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Kwi-Gon Kim

Low-Carbon Smart Cities

Tools for Climate Resilience Planning

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Low-Carbon Smart Cities

Tools for Climate Resilience Planning

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Foreword

Climate change, disaster risk management, and dramatically increasing urbanization-associated challenges have come to the forefront of global discussion on the agenda of sustainable development and sustainable "human-friendly" living. The recent Paris Agreement has highlighted the urgent need for and recognized the criticality of immediate action to deliver a sustainable and livable planet and world to the future generations.

For over 3 decades, the notions of green cities, eco-cities, climate resilient cities, and cleaner cities have been evolving and tested to address the challenges facing the cities, the citizens, and the planet and mitigate the threats to cities and by city expansion. However, these approaches have tended to be disconnected, spot, or sectoral initiatives rather than fully integrated and coordinated and driving city planning. In addition, financing has remained a major challenge, deterrent and a Gordian knot. Yet, the rapid expansion in urbanization and urban dwellers—whereby in about 30 years close to 70% of the world population will be living in cities—is forcing policy makers, researchers, technicians, planners, civil society, and the world community to roll up their sleeves and waste no time in finding new viable and affordable options and taking actions to deal constructively with this unavoidable reality.

In parallel, the world has witnessed an explosion and revolution in terms of technological development and especially in the fields of ICT and IoT-based and supported innovation, opening an infinite world of options and permeating all fields of activity. "Connectivity" has become the new trend.

Based on decades of teaching, research, exploring, advising, guiding, and implementation, brainstorming with scientists, politicians, practitioners, civil society, researchers, private sector around the world, Prof. Kim Kwi-Gon is now proposing a challenging, creative, and stimulating approach to connect the various agenda and dots of low-carbon sustainable cities through an integrated "global climate city platform" supported by and making the best use of new technologies—in particular—in the field of ICT, to plan, build, and manage the new "low-carbon smart cities."

Along with it he makes the business case that adopting this approach could generate new stimulus for the economies with the development of new research, technologies, businesses, investment, and job opportunities.

This proposal offers a comprehensive, detailed, and circular journey through the key components of an ICT-facilitated, ICT-connected, and ICT-integrated "low-carbon smart city" implementation. It takes us through an extensive analysis of current challenges and trends, new ICT-supported planning models bringing about increased efficiency and resilience through circularity and connectivity, new integrated planning approaches in terms of process and methods, the thoroughly documented presentation of selected practices and case studies of methods and techniques for climate resilient and "low-carbon smart city" planning and learnings derived from them, financing challenges and options, research needs and opportunities to implement this vision, to the description of the proposed comprehensive global climate smart city platform and smart grid itself—unlocking the value added of digitalized urban eco-systems built through public–private partnerships, but also the challenges and threats facing increased digitization and connectivity, as well as plans for future development.

While this comprehensive analysis and proposal does not have the pretention to offer all the options, solutions and answers for all the potential questions and challenges in implementing "low-carbon smart cities," it provides a solid platform for policy, technical and partnership discussions, dialogue, testing, actions, research and the development of a new efficient, interconnected, ICT-supported approach to addressing some of the key current and future challenges of climate change, exponential city expansion and "human-friendly" sustainable development.

Each chapter is an open door to further exploration and development, but eventually all the elements of these various chapters have to come together—with the help of ICT—to bring about a fully integrated, circular, and connected approach to the effective implementation of "low-carbon smart cities."

Anne-Isabelle Blateau
Former Director of the UNDP Seoul Policy Center
Seoul, Korea

Preface

Very recently, there has been a remarkable and innovative interest in urban planning issues. A major impetus was provided by climate change which is one of the biggest development challenges of our times. The Paris Climate Change Agreement and Post-2015 Sustainable Development Goals (SDGs) in 2015 and the New Urban Agenda in 2016 sought to accelerate the impetus for evolution of climate smart urbanism. Much of the discussion on low-carbon smart city issues and on climate resilience planning is about the better application of ICT and smart connect-tech in every aspect of urban planning. However, there will always be pressure for innovation planning. How much better tools for low-carbon, resilience planning would be to mitigate the potential emissions of GHG or to reduce disaster risk of future urbanization at the planning stage.

Climate resilient and low-carbon smart cities can be defined as one that has digitalized connections of all sectors and functions, in which everything is connected, acknowledging sustainability, resiliency, circularity, efficiency, and connectivity of the city. It incorporates climate mitigation and adaptation policy goals at each stage of planning process and with urban policy. Low-carbon, resilient smart city planning is at the developing stage. This is not mandatory. There is no internationally recognized city climate planner certification system yet. However, its importance has spread worldwide and receives a significant boost all over the world with the introduction of ICT and innovation connect-tech. Low-carbon resilient smart city planning is an approach in good business. It is also an area where many of the planning practitioners in both public and private sectors have limited experience.

This book provides a comprehensive introduction to the various dimensions of low-carbon, resilient smart city planning. It has been written as a seminal book with many case studies and with trial-and-error test bed examples. It should be of considerable value to those in practice for integrated solutions to unfinished urban agenda–policy decision makers, planners, developers, business people, and various interest groups.

This book is structured into eight chapters. The first provides an introduction to the impact of urbanization on urban ecosystem and their services, and overview of planning responses to climate change with selected case studies and introduces the concept of climate resilient and low-carbon smart urbanism: city climate urbanism. Chapter 2 provides planning models for climate resilient and low-carbon smart cities as an urban innovation for sustainability, efficiency, resiliency, circularity, and connectivity. Chapter 3 examines integrated planning approach to climate resilient and low-carbon smart cities in terms of process and methods. Chapter 4 addresses methods and techniques in more detail through selected practices. Chapter 5 takes a look to urban CDM-based approach and carbon financing banking system as a carbon governance approach. Chapter 6 examines research needs related to technology and smart urban investments. Chapter 7 describes implementation of climate smart cities through global climate smart city platform solution. Chapter 8 considers possible future developments.

Although this book has, to some extent, a planning orientation, it does draw extensively on application of ICT and smart technology innovation in urban environmental planning, and it should be of interest to readers from many different disciplines. This book seeks to highlight innovation practice and to offer enough insight to methods and techniques, and to provide market opportunities through valuable platform/guide to practitioner and investors.

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Contents

Abbreviations

3Cs	Carbon-Centered Comprehensive
B/C	Benefit-Cost
BAU	Business-as-Usual
BIM	Building Information Modeling
BINT	Bio-Nano-Information Technology
BIT	Bus Information Terminal
BSI	British Standard Institute
CBA	Costs and Benefits Analysis
CBI	Confederation of British Industry
CBS	Carbon Banking System
CCPP	Climate Change Preparation Projects
CCTV	Closed-Circuit Television
CDM	Clean Development Mechanism
CDMEB	CDM Executive Board
CER	Certified Emission Reduction
CH_4	Methane
CHP	Combined Heat and Power
CHP/DH	Combined Heat and Power/District Heating
CO_2	Carbon Dioxide
COP22	Conference of the Parties to the United Nations Framework Convention on Climate Change 22
CPS	Cyber-physical Production System
CSF	Connected Smart Factory
CT	Carbon Trust
CTCN	Climate Technology Centre and Network
DNA	Designated National Authority
DOE	Designated Operation Entity
DSS	Decision Support System
DT	Data Technology
EC	European Community

ECBA	Extended Cost-Benefit Analysis
EE	Energy Efficiency
E-grid	Energy Grid
EIA	Environmental Impact Assessment
EMIS	Environmental and Ecological Management Information System
EP	Environmental Profile
EPA	Environmental Protection Agency
ESS	Energy Storage System
ETS	Emission Trading Scheme
EU	European Union
EV	Electric Vehicle
FCEV	Fuel Cell Electrical Vechicle
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GI	Green Infrastructure
GIS	Geographic Information System
GPC	Global Protocol for Community-scale Greenhouse Gas Emissions
GPD	GHG Projection Diagnostics
GPS	Global Positioning System
GSA	Great Suva Area
GWP	Global Water Partnership
HFC	Hydro Fluro Carbon
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IDC	Intelligent Digital Connections
IDMP	Integrated Drought Management Program
IoE	Internet of Everything
IoT	Internet of Things
IP	Indigenous People
IPCC	United Nations Intergovernmental Panel on Climate Change
IPS	Indoor Positioning System
ISDR	United Nations Secretariat of the International Strategy for Disaster Reduction
ISO	International Organization for Standardization
IT	Information Technology
IUTC	International Urban Training Center
IWRM	Integrated Water Resources Management
JI	Joint Implementation
KECO	Korea Environment Corporation
KEI	Korea Environment Institute

KLC	Korea Land Corporation
KOICA	Korea International Cooperation Agency
KP	Kyoto Protocol
LC_2	Livable Cities Initiatives
LCE	Low-Carbon Economy
LED	Light Emittig Diode
LED	Low Emission Development
LEDS	Low Emission Development Strategy
LEED	Leadership in Energy and Environmental Design
LFG	Landfill Gas
LID	Low Impact Development
MAB	Man and Biosphere
MEET	Munster Electrochemical Energy Technology
MKWD	Metro Kidapawan Water District
MP^2D	Methods, Procedures, Planning and Development
MR	Monitoring Report
MW	Megawatt
N_2O	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organization
NIMBY	Not In My Back Yard
NMM	New Market Mechanism
NO_x	Nitrogen Oxide
NYCDEP	New York City's Department of Environmental Protection
NYU	New York University
OECD	Organization for Economic Co-operation and Development
OLED	Organic Light Emitting Diodes
PAHD	Public Authority for Housing Development
PDD	Project Design Document
PHEV	Plug-in Hybrid Electric Vehicle
PIMFY	Please In My Front Yard
PoA	Program of Activities
PPP	Public–Private Partnership (P3s)
PUD	Planned Unit Development
PV	Photovoltaic
R&D	Research and Development
RC	Reverse Carboning
RE	Reverse Engineering
RFID	Radio Frequency Identification
SC	Smart City
SCAM	Smeared Concentration Approximation Method
SCS	Sustainable Community Strategy
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment

SMG	Seoul Metropolitan Government
SNU	Seoul National University
SWG	Smart Water Grid
SWOT	Strength, Weakness, Opportunity, and Threat
t	Ton
TD-SOS	Transdisciplinary Systems-of-Systems
U-CDM	Urban Clean Development Mechanism
UK	United Kingdom
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
Vi-world	Virtual World
VR	Virtual Reality
WCCD	World Council City Data
WTO	World Trade Organization
ZED	Zero Emission Development

Introduction

The Smart City for Integrating Climate and Disaster Risk Considerations into Urban Planning

Key Areas to Implement our Sustainability Goals: Smart, Inclusive, and Green Growth

Climate change is the term commonly linked to the issue of global warming and cooling resulting from the increased emissions of GHG. The term *climate change* refers to any distinct change in measures of climate lasting for a period of time, that is, major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer (Momoh 2012). Climate change may result from the following:

- Natural factors, such as changes in the Sun's energy or slow changes in the Earth's orbit around the Sun.
- Natural processes within the climate system, for example, changes in ocean circulation.
- Human activities that change the atmosphere's composition (e.g., burning fossil fuels) and the land surface (e.g., cutting down forests, planting trees, and expanding cities and suburbs).

Global warming is an average increase in temperatures near the Earth's surface and in the lowest layer of the atmosphere. Increases in temperatures in the Earth's atmosphere can contribute to changes in global climate patterns. Global warming can be considered part of climate change along with changes in precipitation, sea level, and so on.

