource inputs than can be sustained in times of extreme ecological and economic transition. Examples can include water and energy shortages experienced in places across the world.

The underperformance of individual urban fixed assets (e.g. individual buildings) within their locations can only be addressed by further investment and development of those assets within the context of a more optimized *place-based system*. By increasing the performance of the asset *as part of a location or place-based system* of numerous assets that are optimized and managed to perform together, the revenue generated from the asset and the asset's value can increase. Part of the performance gap that can and must be increased is the assets' and area's resilience to changing conditions or, in other words, the reduction of risks that the area will not perform under a range of probable circumstances.

This orientation towards urban asset value creation offers a way to think about how limited climate adaptation funds can be leveraged with massive flows of urban fixed asset expenditures to build more resilient cities. The opportunity is to catalyze and support profitable, market-based investment in value-adding measures to increase asset and urban system performance and to reduce the risks of underperformance to investors and users, i.e. to increase 'resilience'. This broader view of the phenomenon of urban risk sees climate-related risks as a subset of a larger pool of asset-related risks.

To increase resilience and area performance, adaptation projects need to shift from a singular, special-purpose focus on specific climate-affected infrastructures and locations towards a more integrated approach to developing the performance and resilience of specific areas, districts, and places that are vulnerable to very distinct types of risks, development conditions, and local performance opportunities.

3 Building Performance-Based Resilience

Resilience based upon place-based performance requires comprehensive resilience upgrading of vulnerable urban areas, which only becomes possible if local capacity is created and supported to organize effective demand for resilience (i.e. specifically from those making fixed asset investments).

The approach begins with the identification and establishment of specific 'resilience upgrading' areas or zones, which are defined according to the combination of specific performance ambitions and specific vulnerabilities. In general terms, as illustrated above (Fig. 1), a resilience upgrading process might have four stages, beginning with a high-level understanding of climate/disaster scenarios and likely impacts. This would be followed by an assessment with identified stakeholders of local vulnerabilities to the identified scenario impacts. The assessment of vulnerabilities would include an assessment of performance vulnerabilities of the area's or zone's different assets. These vulnerabilities can then be further evaluated and prioritized as risks, which require mitigation. On this basis, a set of measures can be developed as the activities and investments of a resilience upgrading plan for the area.

The plan would include investments, risk controls, and management routines, which can each be evaluated and prioritized according to investment worthiness and staging. Thereafter, the effectiveness of the implemented measures can be monitored and evaluated, including the resulting increases in the performance of the area and its individual assets. The measures of performance would include evaluation of increased revenues, decreased costs/inputs per unit of revenue, and increased asset values. On this basis, mechanisms can be devised for capturing part of the increased value that arises from the resilience measures. These 'value capture' revenues can be used to pay off the resilience measures or to invest in further measures. In this way, resilience upgrading leverages initial climate adaptation funds to create a value stream for iterative investments in risk reduction and the area's/assets' performance enhancement.

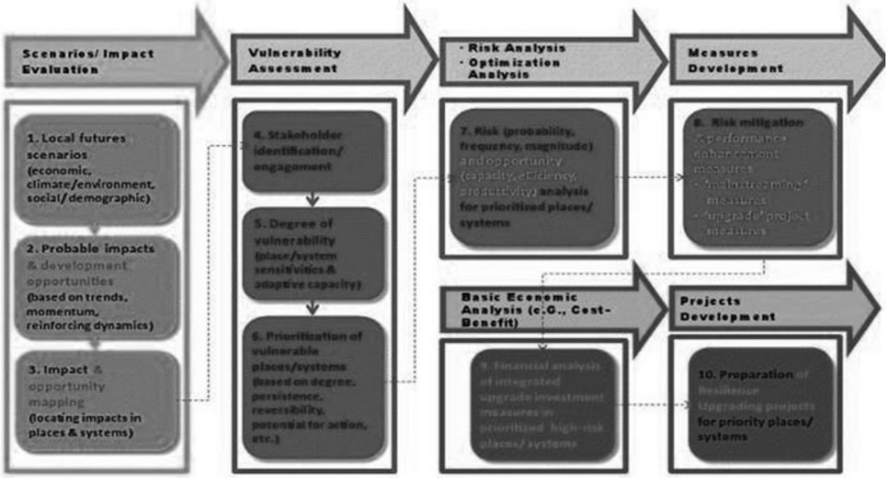


Fig. 1 A generalization of integrated planning for resilience upgrading (*Source*: ICLEI 2011)

4 Advantages of a Resilience Approach for International Climate Financing

With such an approach, three problems can be addressed. Firstly, where there is potential in cities for further value creation and performance enhancement, the limited climate adaptation funds can be used to leverage private capital flows for adaptation purposes. Rather than assuming the extreme ambition of planning and investing in adaptation projects with very limited resources across extremely different local contexts – the historical challenge of international development strategy – adaptation funding mechanisms can specialize in funding capacity building and technical assistance to 'mainstream' resilience upgrading.

Areas for adaptation funds investment could include: (a) mainstreaming adaptation and sustainability into conventional urban planning, municipal operations, and infrastructure maintenance; (b) building local institutional capacity for complex redevelopment projects; and (c) the development of special local planning processes to integrate resilience and sustainability performance into area upgrading. Additional specialization and funding allocation can be focused on vulnerable urban areas or systems with little or no value creation opportunity for private investment interest. Finally, the adaptation funds also can support collaboration with the private sector to develop new financial instruments for urban resilience upgrading. The contribution of the climate adaptation funds will increase the more they effectively assume such a catalytic funding role.

Secondly, by assuming a strategy based upon supporting local bottom-up capacity for resilience upgrading, the adaptation funds can avoid the historical pitfalls of top-down development assistance. The conventional approach of supply-driven and technically siloed lines of funding is particularly problematic with reference to climate adaptation in complex, interdependent urban systems. Perhaps, even more so than development, adaptation is inherently unique to changing local circumstances. The resilience upgrading strategy redefines the adaptation project from a singular, special-purpose focus on specific climate-affected infrastructures towards a more integrated approach to the overall risks, development conditions, and performance opportunities of a distinct local area.

Thirdly, by shifting the main focus of adaptation strategy from the problem to the pursuit of tangible opportunities to increase the performance of urban areas and fixed assets, the adaptation investments themselves can be revenue generating and self-replenishing through value capture mechanisms. This leveraged finance approach reflects the more decentralized and market-oriented character of urban growth internationally.

5 Challenges to the Demand Side of Finance

Providing comprehensive urban (re)development or 'resilience upgrading' projects can be extremely complex in terms of staging, financing, risk sharing, and governance. But their comprehensive nature and the opportunities provided to further optimize use of space, location, and infrastructure also creates opportunities to recruit finance from a variety of public and private sector investors who seek different benefits and returns. The challenge is to match responsive and well-organized bottom-up demand needs with responsive and similarly well-structured finance supply. This requires innovation on both sides. The local demand-side investment challenge requires local capacity in form of:

- Bottom-up *planning processes* for identifying vulnerabilities and risks, and linking the related risk mitigation solutions with priority performance enhancements in relevant areas or systems
- Bottom-up *technical and institutional capacity* for designing comprehensive resilience upgrading projects, for managing and staging complex project execution, and for preparing the different investment propositions related to different components of these projects
- Bottom-up *procurement of investment* through managed, competitive sourcing mechanisms and processes

Good practice and, in some regions, standard practices demonstrate that, with an adequate mandate and support, bottom-up processes and capacities can be established in cities to prepare very large-scale, sophisticated, complex projects and to directly source investment for these projects. With the right bottom-up capacity, local demand can advance a large project as quickly as or perhaps more quickly than in a conventional top-down project planning and financing cycle of an international development institution.

The development of local institutions with special financing and redevelopment authority and capabilities, focused on the upgrading of specific areas or systems, is a critical capacity-building requirement in societies wishing to rapidly and effectively reduce their risks from climate change and other disasters. Considering the variety of measures necessary for resilience upgrading – or for any complex urban redevelopment project, even of a conventional nature – and the different ways that these measures must be bundled together and staged in integrated projects for purposes of efficiency and efficacy, the financing of these projects will also often require combinations of different forms of finance for the different types of measures in these project.

The creation of this kind of local institutional capacity is essential for international development banks and special climate funds, which lack such local capacity, so that they can leverage their limited resources to respond to rapidly emerging risks and to develop quality project portfolios. Supporting the development of such institutions, particularly in high vulnerability urban regions, may be the most important capacity-building investment that the adaptation funds can make.

6 Challenges to the Supply Side of Finance

At the same time, expenditures and investments in urban fixed assets have their own investment logic. The increased capacity and resilience of basic infrastructure systems, urban services, individual building assets, and of public amenities enhances an area's overall performance and also *the resilience of its performance* – in other words, the range of circumstances under which the area will function at a higher performance level. Each increase in performance offers the potential of increased revenue streams or asset values, which can be linked to distinct investment propositions. However, although the systemic (re)development of urban areas and infrastructure systems offers a common ground between private capital accumulation, risk reduction, sustainability, and local economic development agendas, coordinating those agendas into specific reinforcing investment propositions can be politically and institutionally complex. It underlines that project planning and design must be made as responsive as possible to unique local development challenges and opportunities, which can only be achieved with a bottom-up approach.

Figure 2 provides a snapshot of the working elements of any complex urban redevelopment project. There are multiple types of investment, ranging from investment in the development institutions to investments in specific measures and fixed assets, and the funding of local capacity building and technical support.

To secure finance, the project proponents must prepare robust performance propositions for prospective investors, in the form of business plans, investment prospectuses, contracts, or capacity-building proposals. Different types of financial instruments are available or must be created to structure the finance for each of the different performance propositions. This results in the use of a mix of financial instruments for each project. A matching between instruments and

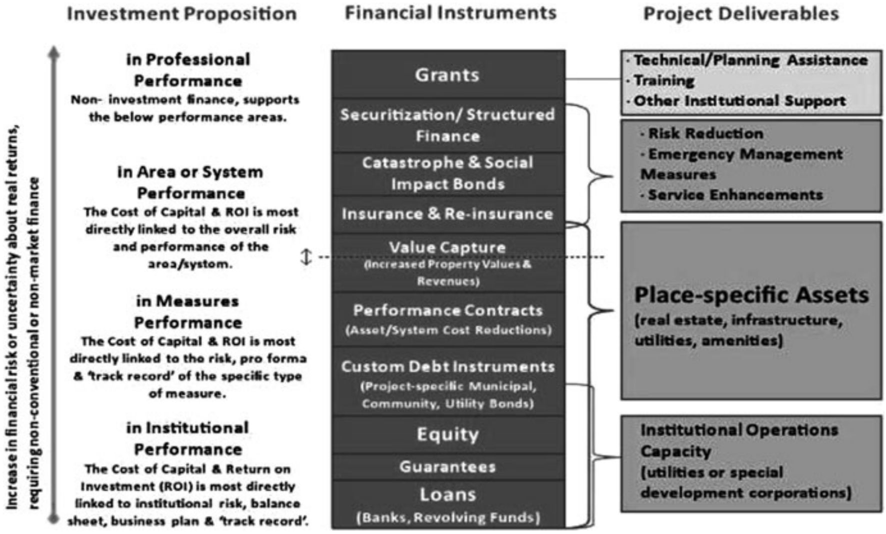


Fig. 2 Investment structuring for complex urban upgrading projects (*Source*: ICLEI 2011)

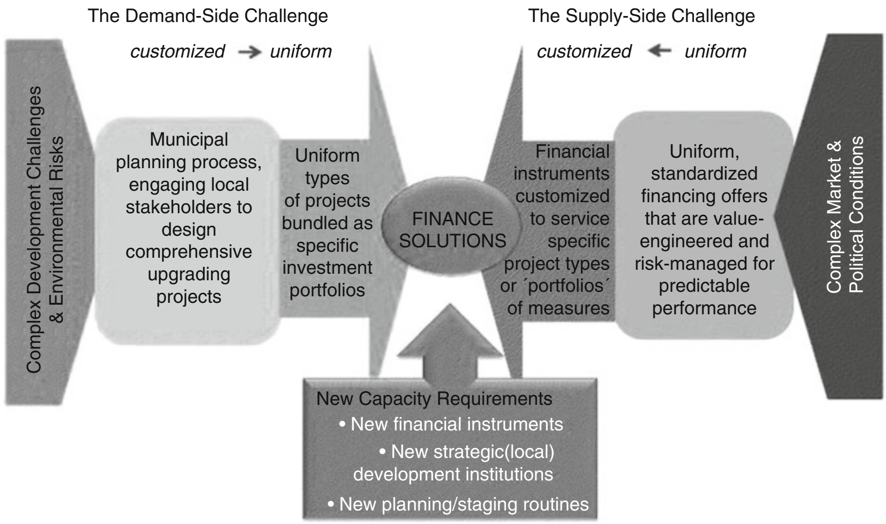


Fig. 3 Creating a market for resilience: resilience upgrading innovation challenge (*Source*: ICLEI 2011)

measures/deliverables may provide opportunities to create portfolios of similar measures across multiple cities and projects, enabling more scaled-up investment recruitment (Fig. 3).