Global change is a broad term that refers to changes in the global environment, including climate change, ozone depletion, and land-use change.

The key implications of climate change include the following:

- Energy: Increased temperatures will cause an increase in energy bills as consumers use more air-conditioning.

- Health: Extremes of temperature such as excessive and long-term exposure to heat will contribute to disease.
- Agriculture and wildlife: Irregular weather variability implies lack of proper water supply, and increased temperature may result in worsening crop production and, ultimately, rising food costs.
- Water resources: Temperature and weather irregularity increase the possibility of flooding and droughts and impact the quality and availability of global freshwater supply. As the water supply is affected, farmers will need to irrigate crops.

Pope Francis warns about climate change. He said it is a moral issue because it affects the poor. The sense of urgency is needed.

On 10 September, 2014, the UN General Assembly has adopted a resolution that paves the way for the incorporation of sustainable development goals into the post-2015 development agenda. In adopting the "Report of the Open Working Group on Sustainable Development Goals (SDGs) established pursuant to General Assembly resolution 66/288," the Assembly decided that the Open Working Group's outcome document would be the main basis for integrating the SDGs into the future development agenda.

The resolution states that other inputs would also be considered during the intergovernmental negotiation process at the upcoming General Assembly session.

At the opening of the 69th session of the General Assembly on 16 September, the body's new President, Kahamba, Kutesa, declared the theme of the 2014 general debate "Delivering on and implementing a Transformative Post-2015 Development Agenda" and said the framework must strive to eradicate poverty and hunger and promote sustained and inclusive economic growth. The Post-2015 SDG has been formally adopted by the UN General Assembly in September 2015.

Officials from 175 countries signed the Paris Agreement on climate action in New York City on Friday (22 April, 2016), signaling a crucial milestone in international efforts to combat climate change. Very recently, the USA and China have confirmed their ratification of historic Paris Agreement, tipping the balance in favor of a quick entry into force of the Agreement by the end of 2016. Finally, it has been enforced on 4 November, 2016. So far, 87 countries have ratified the Agreement. This Agreement encourages the ratified countries to prepare the Low Emission Development Strategy (LEDS) and Nationally Determined Contribution (NDC).

The climate smart city planning can be used as a sustainable tool for green economic development with particular emphasis on climate resilient and low-carbon cities within the broad framework of the sustainable development goals.

Integrated Approach to City Climate Planning and Design: Smart Connect-tech Business for Planning and Scientific Imagination, and Technological Advancement to Avoid Climate Impacts

What sort of changes in the current planning, management, and governance of humans settlements are needed to face the changing environment including the climate change and increasing disaster risks in cities?

A city's structure is the spatial pattern of its differentiated parts and functions, and its physiology deals with the interaction that occurs between these specialized units. Spatial planning is an important tool for integrating environment and disaster considerations into development plans (UNEP/ISDR 2008).

Current urban planning system, however, proves to be limited to coordinate its cross-sectoral or cross-cutting plans efficiently and systematically with the sustainable development agenda. Multi-sectoral development-oriented zoning can enable governments and other stakeholders to assess possible land-use options for development and to choose the best options on the basis of possibilities, limitations, and values derived from the application of the GIS and GPS techniques.

Poverty issue is critical in choosing the best options for zoning. Poverty contributes to both environmental degradation and vulnerability to hazards and should be addressed accordingly.

Measures to reduce poverty include agricultural expansion, which may require wetlands to be filled, and activities in coastal areas, such as shrimp farming, that considerably degrade the environment or change the entire ecosystem. It is therefore vital that causal link between development, disaster risks, and environmental degradation is recognized in poverty-reduction activities (UNEP and ISDR 2008).

It is predicted that about 50 billion machine-to-machine connections will be achieved by 2020. Bearing in mind that people are becoming more connected than ever, 5 billion people have mobile devices, the usage is increasing, and the ICT infrastructures have been capable of sharing information on every front; together, they can help us monitor energy, resource efficiency, and impact of emissions through enabling energy efficiency, in sectors such as land use, energy, industry, water, waste, and buildings.

Therefore, ICT, which is the connect-tech, can facilitate controlling climate change attributes when deployed with appropriate ingredients and composition. Smart city planning model compositions for climate resilient and low-carbon cities not only entail usage of ICT infrastructure but also associated past, present, and future knowledge bases for carbon reduction and disaster risk management techniques to be developed in a holistic manner.

Main context-aware challenges and attributes that are to be considered in this book are the scenarios with regard to rapid urbanization, global warming, hyper-growth, new value creation, and rapid adoption rate of digital infrastructure.

There are new opportunities to combine the existing smart city (SC) models and climate resilient and low-carbon city models with the help of the evolution of the Internet and availability of low-cost real-time digital technology, tools, and infrastructures. However, this transformation has to start with willingness to address climate and low-carbon development.

These techniques could be used to improve the efficiency, sustainability, circularity, resiliency, and connectivity of policy, planning, technology, governance, and economic tools designed for climate resilient and low-carbon cities. They could contribute to build a new urban industrial ecosystem based on new types of information.

Smart city planning for climate resilient and low-carbon cities incorporates strategic urban growth while keeping under control (or reducing) greenhouse gas (GHG) emissions for green growth benefits through the automation and Internet control system technology development to GHG emissions and climate change adaptation.

ICT such as virtual reality technique is helping to achieve sustainable development goals in human settlements. It is time to act to incorporate smart city concept with ICT into climate resilient and low-carbon city planning and development with a package program for networked connections of people, urban structure and process, and knowledge data.

Building “Big Data” and “Cloud Sourcing” infrastructure is another crucial area as city information base for “Low-Carbon Smart Cities: Tools for climate resilience planning.”

Smart Solution for “NIMBYism”: Urban Climate Governance for “PIMFY”
Smart city planning is an important means of promoting stakeholder engagement to drive climate action.

In 2008, the city of Gwangju, Korea, has adopted the carbon banking system which is a voluntary GHG reduction campaign in the manner of governance approach to climate change at the household level. In this system, the consumption of electricity, city gas, and drinking water is digitally monitored through the respective meters in each household. The results of monitoring can be used for reporting, verification, and certification (MRV) process of the carbon banking system.

It is a public–private partnership (PPP) project. This project has seen as a collaborative and collective effort among many stakeholders including city government and private consulting company.

They developed the operating system which maps out main steps of carbon banking system together with the roles of main actors. These actors are engaged in the carbon banking process. The process starts with signing ceremony for Agreement on the carbon smart model city between central and local governments, and ended up with issuance of carbon points by private banks.

Niederberger (2014) states that, in current practice, stakeholder engagement frequently encouraged in two contexts:

- as an element of good governance (normative justification), with citizens typically in the role of watchdog, ensuring government;
- to facilitate the performance of government functions (instrumental justification), with citizens as more or less active participants, which has been greatly facilitated by the Information and Communication Technology (ICT) revolution and better access to information.

For the operating system of carbon banking system, the emphasis has been on the exercise of citizen as participants and stakeholders as partners.

Behavioral engineering is intended to identify issues associated with the interface of technology and the human operators in a system and to generate recommended design practices that consider the strengths and limitations of the human operator (Wikipedia 2015)

People's changing attitude toward potentially harmful landfills being located near homes is best exemplified by the landfill cases. The smart landfill operation to generate electricity with methane gas from landfill site is a good example.

The modern climate smart technology helps the public be aware that the hazardous materials would not pose threats as long as they are properly treated and managed with ICT, and produce harm to the surrounding community. Information technology (IT) and data technology (DT) help these things a lot.

Environmental racism is another critical climate issue. Ethical implications of NIMBYism are apparent in the poor community where action is not taken by the government for years.

The disproportionate environmental burden placed on low-income, minority communities is due to the disparity in access to political power and decision making (Wikibooks 2015).

City-Minded International Cooperation: Climate Planning-oriented New Urbanism and Climate Diplomacy

Then, the next question would be "how cities are working together with their international partners to study, teach, and implement climate planning methods and tools into their city's framework."

The Post-2015 sustainable development goals (SDGs) are now becoming an international norm for the "climate diplomacy." Goal 11 encourages member states to make cities and human settlements inclusive, safe, resilient, and sustainable. Furthermore, 11a suggests that, by 2020, they will increase the number of cities and human settlements adopting and implementing integrated policies and plans toward inclusion, resource efficiency, mitigation and adaptation to climate change, and resilience to disasters.

Nowadays, many cities clearly see addressing city climate change as a way to drive growth and competitive advantage in their jurisdictions.

Addressing climate change will lead to development of new business industries in cities. This is the most commonly cited economic opportunity for many cities.

The climate change-related report entitled "The Colour of Growth" published by the Confederation of British Industry (CBI) states that environment-friendly approach to British industries is necessary for growth. Low-carbon economy creates the value of $5,000 billion every year all over the world, which is more than the rate of world GDP growth.

Cities can adopt a variety of strategies for attracting new businesses. Two strategies that cities frequently mention are clustering and incentivizing new business. The clean-tech clusters focus on companies and technologies related to sustainable transport and sustainable energy, but also water and solid waste technology. Many cities are actively recruiting new companies with tax reduction, spaces, and other incentives.

It is clear that attracting new businesses and investing in redevelopment, energy savings, sustainable transportation, and other green infrastructure will improve the quality of life for citizens, relaunch the economy, and create new green jobs in cities.

This movement motivates the emergence of “climate planning-oriented new urbanism” inspired by the new type of city-minded international cooperation and emergence of global ICT companies. Climate diplomacy, green growth and green economic development, connect-tech development, and new climate economy have played important roles in promoting climate-oriented new urbanism.

New urbanism is an urban design movement which promotes walkable neighborhoods containing a range of housing and job types. It helps citizens reduce energy consumption and subsequently reduce greenhouse gas (GHG) emissions.

It arose in the USA in the early 1980s and has gradually influenced many aspects of real estate development, urban planning, and municipal land-use strategies.

Now, it is time to look at how the climate development and knowledge base influence urban planning and design.

Our task now is to mainstream city climate planning into urban planning policy. This is only possible by creating the planning conditions necessary to integrate the full effects of climate change into the urban planning process. Creating these conditions involves looking at the importance of climate diplomacy in the negotiations. This work has been focused on how a truly global, ambitions, and legally binding Agreement to limit emissions can be achieved at the city scale. The UK’s Foreign Secretary, William Hague, has said “Climate change is perhaps the twenty-first century’s biggest foreign policy challenge” (Fig. 1).

Fig. 1 Elegy for the North Pole performed in glacier: Warning of global warming. *Source* Chosun Daily Newspaper, A1, No. 29688, 21 June, 2016

Several New Urbanists have popularized terminology under the umbrella of the New Urbanism including sustainable urbanism, tactical urbanism, ecological urbanism, and landscape urbanism. This book promotes what the author describes as a variant of the New Urbanism called the Climate Urbanism, which is intended to be a more climate-oriented.

It promotes the principles of climate resilient and low-carbon smart cities, including:

- Consider the intrinsic suitability of land by smart zoning of certain areas;
- Create digitally connected smart urban form for the resource and energy efficiency with smart energy grid;
- Manage ground and surface water resources to achieve the right balance between the needs of society and requirements of the environment through the integrated water resources management with smart water grid;
- Implement district energy projects with smart heat grid;
- Mange natural and human-induced disasters, and control flood plain and flood risk for the benefit of people and the natural environment and the protection of property;
- Maintain and, where possible, improve the quality of air, land, and water through the prevention and control of pollution, and by applying the "polluter pays" principle;
- Achieve reductions in waste through minimization, reuse and recycling, and improved standards of handling and disposal;
- Conserve and enhance the natural, cultural and historic value of the city, its landscapes, and biodiversity for ecotourism;
- Retain, improve, and promote coastal areas for the purpose of coral reef conservation, appropriate recreational use, and public access and enjoyment;
- Reduce Greenhouse Gas (GHG) emissions through climate change mitigation measures, and
- Promote green infrastructure development in a holistic integrated manner.

The term "climate urbanism" is used to signify smart city efforts, but it includes human settlement development issues for the Post-2015 Development Agenda and SDGs.

The term "climate resilient and low-carbon smart cities" is used as an alternative to the term "eco-cities" for resiliency, efficiency, circularity, sustainability, and connectivity. It may be regarded as the new model of eco-city development planning and development with particular emphasis on urban climate issues. This book assesses how climate resilient and low-carbon smart city planning differs from conventional city planning (Fig. 2).

The need for the climate resilient and low-carbon cities with Intelligent Digital Connections (IDC) can be justified through existing programs such as IBM, CISCO, and World Bank programs.

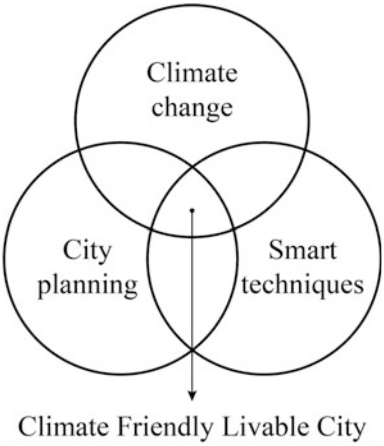

Fig. 2 Three pillars of climate smart city

The World Bank has an active work program in the areas of cities and climate change, smart cities with ICT, and also more broadly in the area of sustainable cities. It also promotes the Urban Climate Planner Certification System (World Bank Task Force to Catalyze Climate Action 2014).

Chapter 1
Evolution of Climate Resilience and Low-Carbon Smart City Planning: A Process

Abstract This chapter presents the global impacts of urbanization on urban ecosystems and their services, planning responses to climate change, and case studies and examines the emergence of climate resilient and low-carbon smart urbanism. Climate as one of the ecosystem services also is impacted by urbanization. The planet is very sensitive to climate change, and exposure to climate-driven natural disasters will increase. In a context where by 2050, almost 70% of the total world population will be living in towns and cities, and the climate resilience planning will become increasingly critical. Based on the selected case studies, energy conservation, low-carbon green city design, and impact assessments of urbanization on environment and climate change were found to be complementary tools for climate resilience planning. The emergence of a smart climate approach bringing together (1) eco-city, (2) sustainable city, and (3) conventional low-carbon green city approaches into the climate resilient and low-carbon smart city development will generate a much higher value added at lower cost.

Keywords Urbanization · Climate change · Urban ecosystem · Planning responses · Eco-city · Sustainable city · Low-carbon green city · Guidelines · Climate resilience planning · Smart climate urbanism · Value added

It has been proven that conventional urban planning fails to meet requirements and demand for the safe and comfortable globe. We, therefore, need ceaseless planning innovation. Comprehensive carbon-centered (3Cs) planning should be the mainstream of planning to combat climate change at the city-scale. It is time to connect urban planning with challenges of global climate change.

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1.1 Impact of Urbanization on Urban Ecosystems and Their Services

1.1.1 Urbanization Trends

It is estimated that the global population will increase from approximately 6.9 billion in 2010 to in excess of 9.1 billion in 2050. By this time, over 6.2 billion people, or almost 70% of the total world population, will be living in towns and cities (United Nations 2011).

In 2050, urban population in Europe, Latin America and Caribbean, and North America will decrease, while it will increase in Africa and Asia as compared with 2009 (Fig. 1.1).

As shown in Fig. 1.2, percentage of population residing in urban areas in more developed regions will be much higher than that in less-developed regions from 1950 to 2050.

In 2050, most urbanization will be seen in Asia, as can be seen in the pie chart (Fig. 1.3).

1.1.2 Ecosystems and Their Services in Urban and Peri-Urban Areas

Bearing the above-mentioned urbanization trends in mind, any kind of urban planning must be based on "ecosystem services" from which citizens can benefit. Valuing ecosystem services with economic value allows for better decisions.

The concept of an ecosystem services looks at the functional relationships between natural and human systems.

Urban ecosystem services include air filtering (gas regulation), microclimate regulation, noise reduction (disturbance regulation), rainwater drainage (water regulation), sewage treatment (waste regulation), food production, erosion control, biodiversity maintenance, recreation, health, and cultural values.

Four main types of ecosystem services with urban and peri-urban response are depicted in Fig. 1.4 and described in Table 1.1.

Among four main types of ecosystem services, provisioning services, supporting services, and regulating services are critical in land development, urban mitigation and adaptation strategies, and physical infrastructure development. The physical infrastructure includes green–blue–white infrastructure corridors and networks to combat climate change in urban and peri-urban areas for climate resilient and low-carbon smart city planning.

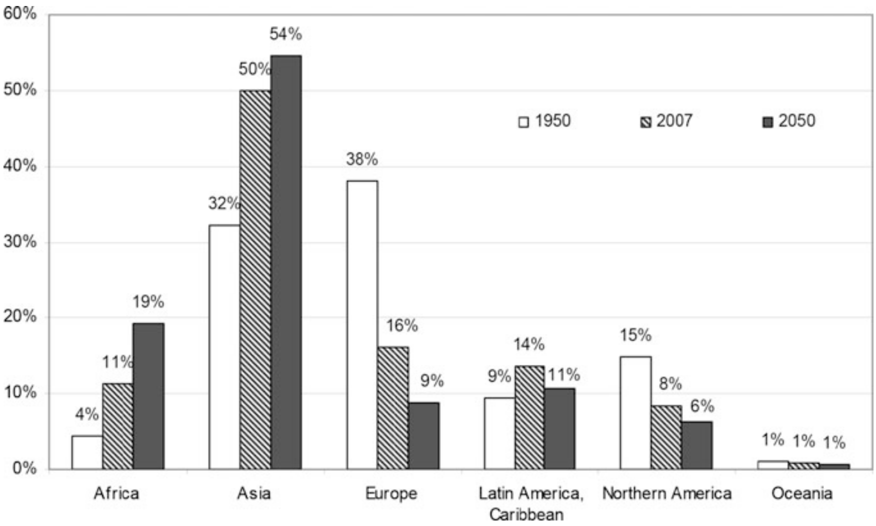

Fig. 1.1 A new geographical distribution by major regions. *Source* UN-DESA (2011), World Urbanization Prospects—The 2007 Revision, 2011, p. 5

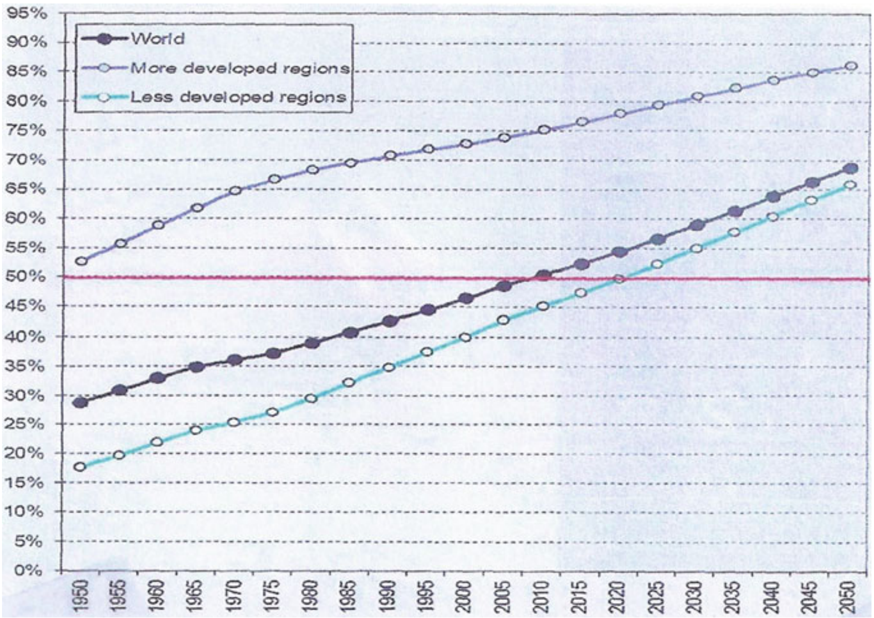

Fig. 1.2 Percentage of population residing in urban areas. *Source* United Nations (2011)

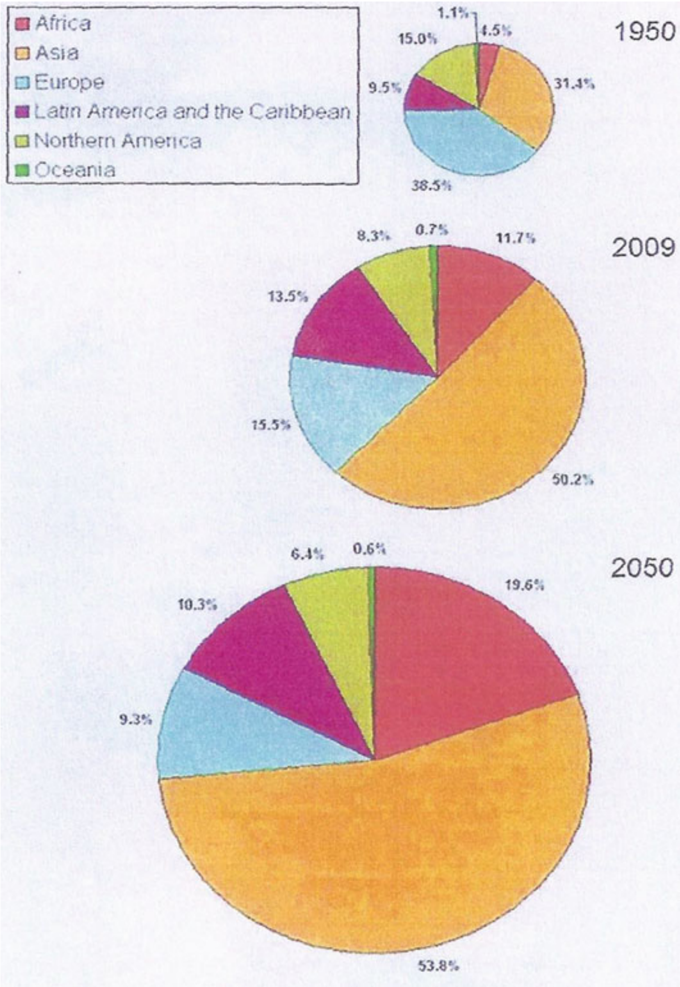

Fig. 1.3 Urban population by major regions in percent of total urban population. *Source* United Nations (2011)

1.1.3 Impacts of Urbanization on Ecosystems and Their Services

The possible adverse impacts of urbanization on ecosystems and their services at the city-scale can be described in terms of environmental and climate impacts and the vulnerability of cities to these impacts.