The challenge is clear. The market for resilience finance requires a high degree of responsiveness to differentiated demand so that the projects themselves can be locally responsive. On the other hand, markets require a considerable degree of standardization of investment propositions and predictability about the pipeline and subsequent performance of the propositions. Until large numbers of cities are engaged in resilience upgrading, and financial intermediaries can realize opportunities to bundle similar types of investment opportunity across a large number of asset- and value-enhancing projects, the start of resilience upgrading will likely depend upon financial mechanisms that directly capture part of the value of each individual upgrading project. These value capture mechanisms have been widely tested in the form of tax increment financing, special-purpose bonds linked to special tax levies, etc. Otherwise, further opportunity exists at scale for investors in risk-based instruments such as catastrophe bonds, whose performance can be directly improved through more direct investment of proceeds from bond sales into risk-reduction measures in the 'insured' areas.

7 Key Lines of Action

- Develop local institutional capacity to prepare, structure, and manage large-scale resilience upgrading (redevelopment) projects.
- Mainstream climate and disaster risk reduction as key factors in conventional urban planning processes, project design, and development decision-making.
- Support the development of specialized financial instruments for value capture and for the risk-oriented components of projects that cannot be addressed via mainstreaming measure.

Reference

ICLEI. (2011). *Financing the resilient city: A demand driven approach to development, disaster risk reduction and climate adaptation.* An ICLEI White Paper.

Smarter Interventions in an Age of Uncertainty

Philip Monaghan

Abstract Despite the current economic downturn which has affected many countries around the world, cities in principle have resources at their disposal to tackle climate change. To make the smartest interventions and to do more with less, urban leaders need to become more 'business savvy' in terms of how they make use of local assets ranging from empowering residents to better policymaking on planning, procurement and pension fund investments.

Keywords Adaptation • Climate • Materiality • Money • Resiliency

Whilst we know the current economic model is fundamentally flawed in the way it discounts the high cost of failure (e.g. banking collapse, water droughts), prevention can save a lot of money. But let us also be very clear that to finance the transition towards more resilient cities, the upfront costs are quite intimidating (Monaghan 2012). Just in terms of climate adaptation, it has been estimated that urban areas will be expected to absorb up to 80% of the US$ 80–100 billion costs per annum (ICLEI 2011).

Having said this, let us also be equally blunt, lack of money is not the problem, even in the worst global economic downturn since the Great Depression. Rather, it is an *unwillingness* to act, either due to selfishness or ignorance about the art of the possible (Brown 2011).

In terms of what cities can and should do to fund climate adaptation, this will mean local leaders extracting more money from the system by becoming more 'business savvy' in two key ways. Firstly, in how they overcome 'discipline silos' (i.e. a failure of different professions to collaborate) to craft bottom-up ' investment

P. Monaghan (✉)
Founder & CEO, Infrangilis, 406 Royal Mills, 2 Cotton Street, M45BD Manchester, UK
e-mail: philipmonaghan@infrangilis.org

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_41,

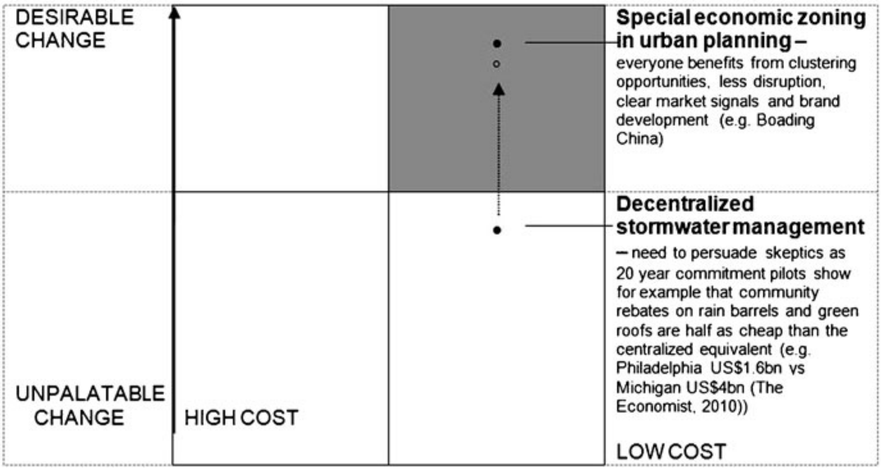


Fig. 1 Intervention matrix for smarter less frequent actions (© Monaghan 2012. Adapted from: Monaghan 2010)

brochures' to be pitched to national government or investment houses or enter into new private sector arrangements, be it insurance cover, bank loans or public-private partnerships (PPP).

Secondly, and perhaps more importantly, an increasingly 'business-like' approach is also about how local assets can be best be utilized by leaders – in particular, people, planning, procurement and pensions. These actions may range from devolving responsibility for civil emergencies to residents controlling development through climate resilient planning regimes, levying a flood tax on high-earning citizens or investing local government pension funds in decarbonized regeneration schemes (Monaghan 2012).

1 How to Select the Best Intervention

How do urban leaders begin to select the best intervention from the choices available in an age of financial austerity? As Fig. 1 shows, an intervention matrix is a helpful tool in whittling down a long list of potential solutions on material issues ('material' referring to importance not resource). Here, the materiality rating may be filtered according to criteria including major natural resource flows, strategic alignment, elected member and leadership priorities, available finance, value for money, compliance with environmental or social legislation, better management of risk, brand protection, delivering expected services or joint ventures with like-minded partners.

Once materiality is determined, the matrix plots desirable change against acceptable cost, with the most promising interventions in the top right-hand quadrant.

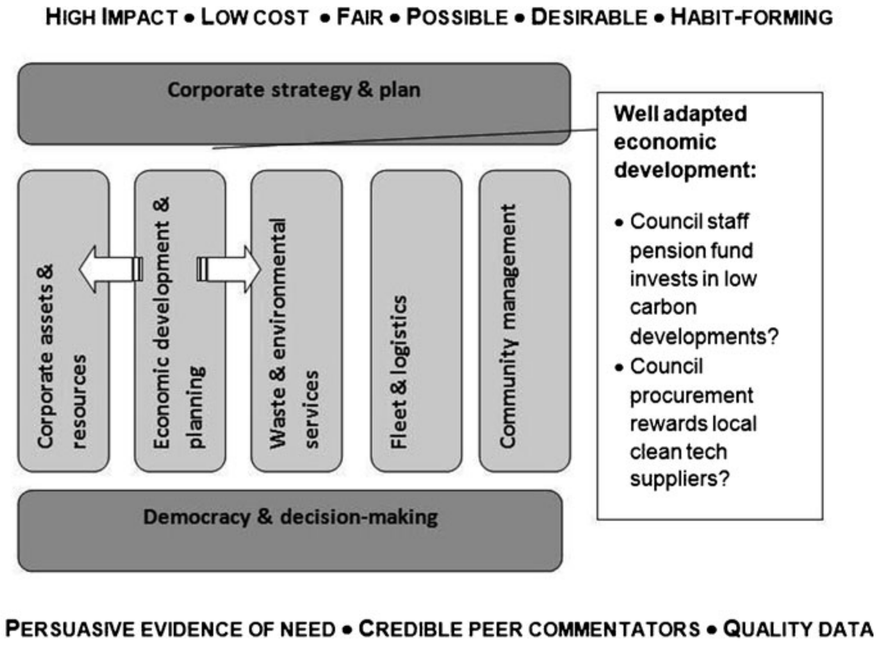


Fig. 2 Key pathways to scaling outcomes (© Monaghan 2012. Adapted from: Monaghan 2010)

The low cost refers to actions that either involve modest or additional outlay, or where any financial outlay is a net cost, as the investment is returned within an acceptable payback period. Of course, depending on the business case, which is context specific, what interventions are desirable for key stakeholders differ from council to council, from context to context. Moreover, in the absence of effective regulation, often a compelling business case will need to be made to take voluntary action, which is where this tool comes in. Desirability here may be impacted by an intervention being on close-to-home issues or values, perceived fairness, existing habits or sheer practicability. The ability to bear costs is again context specific but will include investments to save proposals (i.e. cost prevention). This point is illustrated using the thumbnail examples of special trade zoning versus bottom-up solutions to deal with storm water in China and the USA, respectively.

Just as crucial in formulating the business case, to make use of finite resources, cities need to use all the existing pathways at their disposal, ranging from economic development and planning to fleet and logistics, as depicted in Fig. 2.

Whether local authorities control or influence an action (e.g. planning policy and consumer choices, respectively), they need to mobilize all available levers to achieve the desired impact. This requires genuine cross-departmental thinking and doing. So, for instance, as depicted above, well-adapted economic development willrequire economists and planners, accountants and estate managers and environmental sustainability professionals all working together productively. For example, to ensure municipal pension funds and council procurement, both must invest in low-carbon projects and products, respectively.

An insightful case of this working in practice is the approach by Nillumbik in Australia, which makes use of a 'revolving fund' to assist the council's efforts on water conservation in order to become more resilient to drought (Monaghan 2010). The fund is an internal loan scheme to borrow money to fund water (and energy) efficiency technologies, which is then repaid from the utility savings made as a result. The payback period for these types of investment tends to be reasonably short and commonly between 1 and 5 years (Monaghan 2010).

Making this smart intervention required Nillumbik bringing together colleagues in asset management, procurement and community relations as well as environmental services.

2 Conclusion

From this exploration of the 'art of the possible', we can see that cities in principle have resources at their disposal to tackle climate change. But to make the smartest interventions and to do more with less, urban leaders need to become more 'business savvy' in terms of how they make use of local assets ranging from procurement to pension fund investments. Another key learning is that to address climate resiliency, city officials need to be brave enough to ask for help and to challenge colleagues. Indeed, in a new age of financial austerity for many countries, now more than ever, city officials have a moral duty to do so.

Water Resiliency in Nillumbik Shire Council (Australia)

Located on the outskirts of Melbourne, the Shire of Nillumbik forms part of a north-eastern metropolitan Green Wedge: bounded by the Yarra River and the Kinglake Ranges. The shire has a population of just over 60,000 people who live in close-knit communities which range from typical urban settings to remote and tranquil bush properties. It is a comparatively affluent community in terms of income, health and well-being. Key industries include farming and tourism.

Due to its hot and dry climate, in 2009, about 25 per cent of the shire was affected by bushfire, and there was serious loss of life and property. So a priority over the past 12 months has been, and will be over the next 3 or more years, bushfire environmental recovery and preparations for the annual summer fire period. This cost is in the order of US$6.5 million for the previous year alone.