The environmental footprint of cities is far larger than their physical boundaries, and environmental impacts of urbanization are multifold ones. High-density human habitation is associated with loss, fragmentation, isolation, and pollution of natural

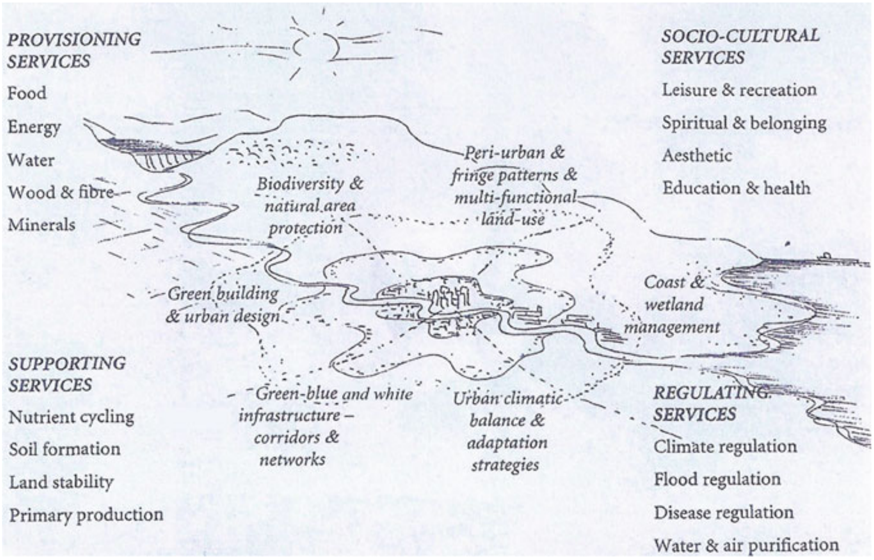

Fig. 1.4 Urban ecosystem services: Four main types of ecosystem services with urban and peri-urban response. *Source* Quoted from Niemela, J., Urban Ecology, modified by the author

habitats, introduction and spread of exotic species, accumulation of waste products, and changes in climate and hydrological processes. Approximately 60–70% of globally derived GHG emissions are from cities.

High concentration of particulate matter is a danger to health. Annually, 5.3% of the deaths worldwide (3.1 million) are attributable to air.

Regarding water, high levels of contamination are observed where the population density is high and the sanitation standards are low, while cities generate 1.7–1.9 billion tones or 46% of global waste.

Cities are highly vulnerable to the impacts of global environmental degradation for the below reasons:

a. High exposure to climate-driven natural disasters and climate change;
b. Concentration of vulnerable people (e.g., the poor);
c. Insufficient and unequal access to basic urban services resulting in social and environmental impacts.

1.2 Planning Responses to Climate Change

This section addresses how to maximize the function of ecosystem services and how to minimize the adverse urbanization impacts through smart planning practices. It focuses mainly on climate change-driven urban issues among other ecosystem services issues and planning responses to these issues.

Table 1.1 Urban ecosystem services

.
• "Provisioning services"—tangible goods which ecosystems provide directly. This could be freshwater for consumption or production; food for consumption; forest and crop plantations for energy and fiber • "Cultural services"—more intangible experiences which are offered or enabled by ecosystems. Landscapes, uplands, community forests, and urban green space are valued for esthetic and recreational qualities: reservoirs, canals, and urban watercourses enable social relations and cultural identity • "Regulation services"—benefits from ecosystems concerning regulation of natural processes. Wetlands, dunes, and floodplains for flood and flow regulation; vegetative cover for erosion regulation; peat bogs for carbon sequestration, are all examples of the regulation functions, which urban development ignores at its peril • "Supporting services"—these underpin the provision of other ecosystem services. Soil formation is essential to other services; wetlands, aquifers, and riparian habitats for water cycling; soil for nutrient cycling

Source Niemela, ibid

The United Nations Framework Convention on Climate Change (UNFCCC) sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change.

It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide, and other greenhouse gases.

1.2.1 Debates in Urban Planning and Development

It can be argued that the climate crisis facing us in the twenty-first century is a direct result of nineteenth century industrialization and the land-use planning and urban design solutions of the twentieth century.

Comparing twentieth century and twenty-first century urban design decisions and their impacts on the climate is shown in Table 1.2.

We have strained the equilibrium between humans and nature to the breaking point. By using the next generation of city building as an opportunity to restore this equilibrium, we can avert further climatic and ecological disaster while reaching new heights of economic and cultural vibrancy. We are now on the eve of a new era of climatic-responsive urban planning.

The old environmental planning paradigm, which assumes that biodiversity and ecosystems can be managed based on relatively static climatic conditions, must be retooled to account for substantial and complex ecosystem change.

Some possible approaches to mitigate climate change with strategic, high performance for the low-carbon development have been suggested as follows:

Table 1.2 Comparing twentieth century and twenty-first century urban design decisions and their impacts on the climate

	Twentieth century	Twenty-first century
Water resources	Engineered solutions were developed to deliver, manufacture, process, and dispose of water resources	Scarcity of water resources and increasing unpredictability of storm events will force us to reimagine how we use and reuse water, thus demanding new water-sensitive urban design form
Habitat restoration	Disconnected land uses and human-made infrastructure encroached biological habitats	Nodes and corridors of human settlement will coexist with ecological corridors of restored and enhanced biological habitat
Energy sufficiency	Centralized fossil fuel burning plants with inefficient grid delivery systems provided a non-renewable, inefficient energy sources	Local generation of energy from renewable and low-carbon sources will deliver heat, cooling, and power on a district-by-district, building-by-building basis
Economic prosperity	Automobile-oriented urban design policy and land planning spurred a synergistic acceleration of real estate, automobile industry, and infrastructure engineering	New economies and technologies will provide the impetus for new land-use planning using efficient renewable energy and mobility. New economic models will invent new ways for speculative real estate entrepreneurs to create smart nodes of development
Social equity	Suburban development in many developed economies stratified populations into sub-economic and racial groupings	New population demographics and migrations will drive a new pattern wherein diversity is the greatest socioeconomic asset
Mobility	The automobile and airplane gad the largest impacts on how we moved globally, regionally, and locally and contribute the largest amount of greenhouse gas emissions	Concern for our carbon footprint and scarcity of oil drive new technologies (and reinvent old technologies, such as high-speed rail) that will radically alter local, regional, and global movement pattern. Proactive policy to encourage these systems and redesign our urban environments to accommodate them will transform our lifestyle
Built form	Singular use, large footprint, isolated stand-alone buildings celebrated a profligate use of energy and an automotive lifestyle	Mixed-use, self-sustaining eco-block development, with integrated smart energy and water saving systems will become desired

Source ORO, Climate Design: Design and planning at the age of climate change, Gordon Goff, 2010, p. 191

- Integrated and holistic approaches to localized production of energy, water, and food with respect to their nexus within the public urban realm.
- Integrating small-scale organic farming into new communities for local low-carbon food production.

- Improving storm water resource utilization and water quality with low impact development (LID).
- Establishing a no-pollution zone called NO-POL in the region to promote a carbon-negative and ecologically regenerative eco-urban fabric.
- Balancing environmental and social sustainability with economic progress.
- Encouraging high-density, mixed-use land and transit options which allow people to live in very close and productive proximity to work, amenities, and cultural assets.
- Promoting water-sensitive urban design.
- Seeking urban vibrancy and convenience paired with a sustainable lifestyle and an authentic experience of nature.

1.2.2 Different Forms of Eco-City Planning and Development

A variety of approaches to eco-development since global environmental issues have emerged in 1980s. This section tries to critically evaluate them in terms of ethical value, development process, the role of technologies, and novelty in new and retrofit developments.

In broad terms, Table 1.3 summarizes a comparative analysis of conventional planning, holistic eco-city planning, and climate resilient and low-carbon smart city planning.

1.2.3 Historical Review on Eco-Development Movements

The Korean society and government have recently embraced a low-carbon green growth strategy by funding both climate change mitigation and adaptation projects, mainly through a “Green New Deal” that focuses on a four-river restoration and renewable energy project. Many other nations also have similar new agendas to address how climate change is affecting their environment.

Now that we are finally moving in the same direction toward investing in greener economies and renewable energy, and we must also convene on similar strategies for urban planning, transforming our cities into low-carbon resilient smart cities.

Until recently, our land-use actions and emissions did not pose a global threat to the ecological systems that sustain us and other life on earth. But now change is happening at an unprecedented speed. Some forward-thinking leaders in island nations are investing in a second homeland for their people to move when their islands are submerged by rising sea levels. In some countries, agricultural lands are becoming salinized due to the sea-level rise. We live now in the era of the 4th industrial revolution with the development of artificial intelligence (AI) based on big data.

Table 1.3 Comparative analysis of conventional planning, holistic eco-city planning, and climate resilient and low-carbon smart city planning

Classification	Conventional planning	Holistic eco-city planning	Climate resilient and low-carbon smart city planning
1. Philosophical basis	Deterministic/comprehensive rationalism	Holistic/organism/whole/circulation theory	Planet-sensitive paradigm/connectivity theory
2. Ethical value	People centered/anthropocentric value	Coexistence of human being with nature/evolutionary ethics/life for future generation	Moral value/climate ethics/climate diplomacy
3. Major planning element	Form/function/structure/space/materials	Human being/other species/places/living organism/experience	Internet of Things (IoT)/smart grid
4. Planning concept	Closed concept system	Open concept system/more open-minded cities	Smart connected cities
5. Conceptual understanding of planning problems	Understanding as problem solving process	Understanding of evolutionary process of biological and cultural system	Understanding of 2° (two degree) initiative and sensor innovation
6. Planning object	Planning of form and space	Planning of place, experience, and ecosystem	Planning of climate change, scientific imagination, and SDGs (mitigation/adaptation)
7. Planning process	Linear process	Cyclical iterative process	Demand–supply process
8. Planning principles	Master planning principles	Sustainability principles/ecological principles	Connectivity/resiliency/circularity/sustainability principles
9. Planning indicators	Intergenerations	Intergeneration and intrageneration as well as sustainability indicators	Carbon footprint
10. Post-occupancy evaluation	Socioeconomic effectiveness	Ecological effectiveness	GHG reduction and resiliency

The problem of global climate change was created largely by industrialized cities. Approximately over 60–70% of greenhouse gas emissions are produced by cities. Our propensity to gather into urban areas and industrialize has gotten us into this mess. Now we need to use the principles of space efficiency, organization, and technical innovation to urbanize in a way that is sustainable.

Urban areas are continuing to grow at a rapid rate in Korea, as they are in many parts of the Asia–Pacific region. We must design energy-efficient and harmonious physical structures, as well as the economic, social, and ecological aspects of each city to accomplish the sustainability of human activities and environment in dense urban areas. In this regard, the connection of urban planning with global challenges has emerged, and eco-city, sustainable city, and low-carbon green city movements, all with similar goals of energy conservation, renewable energy, low impact, development and revegetation, have been promoted in Korea and elsewhere.

1.2.3.1 Evolution of the Eco-City/Sustainable City

The idea of eco-city grew from the perception that the problems of the urban environment could be understood by recognizing its complex relationship with organisms in nature, which ranges from metabolism, food chains, the heat island phenomenon in cities, to atmospheric pollution, water pollution, and the decrease or loss of biodiversity.

The city itself can be viewed as a living organism, with analogous systems. Transportation networks are the circulatory system; sewers are the urinary tract; and so on. A healthy city, just like a healthy body, must be able to process pollutants effectively or limit their intake for longevity. Figure 1.5 shows one aspect of

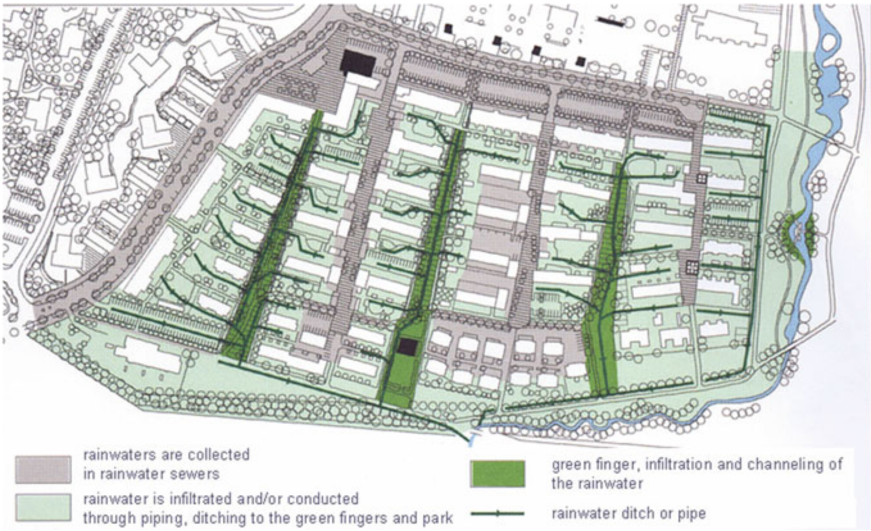

Fig. 1.5 Features of an eco-city, Vikii, Finland

eco-cities—a rainwater collection system in vegetated green belts that helps to purify water as it travels through the system.

The idea of a sustainable city has grown from the perception of a sustainable agenda—that the conservation of the global environment is a significant issue, and, therefore, extensive strategies via collaboration with each nation need to be suggested. Its main purpose is to recognize the responsibilities toward the future generations of our world via a wide framework of Sustainable Development Goals; therefore, it concerns a wide range of aspects of society from economic, societal, and cultural structures to the mechanisms of production and consumption, as well as the environmental aspect. Supporters of the sustainable city follow sustainable developmentalism and argue that the environment should be the foundation for humans to live in it; at the same time, they allow a long-term, continuous economic development throughout the conservation and utilization of the environment as a crucial resource.

As well, they continue to argue that we need to understand the environment as a limited resource, and to create a city that can sustain itself from the present generation into the future. It is characteristic that the idea of sustainable city seeks to consider a city not only as a living organism, but as a societal, economic, cultural, traditional, and even a spiritual system.

The projects of a sustainable city include those related to ecology or energy issues as well as culture, and public welfare projects for the socially disadvantaged.

1.2.3.2 Climate Action Planning for Low-Carbon Green Growth

Meanwhile, the low-carbon, green city is an idea that has recently appeared as a way to fight climate change. It intends to systematically incorporate mitigation and adaptation measures to enable the city to respond to climate change through a well-planned and designed urban environment. Through such a plan, green cities can improve the energy efficiency and water use within a city and promote the development of solar energy and wind power, all of which are part of the climate agenda.

The concept of the low-carbon, green city also decreases the cost of transportation energy and can prevent development in the places that are ecologically sensitive or vulnerable. This idea is based on the principles of green growth, and the image of the ideal city—which takes the idea of environmentally sustainable development—reflects "low-carbon green growth (Fig. 1.6)."

Cities begin their process of transformation into low-carbon, green growth with a climate action plan. The basis of this plan rests on a thorough understanding of the carbon cycle and how the city's inputs and outputs affect this cycle.

Therefore, the low-carbon green city considers the plan for making a climate agenda as a key mission and seeks to contribute to the creation of jobs and revitalization of the local economy, by raising both the ecological and economic efficiencies.

The projects of green cities include the creation of wind passages, transportation planning, the dispersion of heat through site planning, the utilization of new renewable energy sources, efficient energy use and supply, the restriction of automobile movement in downtown areas, systems of interconnection between modes

Fig. 1.6 A conceptual model of low-carbon green city

of public transportation, pedestrian-friendly streets, bicycle-oriented projects, and the recycling of waste materials for district heating purposes (Table 1.4).

1.2.3.3 Guidelines for Creating Climate Resilient and Low-Carbon Smart Cities from Eco-Development Point of View

Many cities around the world have recently established and presented their climate action plans. This movement is a reflection of the efforts to meet global trends and standards related to climate and energy while simultaneously generating economic growth.

In order to lead cities toward becoming climate smart cities, the creation of these urban climate action plans should be mandatory; as such a framework is indispensable for transforming the green cities project into the "Green New Deal" project, as practiced in Korea.

With the review of urbanization and planning responses to climate change, the following guidelines can be suggested to describe climate parameters for mainstreaming of smart methods and techniques in every aspect of city planning, delivering, monitoring, and reporting.

First, it is suggested that the response to climate change in cities needs to be integrated into national, regional, and local plans, so as to make such a response the gist of national business planning. The long-term and short-term plans for making

Table 1.4 Strategy and projects used in the low-carbon green city projects in Korea

Strategy	Project contents
Land use	• Low-energy structure and function of city • Compact city
Application of plan for reducing heat islands	• White network, blue network, and planning schemes • Heat dispersion through traffic and site planning
Better efficiency in energy supply; use of renewable energy	• Geothermal power, CHP • Renewable energy plants
Creation of energy consumption limits in each sector; renovation of energy production sources	• Energy-use standards for each size and type of building • Renovation of transportation energy fuel, renewable energy in buildings
Creation of sustainable mobility system	• Limiting automobile use in urban space • Public transportation linkage system, pedestrian/bicycle-oriented roads
Rainwater use; creation of gray water reuse system; reuse of sewage	• Use of porous pavement to reduce rainwater runoff • Gray water system • Methane gas energy plant, compost of sludge
Plan for urban green network, conservation, and restoration of ecology	• Greening plan for entire city • Conservation of urban ecosystem • Restoration and linkage (creation of eco-green corridor)
Reuse of solid wastes, management of business, and construction waste	• Waste management from construction stage • Separated recycling system • Waste reuse business • District heating system

low-carbon green cities have not been systematically developed yet, and, therefore, what is required is to develop the overarching objectives and the associated steps necessary to bring about climate smart cities.

Second, it is necessary to connect city and site planning with the introduction of new, renewable energy technologies. Accomplishing the goal of making low-investment, high-efficiency cities requires the introduction of a total city energy system. In doing so, the preparation and evaluation of the degree of city energy density must be undertaken. Through this process, the feasibility and legitimacy of the site where the new renewable energy technology is introduced need to be reviewed in advance, because its efficiency can be high when two approaches—both the active solar energy approach and passive solar one—are integrated with each other.

Third, the rule of evaluating the effects of climate change in cities may be suggested as one element of the city climate action plans. The USA considers climate change as a form of environmental pollution and has recently been preparing both mitigation and adaptation measures after evaluating how proposed projects may influence the climate.

Fourth, urban planning guides should be devised based on the carbon footprint concept and approach. In particular, it is necessary to include the carbon index and its standard in the city laws and to make carbon footprint analysis mandatory. To reduce a city's carbon footprint, measures including planting trees to create carbon offsets, developing "rainwater cities," and creating wetlands within the city may be suggested as well (Fig. 1.5).

Fifth, it is necessary to prepare a strategy for new urban development, which could integrate the various plans for climate-friendly land use, environmental conservation, and transportation systems. This needs to be approached at the unit building, site, and city levels. What needs to be done in this process is to systematically establish a mechanism of planning that includes variables such as land use, climate change, biodiversity, and disaster management, and to develop an organization that can coordinate the issues of city climate and energy, mainly because the image of the city sought by the eco-city and sustainable city needs to be included into the low-carbon resilient smart city.

The kinds of urban forms listed below may give a functional legitimacy to the process of climate-friendly urban planning: These include water circulation systems and the urban form, conservation of energy/resources and urban form, biodiversity and urban form, and wind passes and urban form.

Sixth, the economic operation means and social, governance-oriented approach may be utilized. Under the incentives of various economic supports and restrictions (i.e., congestion fee) and the participation of the people who are interested in the project, climate smart cities could be constructed in the right place that set benchmarks nationally and internationally.

Seventh, it is necessary to develop and use resources efficiently, as well as employ energy-efficient technologies. Technology is the key to transforming cities into places where less dependence on the environment, and particularly on carbon-emitting fuels and practices, is required. In the new approach of constructing the low-carbon, resilient smart city, rapid technological development may potentially be expected in certain fields.

The technologies and technological developments that may be expected include methods of analyzing the carbon circulation process, new renewable energy technologies, the use of LEDs, smart connect-tech and control of non-used energy in the city (i.e. the embodied heat in sewage disposal water, factory production processes, and in buildings), and their utilization within the city energy system (Fig. 1.6). Technologies have impact on new jobs. To accomplish these technological developments, active research and development are needed to make the Carbon Neutral City, progress pilot projects, and accumulate and circulate the related information.

It is time to connect urban planning with the challenges of climate change. We do have effective ways to both decrease our carbon footprint and adapt to climate change through urban planning techniques that incorporate energy conservation, use of renewable energy, and ecological restoration (Table 1.4). Now we need to

Fig. 1.7 Industrial building development in the landslide-prone area, Seoul, Korea: an urban planning solution is needed for disaster risk zoning

formulate and implement climate action plans that incorporate these techniques at all levels, spanning from global to local, to reach our goals for sustained prosperity for ourselves and all future generations (Fig. 1.7).

1.2.4 Selected Approaches to the Green Urban Development and Low-Carbon Economy at the City Level in Korea

As concerns about climate change grow, green growth in the form of low-carbon economy (LCE) has been an effective policy as an alternative in the transition from fossil fuels since global warming has become a critical issue facing the planet.

Korean government officials say green growth is more than just a concept to tackle climate change. The officials say it involves a fundamental shift in the growth paradigm-from the current one oriented toward quantitative growth and based on the massive consumption of fossil fuels, to one prioritizing quality of life and founded on a virtuous cycle of economy growth and environmental protection.

In 2009, the Korean government unveiled the 5-year Green Growth Plan, a medium-term plan for implementing the green growth strategy. The development of low-carbon green city was a key area.

In order to combat climate change and to adapt national vision for low-carbon green growth, Korean government designated some municipalities as low-carbon green cities. With the Ministry of Environment, Korea, the Green Growth Committee implemented demonstration projects in these municipalities. Gangneung city, a city located east of Seoul, made the “model and vision for low-carbon green city” and took a leadership role in embodying a green society.

President Lee Myung Park has remarked in the Forum for Development of Gangwon Area on February 10, 2009, that “We need to develop the low-carbon and green city in Gangwon province and promote the city as the global premium city, setting an example for low-carbon and green growth”. Korean government has launched the service for development planning of the pilot city on March 31, 2010.

The Gangneung low-carbon green city strategies for green growth made several political implications for low-carbon economy:

1. It was expected that production and additional values triple the budget of green city development.
2. The program was expected to create over 5000 jobs by 2013.
3. The program was expected to stimulate the local economy by increasing the number of tourists by about 6.7% (920,000) and generating tourism revenues of KRW 85 billion.
4. The program would significantly reduce greenhouse gas emission by recovering lakes and improving the green transportation system.
5. The programs had developed the model to save energy and respond to climate change by promoting of bicycles and distributing green homes.
6. The program has been utilized as channels for education, promotion, and experience for the public.
7. The program has served as the test bed to create new growth engines and build the foundation for overseas market entries.