(continued)

(continued)

Having been in drought for the past 10 years, in addition to state government enforced water restrictions, the council has devised a Sustainable Water Management Plan. The plan has been developed to align with global best practice using guidelines set out in the ICLEI – Local Governments for Sustainability Water Campaign.

In terms of its own water use, the council set to achieve a 45 per cent reduction (from 2000 to 2001 levels) by 2011. Since 2000, it has already achieved 35 per cent reduction. In addition to improving its resiliency against drought, this constituted a net saving of approximately US$40,000.

The plan aimed to improve water management practices through:

- Education and behaviour change programmes within the council and the community.
- Phased retrofit of council buildings with water efficient devices.
- Staged implementation of water efficient practices in open space management.
- The strategic development and implementation of guidelines that support water conservation and water quality management.

Council operation actions to achieve this goal included:

- No irrigation of parkland.
- Use of indigenous plant species in new amenity plantings.
- Water conservation audits completed on priority council buildings.
- Rain sensors and electronic irrigation system installed at its community environment centre.
- Rainwater tank installed at preschools, community facilities and at its environment centre for use in toilet flushing.
- Drought-tolerant grass species installed on all golf fairways as part of a wider water management plan for its golf course.
- Reuse of pool and dam water in road grading operations.
- Conduct of regular irrigation system audits and maintenance.
- Connection of backwash system from swimming pool to sewer.
- Water sensitive urban design features incorporated into offices, leisure centres and roadworks.
- Warm season grasses and subsurface drip irrigation installed at priority sporting fields.

The above council-centric actions compliment other council-led community actions.

For further information, visit www.nillumbik.vic.gov.au.

Source: Adapted from Monaghan (2010)

References

Brown, L. R. (2011). *World on the edge: How to prevent environmental and economic collapse*. Washington, DC: Earth Policy Institute.

ICLEI. (2011). Financing the Resilient City: An ICLEI White Paper (Freiburg: ICLEI-Local Governments for Sustainability)

Monaghan, P. (2010). *Sustainability in austerity: How local government can deliver during times of crisis*. Sheffield: Greenleaf.

Monaghan, P. (2012). *How local resilience creates sustainable societies: Hard to make, hard to break*. London: Earthscan.

The Economist. (2010). 'The world in 2011', *The Economist* (22 November 2010).

Linking Resilience and Green Growth: How Green Business Can Contribute to More Resilient Cities in India

Ulrich Mans

Abstract In the face of a growing sustainability challenge, cities are becoming increasingly important actors. Municipal leaders are stepping up their efforts to adapt to the consequences of climate change and to mitigate the future impacts of greenhouse gas emissions. Becoming more resilient has become a key challenge for many cities. At the same time, major bottlenecks remain, and financial restrictions continue to be a stumbling block for cities when turning vision into reality, particularly those in less-developed regions. This chapter aims to contribute to this emerging discussion on the synergies between mitigation and adaptation and argues that the private sector has an important role to play. This is captured in the concept of green-driven growth, which emphasizes the potential benefits of a local green industry to a city's quest for greater resilience: green jobs and green products. When looking at the various types of wind energy businesses in selected Indian cities, an assessment of company activity shows that the majority of green business can indeed be found in those sectors that either create additional jobs or those that offer green products for the municipality.

Keywords Urban resilience • Green economy • Renewable energy • Green-driven growth • India

1 From Urban Resilience to Green-Driven Growth

Over the last decade, a growing number of municipalities have initiated a sustainability agenda. Stockholm, Copenhagen and Freiburg are acknowledged frontrunners in Europe. Portland and San Francisco are considered to be

U. Mans (✉)
Department of Geography, Planning and International Development Studies, University of Amsterdam, Nieuwe Prinsengracht 130, 1018VZ Amsterdam, The Netherlands
e-mail: u.mans@uva.nl

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_42,

spearheading green city developments in the United States. However, these initiatives are not limited to the developed world. Songdo in South Korea aims to become a new low-carbon city, and Masdar, near Abu Dhabi, plans to be fully carbon neutral with some 40,000 inhabitants expected to live in the city. In Africa, Cape Town has long been active in environmental politics and has set ambitious targets for reducing the city's carbon emissions. A number of cities in emerging economies are also renowned for their major achievements in the field of sustainability, such as Curitiba in Brazil or Rajkot in India. Many of the most committed municipalities are cities that fear the consequences of natural disasters in the form of storms, floods, earthquakes, etc. Other cities have less threatening environmental concerns and thus chose to promote green-inspired urban planning with CO_2 reduction targets, air quality improvements or building energy standards (REN21, ISEP, ICLEI 2009).

All these initiatives are driven by the growing understanding that in the twenty-first century, cities need to transform their overall ecological footprint in order to increase urban resilience (Newman 2009). This goes beyond adaptation to climate change and disaster risk reduction; it includes the ability to withstand external shocks such as price fluctuations or economic downturns as well as the ability to formulate adequate policies geared at job, food, water and energy security. At the same time, the concept of resilience goes beyond the mere reduction of vulnerabilities (Meerow 2010). As Baud and Hordijk argue, resilience in the urban context has to be more forward-thinking, more comprehensive in its nature and should acknowledge the effect of repetitive loops of external influences on different scales (Baud and Hordijk 2009). This highlights the key difference to the notion of sustainability, which, according to Cascio, is 'inherently static' (Cascio 2009: 2). Instead, the concept of resilience emphasizes the dynamics of necessary changes and is 'an important underpinning for understanding transformation' (Newton and Bai 2008: 12). Making cities more resilient can therefore be seen as a gradual, long-term process that requires structural changes.

In this need for structural change, one of the major challenges for municipalities can be found in the costs associated with enhancing urban resilience. Water treatment plants are expensive, and flood control systems or waste collection schemes also require large-scale investments. While the long-term benefits are universally accepted, short-term financing remains a key bottleneck for most cities, particularly those outside the industrialized world. In Cape Town, for example, the fact that sustainable energy has been mainstreamed across all layers of municipal governance does not take away the most urgent budget priorities, such as waste management or urban poverty. If more sustainable solutions do not result in any tangible benefits for the municipality (regarding, e.g. jobs, public infrastructure, services, taxes), making a city more resilient becomes a financial, and thus a political, burden. The challenge for urban leaders is clear: how can cities pay for resilience?

In a recent report, the OECD has put forward the concept of 'green growth strategies' in order to define policy choices that combine economic growth and resilience: '[a] growth strategy that accounts for increases in public and private investments and consumption leading to sustainable resource use, lower greenhouse gas emissions, and reduced vulnerability to climate change' (Kamal-Chaoui and Alexis 2009: 138). While useful as a broad guideline, this framework focuses on national policies and does not offer city-specific strategies.[1]

In order to understand how urban centres can follow such a green growth strategy, this chapter proposes that it is useful to divide green growth into two separate, interrelated aspects of urban economic development. On the one hand, economic growth can be conditioned to certain environmental standards (e.g. by introducing emission targets for industrial activity). This can be referred to as 'green-conscious growth'. In many instances, these initiatives, while enhancing urban resilience in the ecological sense, pose a barrier to economic growth, for example, companies may struggle to pay for the additional costs of being environmentally friendly. On the other hand, economic growth can be driven by the demand for environmentally friendly solutions and products. For example, when a city's local industry manufactures solar cells or wind turbines, municipal revenues increase parallel to a greening economy. This latter can be called 'green-driven growth' and represents a more entrepreneurial vision for a green city, where the green business community creates co-benefits for the city regarding resilience.

The notion of green-driven growth provides an interesting starting point for urban scholars working on resilience. While most studies in this field focus on green-conscious growth and, therefore, tend to emphasize the costs of being environmentally friendly, it is worth investigating whether today's booming green economy offers benefits to a municipality's prospects to become more resilient. This assumption divides into two separate aspects. On the one hand, a growing green economy means green job creation. Despite the fact that there is no definition of what exactly constitutes a green job, the green economy offers alternative ways of employment at a time when many metropolitan regions struggle to keep unemployment low. Thus, green jobs offer more job security in a post-industrial era: citizens are able to make a living in green rather than only in conventional industries. On the other hand, a local green industry creates certain green products that are readily available to the particular urban area. This can encourage the uptake of green developments or related technologies to the advancement of a more resilient municipality. In the following, we attempt to empirically test this assumption.

[1] In comparison, the World Bank in 2010 launched its so-called Eco^{2}City concept, which aims to provide solutions for the urban financing dilemma. It includes a toolbox for local governments to facilitate economic growth that is both durable and ecologically sound. In doing so, Eco^{2}Cities looks at opportunities to promote ecologically sound solutions in participatory planning and financial management.

2 Case Study: Renewable Energy in India

Despite growing interest in the green economy, there is no consensus on what the green business actually entails. While some focus on the 'clean economy' and thus include nature conservation organizations when counting green jobs (Muro et al. 2011), others make a distinction between different sub-markets in the green economy (Ronald Berger 2011).[2] It is beyond the scope of this chapter to provide an adequate contribution to defining green business. Instead, it focuses on a sector that is generally uncontested as green industry: the renewable energy business. The quest for sufficient and sustainable sources of energy in urban centres is a key aspect to enhancing urban resilience. With the expected end of cheap oil, fossil-based energy will have to be complemented with alternative sources of energy. This holds particularly true for metropolitan areas with a growing population and rapidly increasing living standards. In those regions, urban centres are expected to require much more energy than today (Mans and Meerow 2011). Countries that are likely to face the highest energy growth rates include emerging markets like Brazil, China and India.

The renewable energy sector is a relatively recent addition to the international business horizon and is growing fast. Since 2004, global investment increased fivefold by 2010. Bloomberg New Energy Finance cites a total of US$ 35 billion in 2004, up to US$ 186.6 billion in 2009 and US$ 243 billion in 2010. 'Almost all renewable energy industries experienced manufacturing growth in 2009, despite the continuing global economic crisis, although many capital expansion plans were scaled back or postponed' (REN21 2010: 11). A look at the level of investments in nonrenewable energy confirms this trend. For example, 2008 was 'the first year that investment in new power generation capacity sourced from renewable technologies [. . . including large hydro] was more than the investment in fossil-fuelled technologies' (UNEP SEFI and New Energy Finance 2009: 11). As a consequence of this sustained growth, many companies active in the renewables sector are expanding, and a large number of newly established companies have joined the ranks of green energy business. This trend reflects the core idea behind the term green-driven growth and what it means for urban development. Because there is a growing demand for green products and solutions, the green economy is becoming a major driver for economic development, not only on the national level but also in cities. While many scholars have written about the renewable energy business in general, and about its impact on the national economy, much less expertise is available on how these developments play out on the city level.

India is one of the largest emerging markets and has experienced strong growth rates over the last couple of years. As far as renewable energy is concerned, India is an international frontrunner when it comes to overall installed capacity. This is due to India's national and state policies aimed at promoting various forms of renewable

---

[2]The definition used by Roland Berger includes six sub-sectors: energy efficiency, power generation and storage, material efficiency, sustainable mobility, sustainable water management, waste management and recycling.

energy solutions, and driven by the general boom in global green economics. In June 2010, renewable energy capacity in India stood at 17.5 GW, which represents 10% of the domestic energy supply (DIREC 2010). Existing policies include a large variety of regulatory and financial support mechanisms for the uptake of renewables. According to the National Action Plan for Climate Change (NAPCC), India will generate 15% of the country's energy through renewable sources by 2020.

A number of states across India have started with feed-in tariffs and renewable portfolio standards. Its national solar cities program encourages cities to compete for national subsidies to introduce solar technology in their municipalities. This clear commitment to renewables has attracted a significant share of private investment, particularly in the wind energy businesses. By 2008, India's wind turbine industry was ranked 4th worldwide, after the EU member states Denmark, Spain and Germany (Van den Berg and van der Slot 2009), and growth rates are the highest in the world (GWEC 2011). As a consequence, India is considered a particularly important player in the global wind energy industry. This also translates into economic development on the urban level. Where the national economy grows, cities often are a preferred location for company headquarters, manufacturing sites and sales offices. India offers interesting insights in this regard and provides for an adequate case study in order to test the assumption introduced in Sect. 1.

3 Methodology and Findings

While urbanization in India is not as fast-paced as in neighbouring China, the country hosts 59 larger cities (with more than 750,000 inhabitants). Some of them qualify as cities with a green agenda. Using ICLEI membership as criteria for having green ambitions, and limiting the sample to medium-size cities with 1–5 million inhabitants,[3] there are 11 cities in India in this category: Bhopal (1.8 million inhabitants), Coimbatore (1.8), Jabalpur (1.3), Madurai (1.3), Nagpur (2.6), Pune (5.0), Rajkot (1.3), Surat (4.1), Vadodara (1.8), Vijayawada (1.2) and Visakhapatnam (1.6). Two ICLEI member cities with just over five million inhabitants are also included in the discussion of this chapter: Ahmedabad (5.7) and Hyderabad (6.7). These 13 cities all aim to become greener and have over the last couple of years invested various sustainability initiatives. In many instances, ICLEI has assisted their municipal leaders in gaining and sharing lessons learned with other cities across India and elsewhere in the world. This sample provides the starting point for the following analysis.

In order to determine where and to what extent the wind energy business impacts the green economy and its contribution to urban resilience, we collected India-

[3]The midsize city with 1–5 million inhabitants is interesting because of two reasons. They are the fastest growing type of city according to the UN Population Prospects database, and they are large enough to benefit from a municipal tax base that allows for major infrastructural investments.

wide data from a total of 1,565 company headquarters in the wind energy sector.[4] Narrowing down to the selected medium-size ICLEI member cities, the sample included a total of 210 headquarter locations. We then looked at the particular position of each individual company within the wind energy value chain in order to determine how these companies generate revenue. The various types of businesses in this value chain include a number of steps in wind energy generation, each having a different impact on the host city. In general terms, companies are making money with raw materials, machine parts (input, upstream), and power generation or transmission (output, downstream).[5] For the purpose of this chapter, we defined the value chain to include five subcategories of specific business models: (1) manufacturing, (2) building, (3) operating, (4) owning and (5) transporting (see Fig. 1).

Manufacturing includes the various parts or products needed in order to build a functional energy system. Building refers to the conceptual development and the construction of a given wind park. When in place, companies operate and maintain the system (this can also be the developer or the construction company). The category 'owning' refers to those companies that have invested in a renewable energy system. This is done because a company uses renewable energy for in-house production (captive generation), because of a corporate social responsibility (CSR) strategy, or because a company wants to sell the generated energy.[6] Transmission and generation is again a different business model, based on charging fees for transporting electricity from the source to the end consumer.

For each city hosting one or more company headquarters, the individual companies can be positioned along the value chain, and each sub-sector then compiled per city (see Fig. 2). This was done by looking up the individual companies' business profiles on their websites.[7] When looking at the 210 Indian headquarters, the findings offer a diverse picture across the 13 city locations. The city of Pune accounts for the highest number of company headquarters (56 in total), with Coimbatore (40) and Ahmedabad (27) ranking 2nd and 3rd, respectively. The lowest-scoring cities are Vijayawada (0), Jabalpur (1) and Visakhapatnam (2).

A first look reveals comparatively high scores for the category 'Energy & CDM sellers', which accounts for 53.8% of the total. In Fig. 2, this is visualized by the size of the circles for each of the nine possible subcategories along the value chain. Each city is listed from left to right, stating the total score of company headquarters. When combining the three subsections of the 'owning' category, the

---

[4]The findings are based on a database purchased in 2011 from *Globaldata*, a renowned business data service provider. The full database also includes office locations (such as manufacturing sites, sales offices) and subsidiaries in across India. Only the headquarter data was used for this analysis.

[5]Maharashtra Industrial Development Corporation, Presentation on Renewable Energy in Maharashtra State, 2010.

[6]Since the introduction of the Clean Development Mechanism (CDM), ownership can create revenue through selling associated carbon credits to international buyers.

[7]In case no website was available, second-hand sources such as business data providers were used instead.

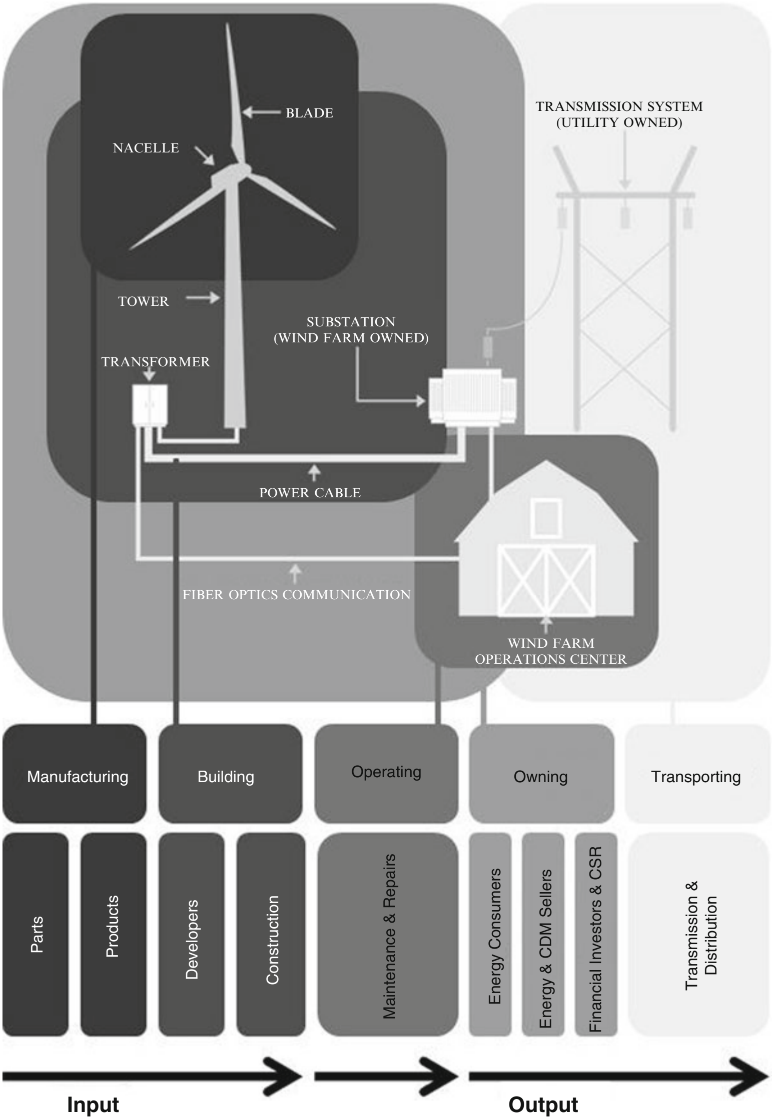


Fig. 1 Possible business models in the wind energy value chain (Modified from Wind Capital Group)

dominant role of this part of green business becomes even more evident: 79.5% of all companies headquartered in one of the selected cities own (part of) a wind energy plant. In turn, 15.7% create revenue with the 'input' side of renewable energy (parts and products manufacturing). Only 1.4% represent companies specialized in maintenance, and 3.3% make money with transmission and distribution.

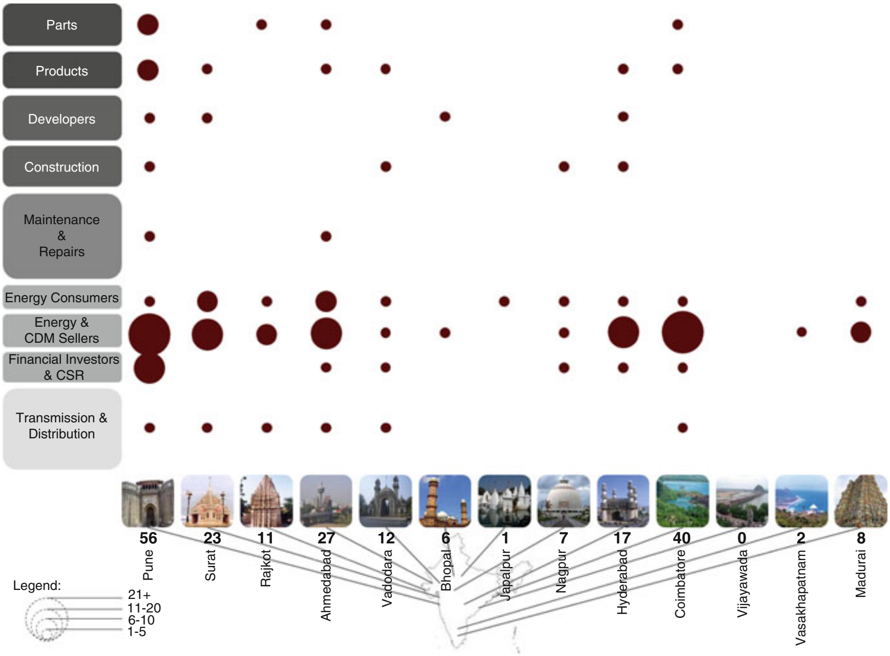


Fig. 2 Number of companies in India's wind sector that are headquartered in the selected cities

The importance of the 'owning' category is in line with the general trend in India's renewable energy industry: '[A] small investor with ownership of just one or two [wind turbine generators] was in fact the predominant market phenomenon' (GWEC 2011: 43).

The manufacturing activities in the wind energy sector – 1 in 6 companies in the sample – are heavily concentrated and can be found in mainly three cities. Pune is the city with the highest count for Indian company headquarters in the first two manufacturing categories, followed by Ahmedabad and Coimbatore. A look at India's wind turbine manufacturers confirms this finding: the ten largest wind turbine manufacturing companies[8] – which in 2010 together had a market share of 95.4% of all Indian wind turbine sales – account for 15 company locations (headquarters and branches) in the 13 cities: 6 in Pune, 5 in Ahmedabad, 2 in Vadodara and 1 in Hyderabad and Coimbatore. In other words, India's wind energy manufacturing base is concentrated in those cities.

When it comes to the largest count of business activity – Energy & CDM sellers – the manufacturing hubs Pune and Ahmedabad also score relatively high. The city of Coimbatore, which has a less pronounced manufacturing profile, hosts a large

[8]These are partly Indian, partly international companies: Enercon, Gamesa, Global Wind Power, Kenersys, Leitner-Shriram, Regen Powertech, RRB Energy, Suzlon, Vestas India and Winwind.

number of businesses that belong to the ‘owning’ category. This is of particular interest because it stems from the fact there are a great number of energy-intensive textile industries in Coimbatore. Our online research further shows that many of the companies found in this category are textile mills that decided to invest in wind energy with a view to cut their carbon-related energy costs – or to safeguard against energy shortages. This latter example is an illustration of how green business can directly contribute to resilience. A company that invests in renewable energy can not only profit from lower electricity costs (which is the case when a company sells its energy) but can also decrease the risk of costly blackouts when they consume their own energy. Either way, they contribute to the overall electricity supply – and thus contribute to making the entire system more resilient.

4 Discussion and Conclusion

Emerging market cities often struggle to find the necessary resources for enhancing urban resilience. Flood management, building standards or energy efficiency measures call for new, sustainable solutions. These are often too expensive and can easily become a financial burden for municipalities. But urban resilience is not only a cost factor; it also offers economic opportunities. In order to unlock this potential, it is useful to take a closer look at the role of the private sector.