One of key components of low-carbon economy is to drive city competitiveness. Cities clearly see addressing city climate change as a way to drive growth and competitive advantage in their jurisdictions. Addressing climate change and green smart urban development will lead to development of new business industries in cities.

Considering increasing attention put on urban-related issues, cities are in the age of low-carbon green growth. These are effective ways to both decrease our carbon footprint and adapt to climate change through urban planning techniques that incorporate energy conservation, use of renewable energy, ecological restoration, green transportation, buildings, and other sustainable technologies.

As an example, Suwon City, Korea, is a member of the EcoMobility Alliance and has achieved excellent results in certain dimensions of sustainable mobility. The city has adopted an eco-mobile lifestyle to experience how EcoMobility can influence lives of residents in a neighborhood in Suwon. Local Agenda 21 Movement is very strong in Korea with the slogan “Think globally, act locally”. The Korea Climate and Environment Network plays a main role in promoting the Movement in Korea. Virtually all local governments in Korea have adopted their Local Agenda 21 plans and have secretariats for the implementation of their plans with active participation from 9 stakeholder groups which were identified by UNCED. The Korea Climate and Environment Network took over the job of the Korea Green Star Network which was responsible for the Local Agenda 21 activities.

The Ministry of Environment of Korea has launched Eco-City initiative according to the 2012 UN Earth Summit for Sustainable Development Rio+20. Korea is one of countries to create UN sustainable cities, "Agenda 21 Eco-Cities." Urban eco-cities claim to regulate climate change, food distribution, water securitization, culture, and support in ways that are not facilitated by the current living conditions.

In April 2012, Seoul Metropolitan Government (SMG) has launched a program with the slogan "One Less Nuclear Power Plant," to reduce the city's use of energy by 2 million tons of oil equivalent, equal to the annual output of a nuclear power plant, and to reduce its environmental impact accordingly. The citizens of Seoul were inspired. They achieved their target in June 2014, six months ahead of schedule. Now SMG has launched phase 2 of the program, confident that the citizens of Seoul can do even better. Their crucial aspect of phase 1 was its success in enlisting active participation from the citizens of Seoul, individuality, and in their many affiliations.

Carbon banking system is a voluntary GHG reduction campaign in the manner of governance approach to climate change at the household level. The Gwangju city's carbon banking system is a carbon finance system which has implemented in 2008 as the first of its kind in Korea to reduce GHG emissions per capita. Because Gwangju's household and commercial levels accounted for 39% of GHG emissions in the city, reductions at the household level were urgently needed. Gwangju signed an agreement as a pilot study for climate change response (April 10, 2008) and planned activities around a carbon banking system to draw citizens' attention on the plan to reduce GHG emissions by 10%. Gwangju Bank issued a "Green Card," loaded with "Carbon Points" to individuals who reduce energy consumption compared to past usage.

The card operates like a debit or credit card, providing card usage fees to the bank. For the consumers, the carbon points are redeemable for a wide range of green goods, public transportation, and discounts at public sector facilities. The carbon baking system in Gwangju has led to a reduction of nearly 85,000 tons of CO_2 from 2008 to 2012 and projects an estimated 983,188 tons of CO_2 emission reduction by 2020.

The latest approach in developing a low-carbon economy in Korea is to establish Jeju Island as a zero-carbon island by 2030. On July 1, 2006, Jeju Island received provincial status. After the establishment of the governing institutions, economic and other reforms had been carried out including environmental protection laws. In June 2012, Jeju Province and the Korean central government jointly announced the plan to establish the "2030 zero-carbon Jeju Island," aiming at being carbon-free by 2030 and achieving a sustainable development through the only use of renewable energy.

On the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change in December 2015, Korea's President Park delivered a speech reaffirming the 2030 plans for Jeju Island being transformed "into a carbon free island by replacing its entire fleet of cars with electric vehicles and meeting 100% of its energy needs through renewable energy sources.” As for power generation, the envisaged program has three phases:

- In the first phase, a “zero-carbon island demonstration model” will be built. Onshore, seven wind energy pilot areas are being established with expected power generating capacity of 143 MW. Three offshore wind power generation test areas will be established with a total power generation capacity of 398 MW (Fig. 1.8).
- In the second phase of the plan, by 2020, a “zero-carbon island” infrastructure shall be established with the use of smart grids for renewable energy transmission. According to the plans, Jeju renewable energy generation shall account for more than 68% of total primary energy supply by 2020.
- In the third stage, up to 2030, Jeju Island will entirely use onshore and offshore wind power, solar energy, and energy storage systems (ESS) to replace all fossil primary energy. The ultimate goal of the Jeju government is to install 2.35 GW wind power (350 MW of onshore and 2 GW of offshore).

Wind power generators, Jeju island, Korea

Energy Technology Center, Jeju island, Korea

Fig. 1.8 Zero-carbon island demonstration facilities

It is planned to even produce 20% more electricity than needed on the island and feed in the surplus energy into the national grid in order to compensate for remaining fossil fuels used in other sectors of the economy and to become a true "zero-carbon island."

Very recently, Korean government has announced that new public buildings should be zero-energy buildings from 2020 according to "The 2030 National GHG Reduction Basic Roadmap."

On Tuesday (December 6, 2016), the Korean government announced mid- and long-term action plans to reduce greenhouse gas emissions in the country.

The pan-governmental comprehensive framework, approved by the cabinet, is intending to achieve the country's goal of cutting carbon emissions by 37%, or 315 million metric tonnes, as set out by the Paris Agreement.

In the new plan, the government seeks to boost incentives for renewable energy and cleaner power projects, in the hope of raising the share of renewables to 7% by 2020.

They also plan to introduce a cap-and-trade system to expedite industry innovation and environmentally friendly investment, while helping to integrate it to the future global carbon market.

The plans also pledge to expand funding in the development of climate technologies such as solar and fuel cells and conversion of waste gas, as well as doubling investment in clean energy research to 1.12 trillion Won ($957 million) by 2020.

According to the International Energy Agency, Korea is the world's seventh largest polluter, with its carbon output reaching 572 million metric tonnes in 2013.

Under the plan, the government aims to slash 219 million metric tonnes, or nearly 70% of the total reduction goal, from eight different areas including power production, industry, and buildings.

The largest reductions would come from electricity generation with 64.5 million metric tonnes, followed by industry with 56.4 million metric tonnes, buildings with 35.8 million metric tonnes, and new energy sectors including electric vehicles and energy storage with 282 million metric tonnes.

Seoul also looks to curb 96 million metric tonnes through international market mechanisms, focusing on carbon credit trading and funding sources.

Upon the release of the plans, the government said: "The action plans were formulated in a way that helps to shift the reduction-focused responses to climate change to a fresh paradigm centering on the market and technology … and strengthen the private sector's role and promote the acceptability of the policy."

The government ended the report by leaving room for future revisions, saying plans would be adjusted according to changing economic condition (Climate Action, December 2016) (Fig. 1.9).

Fig. 1.9 The Gasiri test bed of renewable energy including solar collector fields and wind power generators in the Jeju zero-carbon island

1.2.5 Current Good Practices on Eco-Development

1.2.5.1 Design for Energy-Conserving Cities: The Case of Gwacheon New Town, Korea

This section originated from the author's UNESCO report (Kim 1986), and thanks are due to UNESCO which helped to finance the study.

Energy conservation has become a major tenet of the environmental ethic, especially since the energy crisis of the early 1970s. At the same time, energy consumption in the world's cities continues to rise. In this article, the author presents the findings of a MAB project in Gwacheon New Town, which was conducted by an interdisciplinary research team including both natural and social scientists, under the auspices of the National MAB Committee of the Republic of Korea, in cooperation with the Korea Science and Engineering Foundation and with the support of UNESCO-MAB. He argues that by better understanding the relationship between city form and energy and by analyzing the energy demands of alternative designs, cities can be designed and organized for greater energy efficiency.

Introduction

One image of the city is as a voracious consumer of energy. Many studies have been undertaken of energy flows in cities to find ways to reduce energy use, to shorten energy paths, and to encourage energy conservation. Despite these efforts, the general trend of urban energy consumption is upward.

Less attention has been paid to the design of cities to be energy-efficient. Traditionally, throughout the world, the sites for homes and farms were carefully selected with respect to climate and geography. Factors such as sunshine, shade, wind, cold, and cloud were taken into consideration. In a less-populated world, houses and settlements were often linked by energy-efficient, least-distance routes.

To some extent, to design the energy-efficient city is to rediscover the experience of the past. But cities also pose new challenges to the designer; they are high-density, complex socioeconomic, political, and physical systems. Using Gwacheon New Town in Korea as a case example, studies were undertaken to evaluate the energy-saving implications of alternative urban designs.

Previous studies have generally focused on the distribution of energy. As an example, Fig. 1.10 shows the flows of energy in Hong Kong (Douglas 1983). Knowledge of energy flow patterns is not enough to design more energy-efficient cities. In the Gwacheon New Town MAB project, therefore, a more comprehensive analysis of energy use, and particularly the energy efficiency of alternative urban design, was undertaken. The overall framework for this analysis is shown in Fig. 1.11.

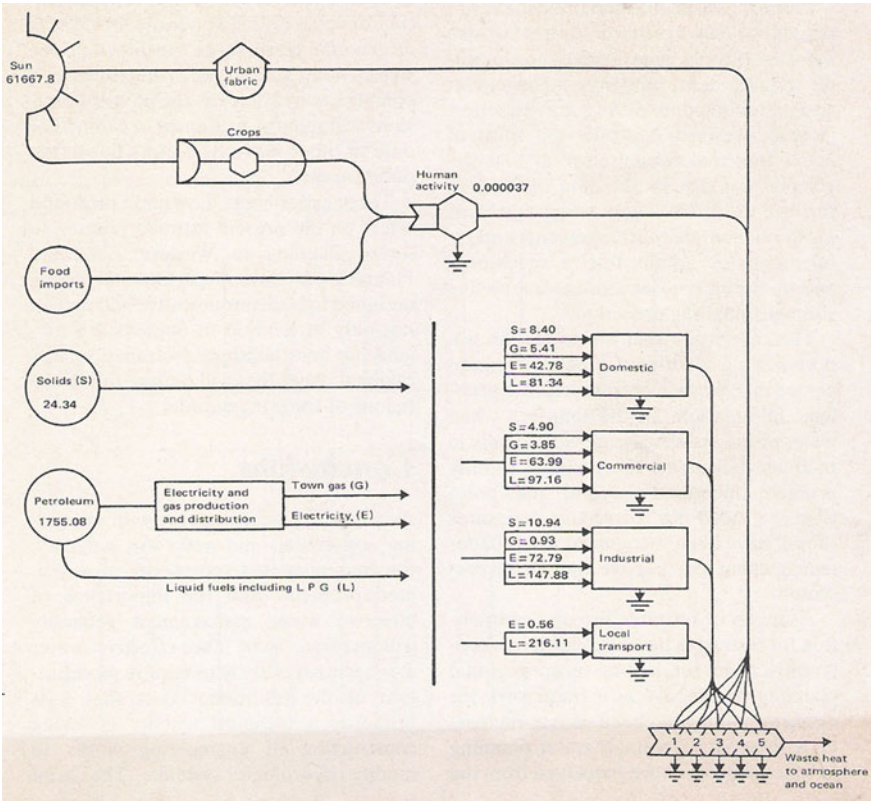

Fig. 1.10 Flow of energy in the Hong Kong ecosystem (based on data in Newcombe 1976) quoted in Douglas (1983)

Approaches to the Identification of Energy-Efficient Cities

Much can be done to conserve energy merely through good design, on both the large scale and small scale. In the USA, big focus is put on insulation and efficient heating/cooling systems.