Green business is booming, and this chapter aimed to test the assumption that the growing business community can contribute to urban resilience by creating (1) green jobs and (2) green products. The presented data from the Indian wind energy sector show that on the one hand, many businesses in the top-scoring cities are working on the ‘input’ side of the value chain. These are work-intensive manufacturing businesses, producing turbines or parts thereof. Industrial employment in these cities is therefore becoming greener because of green-driven growth, and in fact adds to economic resilience. On the other hand, the data confirms the assumption that green companies make available green products to the municipality. The largest number of green companies can be found in the ‘owning category’. These businesses own wind energy generation facilities and produce energy that is added to publicly available electricity. In times of increasing energy shortages across India, this type of green investment enhances resilience by adding to the urban energy supply. In other words, green business can indeed play a role in enhancing urban resilience.

The findings also indicate that in particular, those municipalities with a clear industrial profile are today’s frontrunners when it comes to green-driven growth in India’s medium-size cities. This seems to suggest that green-driven growth, as far as the wind energy sector is concerned, offers an opportunity to those cities that already have a pool of human resources (upstream manufacturing) and/or an industrial infrastructure (energy-intensive businesses).

In the context of the ongoing urban resilience debate, these are interesting findings. However, this chapter presents only a first step in establishing empirical data for an emerging field of expertise. In this, the paper at hand provides a baseline to the concept of green-driven growth and confirms that the green business community has a role to play in creating more resilient cities. Further, it proves useful to include a sector-specific value chain in order to separate between the different types of businesses in a given city. For future research, it would be worthwhile to look in-depth at individual cities and their experiences with green-driven growth in order to learn more about the possibilities for cities to link a green growth to urban resilience.

References

Baud, I. S. A., & Hordijk, M. A. (2009). *Dealing with risks in urban governance: What can we learn from 'resilience thinking'*. The 4th international conference of the international forum on urbanism. Tu Delft, The Netherlands.

Cascio, J. (2009). The next big thing: Resilience. In *Foreign Policy,* April 2009 [online]. Accessed on 28 March 2012. www.foreignpolicy.com/articles/2009/04/15/the_next_big_thing_resilience.

DIREC. (2010). *DIREC Indian renewables status report*, Delhi International Renewable Energy Conference, New Delhi.

GWEC. (2011). *Indian wind energy outlook 2011*, Brussels: Global Wind Energy Council.

Kamal-Chaoui, L., & Alexis, R. (Eds.). (2009). Competitive cities and climate change, Paris: *OECD Regional Development Working Papers N° 2.*

Mans, U., & Meerow, S. (2011). *Green city and green economy – Assessing the link between politics and business*, RESS conference paper, Freiburg, 14–16 September, 2011.

Meerow, S. (2010). *Generating resilience. Exploring the contribution of small power producer and very small power producer programs to the resilience of Thailand's power sector*. M.A. thesis. Amsterdam: University of Amsterdam (unpublished).

Muro, M., Rothwell, J., & Saha, D. with Battelle Technology Partnership Practice (2011). *Sizing the clean economy, a national and regional green jobs assessment*. Washington: The Brookings Institution, Metropolitan Policy Program.

Newman, P. (2009). *Resilient cities: Responding to peak oil and climate change*. Washington: Island Press.

Newton, P., & Bai, X. (2008). Transitioning to sustainable urban development. In P. Newton (Ed.), *Transitions: Pathways to sustainable urban development in Australia*. Collingwood: CSIRO Publishing.

REN21. (2010). *Renewables 2010: Global status report. Paris: REN21 Secretariat.*

REN21, ISEP, ICLEI. (2009). *Global status report on local renewable energy policies*.

Roland Berger (2011). *Green growth, green profit, how green transformation boosts business*. Hampshire: Palgrave Macmillan Publishers.

UNEP SEFI, & New Energy Finance. (2009). *Global trends in sustainable energy investment 2009*. United Nations Environment Programme.

Van den Berg, W., & van der Slot, A. (2009). *Clean economy, living planet – Building strong clean energy technology industries*. Zeist: Wereld Natuur Fonds.

Green Areas Inner-City Agreement (GAIA): How Local Enterprises Can Contribute to Local Adaptation to Climate Change

Raffaella Gueze, Rita Baraldi, Marjorie Breyton, and Giulia Sateriale

Abstract GAIA project has been financed with EU LIFE+2008 call. The purpose of the project is to build up a public-private partnership between the Municipality of Bologna and local businesses in order to finance the realization of new green urban areas. This will actively contribute to Bologna's adaptation strategy by tackling the heat island effects and by creating a more resilient town. New green areas will also contribute to sequestrate carbon dioxide emissions.

Keywords Public-private partnership • "Circle of Responsibility" • Urban forestation • Climate change adaptation • Resilience

1 Introduction

The problem of climate change is now crucial on the global level and needs a strategy aimed at integrating both mitigation and adaptation actions and at implementing policies that can promote a partnership between the public and private

R. Gueze (✉)
Responsible Sustainability Office, Municipality of Bologna, Piazza Liber Paradisus 8, 40129 Bologna, Italy
e-mail: raffaella.gueze@comune.bologna.it

R. Baraldi
Urban Forest Mitigation, Institute of Biometeorology (IBIMET), National Research Council, Via Gobetti 101, 40129 Bologna, Italy
e-mail: r.baraldi@ibimet.cnr.it

M. Breyton
Impronta Etica, Via Marco Emilio Lepido 182/3, 40132 Bologna, Italy
e-mail: info@improntaetica.org

G. Sateriale
Climate Change Policies, Indica srl, Via Montebello 10, 44121 Ferrara, Italy
e-mail: g.sateriale@indicanet.it; giulia.sateriale@gmail.com

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_43,

sector. The planet's very survival depends upon the resolution of this problem and with this the future and well-being of generations to come. Public measures alone have proven to be ineffective in managing global environmental challenges. Through a partnership between private and public bodies for the realization and management of green urban areas, it is possible to contribute to local policies that tackle climate change.

This project has been financed by the EU LIFE+2008 call. The purpose is to build up a public-private partnership (PPP) between the Municipality of Bologna (Italy) and local businesses. This PPP aims at creating new urban green areas drawing upon the concept of corporate social responsibility (CSR). This will actively contribute to Bologna's adaptation strategy by tackling the heat island effects and by creating a more resilient town. New green areas will also contribute to the sequestration CO_2 emissions. The involvement of CNR IBIMET (National Institute for Scientific Research), Unindustria (National Industrial Association), Impronta Etica (a network of local companies active in CSR) and Cittalia (Italian Municipalities Association) will enable the process to be replicable in other European cities.

2 Opportunities of Public-Private Partnership for Adaptation

The reference model adopted to build the PPP of the GAIA project was the "New Social Partnership". The Copenhagen Centre defines PPP as "People and organizations from some combination of public, business and civil constituencies who engage in voluntary, mutually beneficial, innovative relationships to address common societal aims through combining their resources and competencies" (see Jane and Zadek 2000).

Therefore, this project sought to find an innovative way to unite the efforts, commitments and knowledge of different groups and individuals that can contribute – in their own way – to the achievement of their common goals: the reduction of greenhouse gases emissions, the reduction of the heat island effect and the development of a local strategy that links mitigation and adaptation. This is the reason why GAIA stands for Green Areas Inner-City Agreement as it calls upon the public-private partnership to tackle the impacts of climate change and improve the city's adaptive capacity.

Three basic and innovative aspects featured in the Copenhagen Centre model could be adopted by the GAIA: a common objective to pursue innovative ways of collaboration and the mobilization of resources, competences and knowledge of every participant in the partnership.

Private-public partnerships are an innovative approach that can systemize coordination and investment for needed climate action while providing value through synergies and win-win solutions for all partners. Private participants can find it beneficial to contribute their own technical and economic resources to solve a problem that the public sector alone would not be able to resolve. The PPP can also be seen as a way for local authorities to overcome financial constraints, which have been exacerbated by the recent economic crisis. Therefore, PPPs can become an innovative instrument to increase city resilience, in this case, not only resilience to an environmental crisis but also to an economic crisis. This is particularly true in contexts where externalities exist and issues are interconnected such as climate change. In this specific case, the GAIA project will enter the partnership by financing urban forestation with the aim to sequestrate CO_2 and improve air quality through actions that will benefit the whole local community. The long-term objective is to enhance the participation of as many actors as possible in the partnership to widen the awareness of the environmental issues at stake, at the local level. Besides these first results, GAIA will be developed as an incremental project that can expand its focus and increase its results year after year. The number of companies that are expected to subscribe to the agreement is 30. This projection has been made taking into account that our focus is on involving medium/big-size companies of the territory that can have a positive trade-off in investing in environmentally responsible actions on the territory. In addition, the medium/big-size companies have a positive impact on other companies that can subscribe to the agreement in the second phase. These companies are more visible by end consumers and have the instruments not only to implement the projects but also the capacity to diffuse and communicate a positive message to their clients. Impronta Etica already has a network of more than 40 companies, and a recent project by the province of Bologna has involved companies in energy efficiency projects and environmental sustainability policies, collecting around 70 companies in the territory. This means that many companies have started on their path towards sustainability. Among this group, it is plausible that the biggest are willing to enhance their environmental performance by subscribing this agreement with the Municipality of Bologna.

3 Benefits of Investing in Urban Forestation

Urban forests have received increasing attention as an efficient abatement strategy for reducing air temperature, greenhouse gases as well as photochemical air pollutants and for improving air quality (see Niinemets and Peñuelas 2008).

3.1 Adaptation

The main result expected by planting new trees in the urban areas is the mitigation of the heat “island effect” which is foreseen to increase its intensity due to climate change, in addition to creating health problems in the most sensitive population groups (old people, children, etc.). Trees in fact, through direct shading, evaporative cooling and photosynthesis, can regulate local air temperatures and create a pleasant microclimate around green areas.

Temperature effects of large trees on their capacity to ameliorate the urban heat island have been demonstrated by a number of studies. Walz and Hwang (2007a) reported for Huntington (USA) how roadside trees decrease pavement temperature in the shaded area compared to the temperature in those exposed to the sun. The most striking result was that the resulted difference was about 2°C. The most interesting findings were that vegetation patterns across the city have to be strategically planned to increase the mitigative effects (Walz and Hwang 2007b). Lahme and Bruse (2004) assessed the role of a small urban park in a densely built-up area by means of measurements and model simulations. Both measurements and simulations (performed with ENVI-met model) indicate a mean difference between the park and the built-up area of 3°C. Jauregui (1990) found that for Chapultepee Park in Mexico City (550 ha), the effect on air temperature was noticeable at a radius of 2 km, whilst Shashua-Bar and Hoffman (2000) found for a street that is 200 ms long and 22 ms wide, a peak decrease in temperature of about 3°C was obtained by crosswalk trees. Furthermore, Shashua-Bar, Hoffman and Tzamir (2006) reported up to 4°C for accounted effects of shading and evaporative cooling. However, the most impressive results were obtained by Yilmaz et al. (2008) where for the city of Erzurum (Turkey), the difference recorded between the asphalt concrete areas and areas of vegetation reached up to 6.5°C.

3.2 Air Quality

It is well known that trees, like other vegetation, act to reduce the amount of CO_2 in the atmosphere by sequestering carbon through tissue growth. When developing urban planting schemes, it should be taken into account that species are characterized by a specific growth rate and therefore a specific carbon sequestration rate. Emphasis should also be put on plant diversity and developing urban planting schemes.

Furthermore, urban woodlands and the presence of trees in the urban environment can improve air quality through the uptake of gases and particles. The deposition of gaseous pollutants and particulates is greater in woodlands or forests than in short growth vegetation such as shrubs. Vegetation emits volatile organic compounds (VOCs), where isoprenoids (isoprene and monoterpenes) play an important role in tropospheric chemistry. They react with anthropogenic pollutants, such as nitrogen oxides (NOx), in a complex series of photochemical reactions to produce or reduce ozone and other secondary compounds (Fehsenfeld 1992). Since the profile and emission rates of plant isoprenoids vary significantly among species (Peñuelas and Llusià 2001), the selection of low-emitting trees can be a critical factor for large-scale tree planting programs in polluted urban areas (Filella and Peñuelas 2006). However, many locally relevant species' profiles and emission rates have still not been screened.

An innovative aspect of the GAIA project was that the vegetation properties were analysed at leaf level to assess their capacity to mitigate air pollutants, to sequester CO_2 from the atmosphere and to emit VOCs (Baraldi et al. 1999) The data are entered into a database to select the best plants for the urban reforestation projects.

3.3 Mitigation Through Carbon Offsetting of Local Businesses

The concept of carbon neutrality and the other environmental benefits deriving from a local action has been used, in particular, as a driver to involve local enterprises in the project. Whilst carbon neutrality is becoming more of a common concept in an international business context, this is not the case within an Italian context. Few companies have so far implemented a carbon neutrality strategy or have bought carbon credits on the voluntary carbon market to offset their activities. The reason for this is that the offsetting projects offered in the voluntary market located in non-Annex I countries are not perceived as direct benefits for local stakeholders. The PPP implemented in the GAIA project provides companies with a new instrument for their corporate social responsibility strategy in particular for what affects their policies on climate change. Urban forestation, for what concerns carbon sequestration, is more expensive than buying credits from the voluntary market. However, tree planting at the local level is perceived by companies as a more comprehensive intervention because it also contributes to increase air quality at the local level, increase urban ecosystem resilience to climate change and finally increase the quality of urban environment for the communities that are living on the territories (which the companies operate on). This approach combines several benefits and, for this reason is an incentive for companies to invest in this field. In particular, urban forestation gives the opportunity for companies to improve the living conditions of local communities, while at the same time enhancing their awareness on the environmental issues at stake and on the necessity of a common effort at the local level to tackle those issues.

Local enterprises are able to compensate their emissions by planting trees locally and in doing so also contribute to carbon offsetting. In fact, local companies showed a strong interest in initiating a process that, within the framework of CSR, will add value to their business by implementing direct local action for environmental sustainability.

The GAIA project foresees that each subscriber will declare its own target of contribution to the plan in terms of tree planting and, as a consequence, CO_2 sequestration. Innovative solutions will be stimulated and supported, thanks to a series of local training events targeted towards managers and decision-makers and to technicians of all subscribers. Through a specific action plan and target settings, enterprises will identify a product or a service that the company desires to offset either partially or totally. Taking into account this goal, a specific target will be set for each company. This target can be progressive and can be renewed annually. This plan and the protocols will be formulated as a synthetic, realistic and long-term period proposal in order to be effective. The environmental benefits linked with the protocols have to be carefully quantified. Each subscriber will officially approve (using the board of directors in the case of companies, or the committee for public bodies) its own commitments in terms of actions to be implemented and emissions reductions to be obtained. This step will increase the level of commitment of the subscribers and will make the partnership a binding agreement. The product or service to be offset by tree planting can be calculated with the carbon footprint methodology.

This action will be implemented progressively, after a first commitment, on an annual basis. The companies may define stricter targets or increase the offsetting strategy to other products or services in order to go towards the carbon neutrality strategy. Companies will communicate the goals set to their clients through their marketing channels or to the local communities in order to make an example that can persuade other companies to join the partnership.

4 Conclusion

The relationship between a company and the territory it belongs to can be interpreted in terms of mutual interdependence: business is a determining factor for the maintenance of competitive conditions (social and economic) and sustainability (environmental) of the territory. Companies are also very much influenced by the conditions of the territorial context in its own competitive potential.

The purpose of the GAIA project is to develop an example of “Circle of Responsibility” focused upon environmental issues (climate change mitigation and adaptation, increasing of urban quality) as the central element of responsibility. This concept is based upon the collaborative participation of various social actors which are driven by a diffused culture of social responsibility and work together to plan, create and assess common actions which will thus cumulatively be strengthened. The concept of “Circle of Responsibility” means the creation of a temporary network between businesses and various stakeholders collaborating to manage areas of project intervention (or critical situations), each of which participates based on their respective skills and responsibilities.

The development of “Circle of Responsibility” is considered a useful tool, in particular, for creating shared social values and conditions of responsible competitiveness. This begins with the mutual acknowledgement of various participants who shape themselves as each others’ stakeholders. This process will help the entire territory of Bologna to increase its urban resilience as well as to future environmental stress by creating trust and network among private and public organizations.

The development of socially responsible behaviour by companies is an essential element of sustainable development. Such an inclination from companies should not only be encouraged, it must be integrated and channelled in such a way that it is coherent with the governmental policies in the respective area. More specifically, governmental climate adaptation policies, which address costly and dangerous externalities, are a public good par excellence.

The public authority awareness of the urgency to respond to this problem makes necessary the involvement of private companies to make them more responsible in managing and safeguarding local public assets.

An essential condition for the success of the public-private partnership is to ensure a balance among key elements: context, goals, partnership participants and expected results. The added value is found in the choice of sharing specific skills, resources and knowledge as well as in the contribution of various people to find innovative solutions to problems that arise.

The GAIA project builds upon these experiences to then take them one step further and experiment public-private partnerships in an absolutely innovative sphere: environmental protection, more specifically by contributing to decrease the heat island effect, reduce carbon dioxide and improve air quality by creating urban forestation.

References

Baraldi, R., Rapparini, F., Rossi, F., Latella, A., & Ciccioli, P. (1999). Volatile organic compound emissions from flowers of the most occurring and economically important species of fruit trees. *Physics and Chemistry of the Earth (B), 24*(6), 729–732.

Fehsenfeld, F. (1992). Emissions of volatile organic compounds from vegetation and the implications for atmospheric chemistry. *Global Biogeochemical Cycles, 6*, 390–430.

Filella, I., & Peñuelas, J. (2006). Daily, weekly, and seasonal time courses of VOC concentrations in a semi-urban area near Barcelona. *Atmospheric Environment, 40*, 7752–7769.

Jane, N., & Zadek, S. (2000). *Partnership alchemy: New social partnerships in Europe* (p. 14). Copenhagen: Copenhagen Centre.

Jauregui, E. (1990). Influence of a large urban park on temperature and convective precipitation in a Tropical City. *Energy and Buildings*, *15–16*, 457–463.

Lahme, E., & Bruse, M. (2004). *Microclimatic effects of a small urban park in a densely build up area: Measurements and model simulations*. http://nargeo.geo.uni.lodz.pl/~icuc5/text/P_5_1.pdf.

Niinemets, Ü., & Peñuelas, J. (2008). Gardening and urban landscaping: Significant players in global change. *Trends in Plant Science, 13*(2), 60–65.

Peñuelas, J., & Llusià, J. (2001). The complexity of factors driving volatile organic compound emissions by plants. *Biologia Plantarum, 44*, 481–487.

Shashua-Bar, L., Hoffman, M. E., & Tzamir, Y. (2006). Integrated thermal effects of generic built forms and vegetation on the UCL microclimate. *Building and Environmental*, *41*(3), 343–354.

Walz, A., & Hwang, W. H. (2007a). *Relating urban thermal patterns to vegetation distribution at various scales*. http://ams.confex.com/ams/pdfpapers/150185.pdf.

Walz, A., & Hwang, W. H. (2007b). *Large trees as a barrier between solar radiation and sealed surfaces: Their capacity to ameliorate urban heat if they are planted strategically to shade pavement*. http://ams.confex.com/ams/pdfpapers/126564.pdf.

Yilmaz, H., Toy, S., Irmak, M. A., Yilmaz, S., & Bulut, Y. (2008). Determination of temperature differences between asphalt concrete, soil and grass surfaces of the City of Erzurum, Turkey. *Atmòsfera, 21*(2), 135–146.

Financing Climate Change Adaptation: The Copenhagen Case

Lykke Leonardsen

Abstract This chapter will look at the opportunities and challenges of adaptation financing based on the adaptation work done by the city of Copenhagen. The chapter reflects on the city's adaptation plans which have recently been approved by the city council. It describes the different measures that the city has initiated in order to prepare the city for the expected climate changes especially when it comes to storm water management. The implementation, which has just started, has become more pressing after a major storm in July 2011. The chapter also describes the legislative issues connected to financing adaption measures in Denmark. The city of Copenhagen has identified a number of issues where the national legislation is insufficient to meet the needs of the city.

Keywords Adaptation • Cost-effective measures • Extreme storm water management • Financing • National legislation

1 Introduction

This chapter will look at the opportunities and challenges of adaptation financing based on the adaptation work done by the city of Copenhagen. This chapter reflects on the city's adaptation plans and the problems identified in financing the required extensive measures.

Cities all over the world are facing the challenge of climate change adaptation. This will have an enormous effect on the way we perceive cities and how we plan cities in the coming decades. It will be a staggering challenge to finance

L. Leonardsen (✉)
Technical and Environmental Administration, Centre for Parks and Nature,
Islands Brygge 37, Postbox 449, 2300 Copenhagen, Denmark
e-mail: lykleo@tmf.kk.dk

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_44,

the necessary adaptation measures. This necessitates a paradigm shift affecting all aspects of city life. The traditional response to threats has generally been to look at protective measures. However, such an approach will in most cases be too expensive. Cities need to be looked at in a new way in order to determine how we can avoid past mistakes and create resilient and attractive cities.

In Denmark, adaption work is primarily the responsibility of local governments. Therefore, in August 2011, the city of Copenhagen approved its first climate adaptation plan. It identified the largest and most immediate threat as increased precipitation. This threat was dramatically demonstrated in July 2011, where the city was hit by a violent storm with up to 150 mm of rain in just a few hours according to the Danish Meteorological Institute (2011). This storm led to widespread flooding of roads, basements and railway lines. It was the second time within a 10-month period that Copenhagen experienced substantial flooding from storm water. In the coming decades, such storms are likely to increase along with rising sea levels and longer heat waves. Many of the necessary measures will be both expensive and have a substantial impact on life in the city. As such, the city needs to start planning now to include the impacts and risks in long-term planning and city development strategy, as well as to look at how to finance the required measures.

2 Integration of Key Adaptation Components for More Cost Effectiveness

The adaptation strategy of Copenhagen looks at both the changing threats and opportunities for action. With regard to risks, the city has made a strategy that focuses on action where both risks and the potential costs through loss and damage are high. In the strategy, planned action is divided into three levels:

- Prevent the risk of damage
- Minimize the extent of the damage
- Reduce vulnerability

This risk assessment has to be combined with an analysis of the action potential for the city. The aim is to integrate adaptation measures with other planning initiatives that improve the quality of life of the people in Copenhagen, for example, by increasing the recreational areas both in quantity and quality. Adaptation actions will increase green (parks) and blue (water, lakes, streams, ponds) areas in the city, which will also have a positive effect on biodiversity and make the city more attractive to both Copenhageners and tourists.

In comparison to other cities, the challenges Copenhagen faces are relatively small. Nonetheless, the price of adapting Copenhagen to the future climate has been estimated at around 1.5 billion euros. At the same time, the estimated storm's costs of July 2011 were around 300–600 million euros in loss and damages. Initial costs will be worthwhile to prevent greater costs from loss and damages later on. The combination and integration of adaptation measures, such as greener local

Table 1 Estimated damages over the next 100 years

Rising sea levels	2–2.6 billion euro
Storm water	2–2.1 billion euro
Total	4–4.7 billion euro

Table 2 Adaptation measures over the next 100 years

Rising sea levels	530 million euro
Storm water	800 million–1.1 billion euro
Total	1.3–1.6 billion euro
Savings	2.6–3.2 billion euro

drainage of rainwater and diversion of storm water, will be around one-third cheaper than traditional measures, like an expansion of the sewers. The following overview estimates the total costs for the next 100 years (Tables 1 and 2).