Two complementary approaches to the identification of energy-efficient land-use patterns may be distinguished (Owens 1984). The first is a deductive approach in which alternative spatial structure is investigated to identify those with low-energy requirements. This approach was used to identify an energy-efficient land-use pattern for the redevelopment of the Perth metropolitan area in southwest Australia (Fig. 1.11).

The second approach is more normative; it starts with energy-saving principles (e.g., promotion of combined heat and power (CHP) generation), and from these, appropriate spatial structures are then devised. This approach of design in relation to climate characterizes the whole history of building and architecture. However, climatic design means different things in winter and summer. In winter, the objective is usually to resist loss of heat from the building interior and to promote gain of solar heat, such as directly through south-facing windows. In summer depending on the latitude, these objectives are reversed; to resist gain of solar heat, such as thorough sun-shading, and to promote loss of heat from the building interior. To achieve these objectives, Watson and Labs (1983, p. 50) also suggested nine practical climatic design principles (Fig. 1.12).

Once a designer understands the local climate from analysis of weather data, the set of climatic design principles appropriate to that climate can be elaborated and climatic design choices compared. "Energy-integrated" planning and design in the

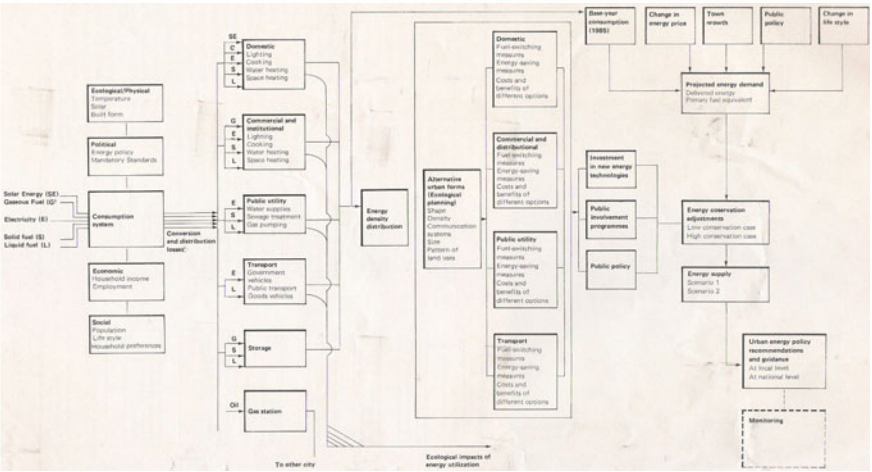

Fig. 1.11 Framework for energy analysis in Gwacheon new town: Gwacheon energy modeling and scenario assessments

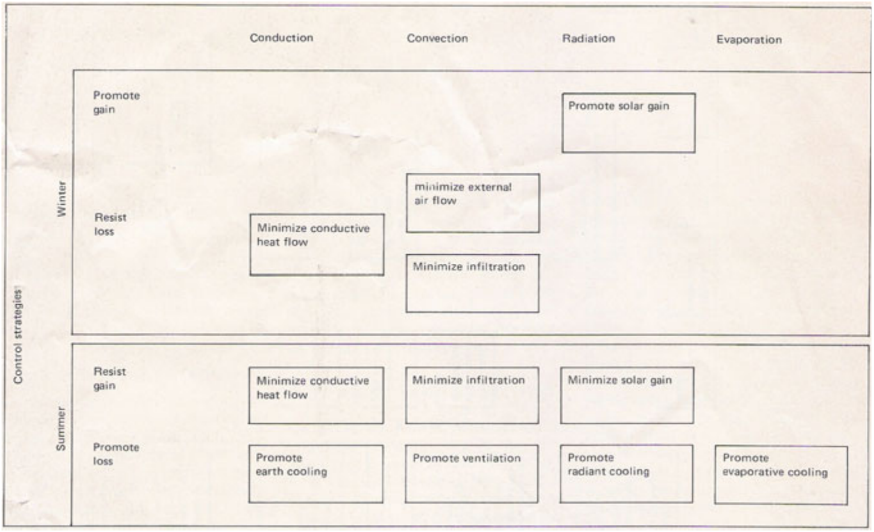

Fig. 1.12 Summary of the principles and strategies of climatic design

context of a highly urbanized area should mean the integration of the basic energy considerations in the entire site selection, planning, and design process (Fig. 1.13).

In the Gwacheon case study, it was recognized that both deductive and normative approach would need to be employed in any truly "energy-integrated" planning process.

Design for Energy-Conserving Cities: An Application

Here an attempt is made to show how "energy-integrated" planning and design concept can be applied to an actual urban area and integrated with site-specific data. It was envisaged that knowledge of the relationships between energy, land use, and climate in town planning and building design could reduce energy demand and thus alleviate many of urbanization's adverse effects and urban environmental risk to human health, plants, and animals.

The Study Area

Construction of Gwacheon New Town commenced in 1979 in an area 5 km south of the municipal boundary of Seoul. It lies in the valley situated between Gwanak Natural Park and Chyongge Natural Park (Fig. 1.14). The town was planned during the period 1979–1984 to be built in four phases to accommodate 63,000 residents and to house the second Government Hall. The initial plans for the town were not based on maximizing energy efficiency, so that the results of the MAB project were able to indicate to the planners, more energy-efficient alternatives.

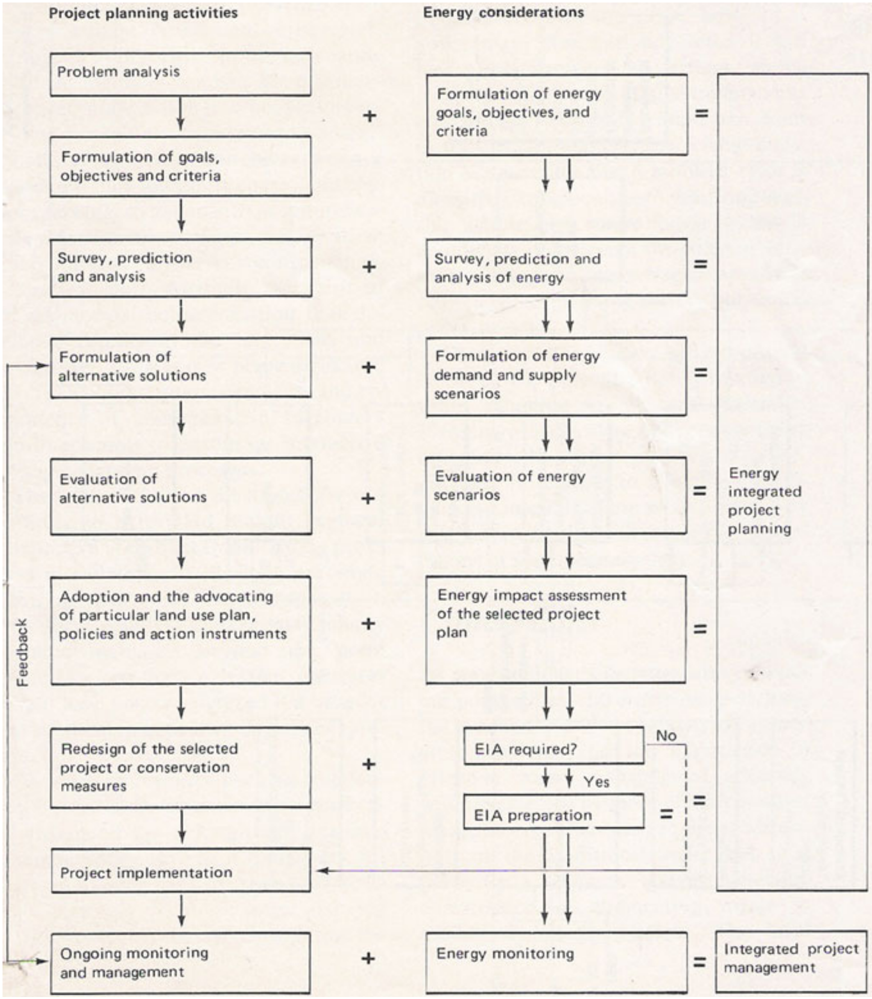

Fig. 1.13 Integrating urban planning and energy

Energy Density

For energy planning purpose, knowledge of the geographical variation in energy usage, i.e., energy density, is necessary. For example, feasibility studies for combined heat and power (CHP) require the preparation of heat load density maps. Other applications are related to assessing the effects of artificial heat release in urban areas on weather and climate, or to the environmental implications of energy-use patterns. Various approaches have been used to produce energy or heat load density maps. Most use land-use data in some form.

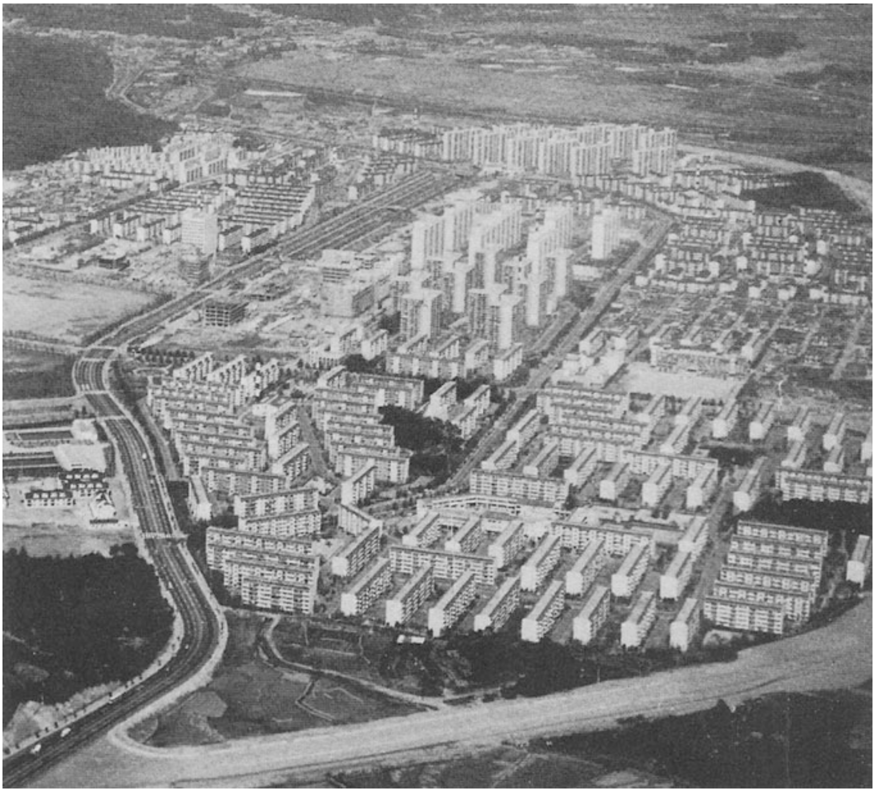

Fig. 1.14 Aerial view of Gwacheon new town

In Gwacheon, the energy-use data were recorded in the form of net heat density on a land-use map (Fig. 1.15). The land-use map was then superimposed on a net heat density map using a 100-m grid system. The resulting energy density map for the town is shown in Fig. 1.16.