The costs of adaptation are high – but the price of repairing damages is even higher. The costs of the extreme rain in July 2011 have so far amounted to nearly 600 million euros in insurance costs alone. So given the fact that we estimate more frequent extreme rain events, it is worthwhile to start preparing immediately.

One of the key incentives to start working on adaptation is the expected positive economic effects and economic growth. By being a front runner on adaptation, it will be possible to stimulate economic growth for the city of Copenhagen. Firstly, it is obvious to most that a climate proof city is more attractive to live and invest in. Secondly, the different measures needed to adapt a city can stimulate technological innovation and economic growth. New technology will be needed for local water drainage in densely built-up areas of the city. Solutions will be needed that not only meet the requirements of the engineers but also the aesthetical demands of the architects. Given the role of Copenhagen in developing high-quality sustainable solutions, for example, in cycling, the green growth strategy of Copenhagen will account for adaptation measures.

3 Challenges to Financing Long-Term Investments

The financing of these adaptation measures is an issue in itself. Although the city of Copenhagen is a wealthy city, financing will still be a problem as the payments will not be evenly spread over the next 30–50 years. One of the measures proposed to protect the city against the rising sea level is the building of a dam to protect the harbour and inner city of Copenhagen. This is the single most costly adaptation measure in the plan. This dam will have to be built over a short period of time, so the money has to be available during that specific period.

As most of the adaptation measures have to be co-financed by, among others, landowners and companies, there is considerable work ahead both in terms of agreeing on the co-financing (who has to pay what and how much) and the actual securing of the necessary capital. The city has discussed the opportunity to establish a fund together with landowners and companies, which the city can use as a savings fund for longer-term investments. These considerations will be a huge task for the coming years.

Another aspect is the national legislation. At present, climate change adaptation is a new activity for public authorities and a new type of activity for the local authorities in Denmark. In so far Copenhagen, in addition to other cities, is exploring a new territory with regard to financing. Questions will need to be addressed and answered, for example, is it legal to establish a fund like the one we have discussed? What about loans? Is it legal for local authorities to finance these activities with loans?

4 Financing Challenges in Storm Water Management Solutions

The challenges in financing are complex. Those challenges confronted in storm water management are illustrative of this complexity. The traditional storm water management solutions, repairs, modernization and expansion are in principle all known. The traditional sewers are financed through water fees that the water company of Copenhagen charges all citizens based on the amount of water they consume during the respective fiscal year.

For many of the adaptation solutions that are being proposed for the city of Copenhagen, it is very unclear how they are going to be financed. For instance, building and expanding the green infrastructure of the city will create run-offs into parks, roads and water beds etc.; this is not a natural process of sewage water management. This makes the financing of such “drainage” unclear. How much can be financed through water fees, and how much has to be paid by the city and/or private landowners? This is partly dependent upon national legislation for water fees and management, which was created to protect consumers and to make pricing transparent. But this legislation does not take into account future changes to the climate and the necessary measures to adapt.

To spell out the implications, it currently looks as if it would be easier for the city to adapt to more storm water by expanding the sewage system and expecting consumers to carry the costs. As has been pointed out in the analyses in the city’s adaption plan, and summarized above, this will be much more expensive. Such an “easy” approach would not be as positive for the quality of life in the city as a whole.

Part of the adaptation measures will be carried out by private landowners and developers as a process of the ongoing modernization of the city. Therefore, choosing untraditional measures, for example, green roofs and local drainage of rainwater, must be made financially more attractive to private stakeholders than conventional methods.

Insurance companies however have woken up to a changing reality following the last storm in July 2011. According to reports to the press from the National

Organization for Insurance and Pension, discussions are now taking place regarding raising insurance prices for flood-prone areas in the city and for the land and house owners who have not secured their homes with flood stoppers and other flood mitigation measures. Debates are also occurring over whether to stop payments for damages in basements used for living.

The problems with capital financing are mirrored in the financing from revenues. Again, as long as we stick to the traditional solutions, financing is clear. Then everything can be paid by the water companies through the water fees.

But when it comes to revenues from the suggested green solutions, things become murkier. Who is going to finance these? An example could be a sports ground that has been transformed to be a part-time rainwater reservoir in case of flooding. For 95% of the time, the area would act as a sports ground, and for only 5% of the time, it would serve as a water reservoir. How are the city and the water company going to divide the maintenance costs? Can the city be trusted to maintain the area so that it can function as a rainwater reservoir in critical periods? Furthermore, if the city and water company decide to share the maintenance costs how will it be organized practically? Again more questions which require answers.

5 Conclusion

As a consequence of all these unanswered questions, the city of Copenhagen has decided to carry out an additional analysis on financing to try to clarify both the legal and practical aspects of how to finance the future adaptation work.

The storms in recent years have shown that we need to act now. This is why the city has raised these questions with the national government. The city's aim is to look into the current legislation to clarify some of the questions. And if these cannot be resolved within the present legislation, both the city and national government need to make the necessary changes in the legislation for cities and local authorities in Denmark to be able to continue their work in making Denmark climate proof.

At present, we are only at the beginning of making Copenhagen climate proof. In so far this short chapter can only show some of the financing questions and challenges the city is looking into. Hopefully, we can present some of the answers at the Resilient Cities conference in May 2012.

Reference

The Danish Meteorological Institute. (2011). Accessed at: www.dmi.dk.

Challenges on the Way to Financing Urban Climate Change Adaptation

Monika Wiebusch

Abstract Climate Change – especially in developing countries – requires additional financial capacity to adapt to more severe climatic stresses and build resilience. Infrastructure needs due to climate change have to be identified in the framework of integrated urban development strategies and need to be distinguished from the "usual" infrastructure and development needs. If looking for finance through international institutions (global funds, development and commercial banks, donors and private investors), cities are well advised to get involved in respective national strategies, influence them and align with them: many of the international sources will channel their resources through national governments. Some observations from a development bank perspective will be offered in this chapter.

Keywords Cities • Climate change • Development cooperation • Finance • Infrastructure

1 Introduction

The need for climate change adaptation in cities is becoming more and more evident. Climate impacts are becoming increasingly evident on a global scale: flooded cities and disastrous land-slides are destroying whole city quarters. For many cities, it is less about anticipating future development but more about dealing with today's realities. At the same time, mechanisms for financing climate change mitigation are in place, but they rarely consider the situation in cities. City authorities wonder how to approach large adaptation funds that are being designed at the global level. This

M. Wiebusch (✉)
Sector and Policy Division Urban Development, KfW-Bankengruppe Entwicklungsbank,
Palmengartenstr. 5-9, 60325 Frankfurt am Main, Germany
e-mail: monika.wiebusch@kfw.de

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9_45,

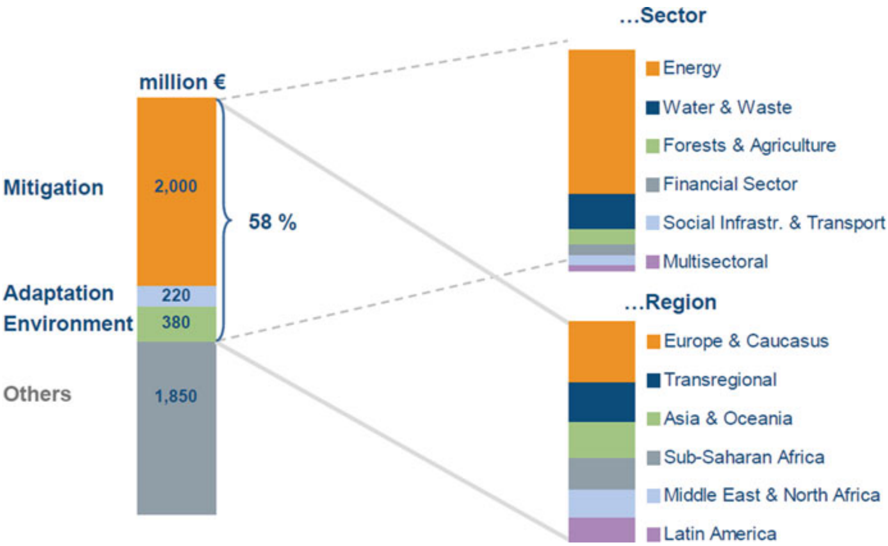


Fig. 1 New KfW Entwicklungsbank Commitments on Environment and Climate in 2010

chapter is far from answering such burning questions; rather, this chapter provides reflections and suggestions from a development bank perspective.

The KfW Entwicklungsbank is one branch of KfW Banking Group, owned by the German Government and the German States (Bundes-Länder). KfW Entwicklungsbank implements bilateral German Financial Development Cooperation as well as Climate Funds, mostly on behalf of the German Government. In emerging market countries, KfW may also give loans on its own behalf.

KfW is already engaged in financing energy and environmental projects, as well as projects on climate change. Nevertheless, so far the focus is very much on climate change mitigation, while funding for adaptation projects is comparably little (Fig. 1).

The focus of this chapter is on cities in developing countries – even though KfW Entwicklungsbank is also operating in emerging markets and developed countries – because cities in developing countries are more dependent on financial support from the national governments and donor countries. These cities face substantial challenges with the urban poor and their largely poor basic infrastructure. Such conditions require large investments.

2 Context of International Funding

Climate change funds and development funding are typically directed from the top for what is needed at the bottom. International funds are typically channelled through national institutions and are not directly accessible to cities. There are various reasons for this.

Firstly, many international donors negotiate with a national government on the joint focus of intervention. The agreed interventions will usually focus on a limited number of focal areas. This is logical, considering the limited budget available. Secondly, following the ideas of the Paris Declaration, programmes and projects funded by international donors should align with their respective national strategies. Thirdly, international development banks and donors have limited options for direct cooperation with local governments. In many countries, local governments have only limited rights concerning financial transactions. The debt lines in particular may be restricted; a very reasonable decision, if seen in the light of actual financial debates in the USA and Europe. Fourthly, as soon as there are reasonable investment budgets, all donors will look for guarantees, which can rarely be provided by local authorities. KfW, for example, will usually need a state guarantee to fund or finance investments in cities.

For these reasons, cities and local governments are in general well advised to accept the guiding role of national governments and involve themselves in the discussions on national strategies. This in turn can foster the influence of cities at the national and international level. This could, for example, be realized through national/international cities networks, as well as through professional and international exchanges among local governments. Participating in such exchanges can be a way of collecting well-informed arguments to influence national strategies on climate change, as well as to gain influence in governmental negotiations with donors. ICLEI's Resilient Cities congress, documented in this book, has been a good example for a successful way of exchanging and lobbying for cities' interests.

3 General Conditionalities of KfW for Financing Infrastructures in Cities

The conditions will vary in detail, but some general dimensions provide an overview of the financing conditions. It is worth noting beforehand that there are a variety of ways to provide financing. Similar to the UN and World Bank, KfW Entwicklungsbank may provide grants (for least-developed countries and some special social infrastructures), soft loans (IDA[1] conditions) and promotional loans with varying conditions for developing and emerging countries.

Grants and soft loans usually are part of a bilateral cooperation between the German and partner government, and financed from the German Government budget. For countries with an improved credit rating, other financial mechanisms can be offered such as "development loans" (interest subsidies), which are a combination of German Government budget grants enriched by KfW capital market funds. "Promotional loans" are exclusively based on KfW capital market funds and address emerging countries.

[1] IDA: International Development Association, part of the World Bank Group.

For financing or loan contracts, the partner governments are typically the contract partners. They will convey the budget to the Project Executing Agency (PEA). Often the PEA is a state or parastatal institution, for example, a city. It may also be an NGO. KfW usually conducts bilateral (KfW and Government) or trilateral contracts (KfW, Government, PEA). This in detail depends on the legal status of the PEA.

3.1 Climate Change Mitigation or Adaptation: Only One Aspect of Urban Development

In cities, “mitigation” and “adaptation” are two sides of the same coin. In many cases, they lie close together. For example, improving energy systems with renewable energy and saving greenhouse gas emissions (GHG) will be counted as mitigation, while changing the location of a power plant to reduce disaster risk from changing sea level will be counted as adaptation. Rehabilitation of the housing stock will reduce GHG emissions (mitigation), while the rehabilitation measures addressing extreme weather events will be counted as adaptation. This shows that the existing separation and diverse funding opportunities for mitigation and adaptation do not necessarily meet the needs of cities.

Cities need financial tools that open co-financing options for projects addressing mitigation as well as adaptation. Additionally, cities do not only need an integrative view of mitigation and adaptation as climate change action is only one aspect of wider sustainable urban development. A climate change strategy necessarily focuses on risk reduction but is in itself not sufficient for integrated urban development. Climate change strategies need to be part of the general urban development.

4 From Climate Change Strategy to “Bankable Projects”

A climate change strategy will have defined various investment needs: infrastructure and building stock to be adapted, public and private vehicles fleet to be improved. One of the crucial questions will be: how to find investors for the identified projects?

This will be a particular challenge: an elaborated and well-integrated strategy, which considers interfaces with various stakeholder activities and the interests of the concerned population, has to be dismantled again to identify single investment opportunities. Investors, private or public, business or donors, need a defined investment project with clear cut boundaries to other investments.

Responsibilities need to be clearly defined: a company providing public transport (be it private or public) may be held responsible for improvements of the bus-fleet to reduce GHG emission. They then will need the opportunity to align the tariffs to finance the improvement. If the city government sees the social need for social tariffs to allow an inclusive use of public transport by all citizens, this becomes a public responsibility taken by the city administration or another public body.

From this perspective, it might be reasonable to check various possible investors for their suitability for the various investments. Primarily, profitable and cost-effective investments (private building rehabilitation, business and industry upgrading and adaptation) will be attractive for private investors looking for an adequate gain or return of investment (ROI). Through financial mechanisms, "unprofitable" investments may be transformed to "cost effective" ones. For example, interest subsidies can produce incentives for private investment on the brink. Micro credits may encourage economic activities of a poor population segment. Public subsidies for social tariffs can be an incentive for public transport, water provision and sewage plants. "Social business" or non-profit organizations may be engaged in respective investments. However, "non-profitable" social costs will always stay with the public budget and thus need consideration, such as "pro-poor" projects, ensuring social cohesion and social infrastructures that satisfy basic needs of those who are not competitive, etc.

5 Examples for Possible Adaptation Projects

KfW Entwicklungsbank is preparing some adaptation projects to be funded by a German "Federal Special Fund". The conditions will vary from other funds, and the examples therefore may not be generalized. Nevertheless, they may give an idea of what could be an "adaptation project". Access to the fund is, as usual in projects of the development cooperation, discussed and agreed in negotiations with the national governments.

Urban rainwater drainage in Mali (approximately 10 million EUR): The aim is to avoid flooding during rainy seasons (due to health risks: malaria and water-borne diseases). The programme will be located at the national level addressing various cities and towns with areas at risk.

National programme on costal protection in Mozambique (approximately 23 million EUR): One component of the national programme will focus on the protection of a large harbour city, which is endangered by a high tidal range.

National programme on the protection of endangered urban areas in El Salvador (approximately 12 million EUR): The national programme will identify especially vulnerable areas (slopes, river lowlands) in various cities and detail investment and social measures, such as construction of protection walls, safe shelters, drainage and accompanying social activities.

6 Conclusion

While single projects can be interesting for smaller and private investors, large donors, foundations and development banks will focus more on programmes instead of "stand alone" projects. Programmes open up the opportunity to bundle sub-projects, in various locations, focusing on the described topic (here climate change) and at the same time provide flexibility for the single project design. Programmes open up opportunities for efficient financing and funding. The same mechanisms and channels can be used for a variety of projects and may well be integrated into the partner structures. Institutions obliged to align with the Paris Declaration and Accra Agenda of Action will try to align with national strategies. Cities are well advised to also engage in aligning with those strategies to thus increase their chances to access the funds.

Glossary

Adaptation Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Various types of adaptation exist; e.g. anticipatory and reactive, private and public, and autonomous and planned. Examples are raising river or coastal dikes, the substitution of more temperature shock resistant plants for sensitive ones, etc.

Adaptive capacity The whole of capabilities, resources and institutions of a country or region to implement effective adaptation measures.

Agenda 21 The plan of action to achieve sustainable development that was adopted by world leaders at the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil, in June 1992.[1]

Agriculture The production of plants and animals useful to man, involving soil cultivation and the breeding and management of crops and livestock.[2]

Civil society The totality of voluntary civic and social organizations and institutions that form the basis of a functioning society as opposed to the force-backed structures of a state (regardless of that state's political system) and commercial institutions.[3]

Climate change A change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Drought A drought is a 'prolonged absence or marked deficiency of precipitation', a 'deficiency that results in water shortage for some activity or for some group' or a 'period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance' (Heim 2002).

---

[1] http://data.un.org/Glossary.aspx

[2] http://www.eionet.europa.eu

[3] World Bank: http://web.worldbank.org/

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9,

Ecosystem A system of living organisms interacting with each other and their physical environment.

Ecosystem-based adaptation (EBA) The adaptation policies and measures that take into account the role of ecosystem services in reducing the vulnerability of society to climate change.[4]

Energy efficiency Ratio of useful energy output of a system, conversion process or activity, to its energy input.

Environment A concept which includes all aspects of the surroundings of humanity, affecting individuals and social groupings. The environment thus includes the built environment, the natural environment and all natural resources, including air, land and water.[5]

Flood protection Protection of land areas from overflow or minimization of damage caused by flooding.[6]

Flooding A general and temporary condition of partial or complete inundation of normally dry land areas from the overflow of inland/tidal waters and/or the unusual and rapid accumulation or runoff of surface waters from any source.

Geographical information systems Information system that can input, process, analyse and visualize geographically referenced data in order to support decision-making processes.[7]

Green economy A system of economic activities related to the production, distribution and consumption of goods and services that result in improved human well-being over the long term, while not exposing future generations to significant environmental risks and ecological scarcities.[8]

Green infrastructure An adaptable term used to describe an array of products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services. As a general principal, Green Infrastructure techniques use soils and vegetation to infiltrate, evapotranspirate and/or recycle stormwater runoff. When used as components of a storm water management system, Green Infrastructure practices such as green roofs, porous pavement, rain gardens and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these technologies can simultaneously help filter air pollutants, reduce energy demands, mitigate urban heat islands and sequester carbon while also providing communities with aesthetic and natural resource benefits.[9]

---

[4] Vignola, R., Locatelli, B., Martinez, C., & Imbach, P. (2009). Ecosystem-based adaptation to climate change: What role for policy-makers, society and scientists? *Mitigation and Adaptation of Strategies for Global Change*, *14*, 691–696.

[5] http://www.eionet.europa.eu

[6] http://www.semide.net

[7] http://data.un.org/Glossary.aspx

[8] http://www.unep.org/greeneconomy/AboutGEI/WhatisGEI/tabid/29784/Default.aspx

[9] US Environmental Protection Agency: http://cfpub.epa.gov

Land use Land use refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g. grazing, timber extraction and conservation).

Local government An administrative body or system in which political direction and control is exercised over the community of a city, town or small district.[10]

Mitigation Technological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to climate change, mitigation means implementing policies to reduce greenhouse gas emissions and enhance sinks.

Open space A plot of vegetated land separating or surrounding areas of intensive residential or industrial use and devoted to recreation or park uses.[11]

Participatory process (active participation) The involvement, either by an individual or a group of individuals, in their own governance or other activities, with the purpose of exerting influence.[12]

Poverty State in which the individual lacks the resources necessary for subsistence.[13]

Renewable resources Natural resources that have the capacity to be naturally replenished despite being harvested (e.g. forests, fish). The supply of natural resources can, in theory, never be exhausted, usually because it is continuously produced.[14]

Resilience The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change.

Resilient city A city that supports the development of greater resilience in its institutions, infrastructure and social and economic life. Resilient cities reduce vulnerability to extreme events and respond creatively to economic, social and environmental change in order to increase their long-term sustainability. Resilient city activities are sensitive to distinctive unique local conditions and origins. Efforts undertaken to prevent crisis or disaster in one area should be designed in such a way as to advance the community's resilience and sustainable development in a number of areas. As such, resilient cities define a comprehensive 'urban resilience' concept and policy agenda with implications in the fields of urban governance, infrastructure, finance, design, social and economic development, and environmental/resource management.[15]

---

[10] European Environment Agency: http://glossary.eea.europa.eu

[11] European Environment Agency: http://glossary.en.eea.europa.eu

[12] European Environment Agency: http://glossary.eea.europa.eu

[13] European Environment Agency: http://glossary.en.eea.europa.eu

[14] http://www.nyo.unep.org/action/ap1.htm

[15] Resilient Communities Program Concept 2002.

Risk The expected losses (of lives, persons injured, property damaged and economic activity disrupted) due to a particular hazard for a given area and reference period. Based on mathematical calculations, risk is the product of hazard and vulnerability. Risk in environmental context means likelihood, or probability, of injury, disease or death resulting from exposure to a potential environmental hazard.[16]

Risk assessment The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by an action or by the presence or use of a specific substance or pollutant.[17]

Sanitation Sanitation is access to, and use of, excreta and waste water facilities and services that ensure privacy and dignity, ensuring a clean and healthy living environment for all.[18]

Sea level rise An increase in the mean level of the ocean. Eustatic sea-level rise is a change in global average sea level brought about by an increase in the volume of the world ocean. Relative sea-level rise occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence. In areas subject to rapid land-level uplift, relative sea level can fall.

Storm surge The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place.

Sustainable development A form of development that meets present-day needs without compromising the ability of future generations to satisfy their own requirements. It aims to improve individuals' living conditions whilst preserving their environment in the short, medium and – above all – long term. The objective of sustainable development is threefold: development that is economically efficient, socially fair and environmentally sustainable.[19]

Urban heat island (UHI) The relative warmth of a city compared with surrounding rural areas, associated with changes in runoff, the concrete jungle effects on heat retention, changes in surface albedo, changes in pollution and aerosols and so on.

Urban planning The activity of designing, organizing or preparing for the future layout and condition of a city or town.[20]

Urbanization The conversion of land from a natural state or managed natural state (such as agriculture) to cities; a process driven by net rural-to-urban migration through which an increasing percentage of the population in any nation or region come to live in settlements that are defined as 'urban centres.'

---

[16] European Environment Agency: http://glossary.eea.europa.eu

[17] European Environment Agency: http://glossary.eea.europa.eu

[18] http://www.un.org/waterforlifedecade/pdf/hrw_glossary_eng.pdf

[19] European Commission: http://europa.eu/scadplus/glossary/sustainable_development_en.htm

[20] European Environment Agency: http://glossary.eea.europa.eu

Vulnerability The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity.

Vulnerability assessment (vulnerability analysis) Process of estimating the vulnerability to potential disaster hazards of specified elements at risk.[21]

Reference

Heim, R.R. (2002). A review of twentieth-century drought indices used in the United States. *Bulletin of American Meteorological Society, 83*, 1149–1165.

[21] UN Data: http://data.un.org/Glossary.aspx

Index

K. Otto-Zimmermann (ed.), *Resilient Cities 2*, Local Sustainability 2,
DOI 10.1007/978-94-007-4223-9,