Urban Form

Urban form includes building density, land use and the pattern of transportation routes, and other infrastructures. Since the density of Gwacheon New Town was already decided, the study concentrated on evaluating possible alternatives in terms of transport, mixture of uses (activities), design, and infrastructure (energy supply). These alternatives were then used as a vehicle for a general discussion on energy-efficient urban form. Figures 1.17 and 1.18 show the existing urban form in terms of land use and layout and an alternative, more energy-efficient urban form.

The two plans show how land use and building in Gwacheon might have been rearranged to take into account the six main findings of the project as follows:

Fig. 1.15 Net heat density (7, 1984–6, 1985)

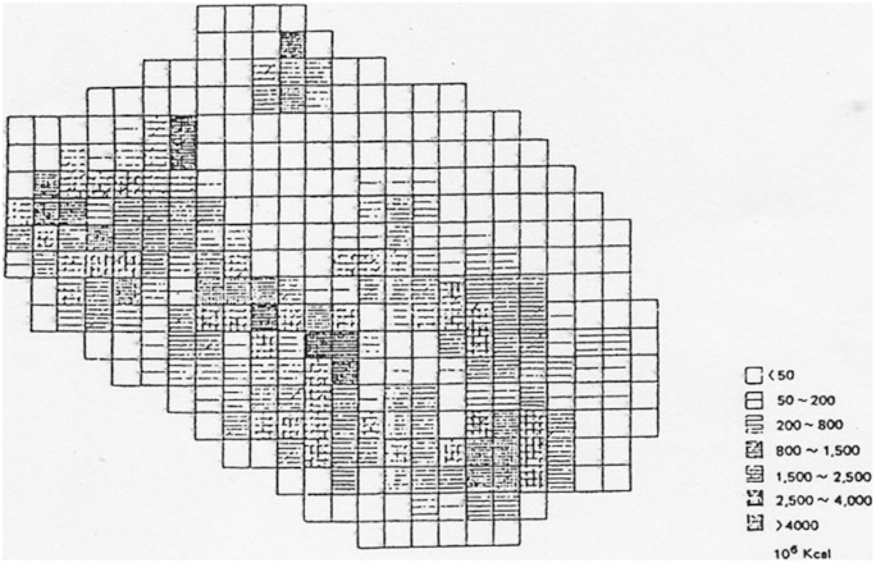

Fig. 1.16 Current land-use and heat load density (7, 1984–6, 1985)

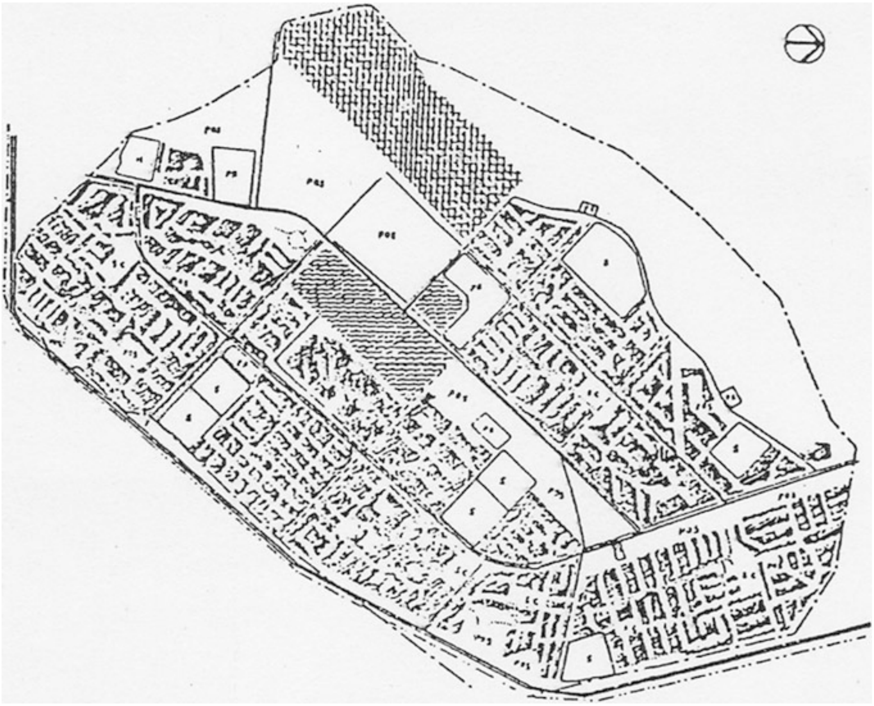

Fig. 1.17 Current urban form

- Defined routes be planned for public transport
- Attractive routes for bicycle ways and pathways be planned
- Higher housing densities be planned in the city center (central business district)
- A majority of houses be oriented toward the south
- Landscape planting for energy conservation be planned
- A possible combined heat and power/district heating (CHP/DH) system be introduced.

The energy-saving implications of some possible alternatives in light of energy-efficient land use are discussed in the following.

Transport

In considering transportation, which is a major reason for urban energy consumption, attention was paid to:

1. The energy-saving implications of non-rectilinear street plans and
2. Facilitating greater use of energy-efficient modes: walking and cycling, and an efficient public transport system.

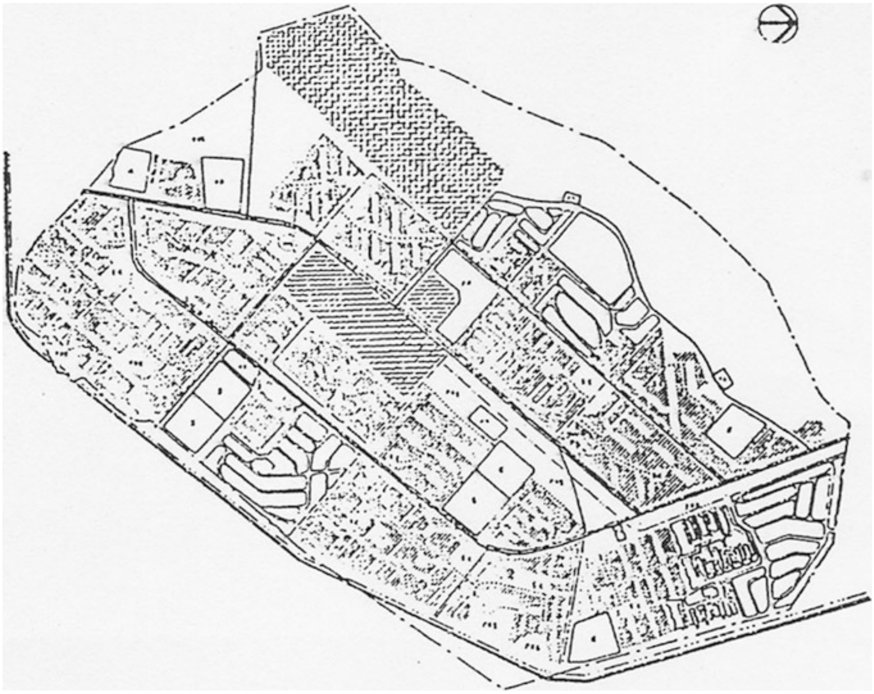

Fig. 1.18 Alternative urban form

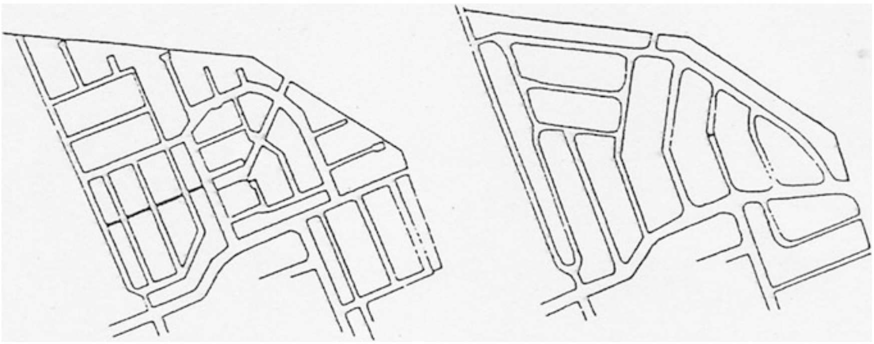

Fig. 1.19 Existing single detached housing area in site 9

One important finding was that curvilinear streets are a useful way to save energy. In Fig. 1.19, a possible subdivision of site 9 in Gwacheon is shown as a rectilinear pattern (left) and curvilinear pattern (right).

Similar non-rectilinear street plans were applied to other residential (single detached) housing area. The comparisons showed that only 2745 m of street are needed for the curvilinear layouts compared with call for 3287 m for rectilinear grids. Thus, curvilinear street plans have shorter loads and utility lines and thus can reduce traveling distances and car usage for private trips.

In the proposed alternative street plans for Gwacheon, bicycle roads and footpaths provide convenient links between residential streets and the town center, where the existing bicycle and footpath system offers segregated routes. The alternative provides comparatively safe and continuous bicycle roads and footpaths. It has other advantages. It reduces dependence on motorized transport which is a feature of the present design of Gwacheon. It also helps to create within the area a sense of extra space; it connects one block of apartments to another. Finally, the proposed layout provides key community facilities such as schools and hospitals.

Design

The study also considered how more attention to climatic aspects of design, particularly orientation and shading with respect to sun and wind, could influence energy consumption.

An important consideration is building orientation. Based on the work of the Housing Layout Study, and the Great Linford and Pennyland projects in Milton Keynes (1982) (United Kingdom), houses should face south ±40°, be reasonably unshaded, and have high insulation standards, to be most energy-efficient.

Table 1.5 shows the basic data resulting from orientation analysis.

In Gwacheon, an orientation analysis of apartments was carried out to evaluate the potential for passive solar heating systems. From the analysis, the effect of over-shadowing on the reduction in solar radiation passing through a south-facing window during a heating season can be determined.

Table 1.5 Orientation analysis by site

Site	Block Total	Block < ±40°	Block ±40°	Block > ±40°	The ratio of block <±40° to total blocks (%)
1	37	3	21	13	8.1
2	38	1	19	18	2.6
3	68	1	23	44	1.5
4	10	–	–	10	0.0
5	7	–	–	7	0.0
6	47	–	29	18	0.0
7	35	12	10	13	34.3
8	12	12	–	–	100.0
9	17	10	–	7	58.8
10	26	5	5	16	19.2
11	16	2	5	9	12.5
12	5	3	–	2	60.0
Total	318	49	112	157	15.4

Table 1.6 Comparison of existing layout for an area of apartment blocks (site 9) and its more energy-efficient alternative

	Existing layout	Alternative layout
Orientation	10 blocks: oriented south ±20° 7 blocks: oriented south ±70°	17 blocks: oriented south ±20°
Distances between apartment blocks	1.4 h	1.4 h
Solar radiation on walls and roof	**Sun data** Altitude: 37.57° Season: winter solstice **Apartment block data** Length: 50 m Height: 13.3 m Radiation: 225,164 (1) × 100 kcal/day	**Sun data** Altitude: 37.57° Season: winter solstice **Apartment block data** Length: 50 m Height: 13.3 m Radiation: 293,029 (1) × 100 kcal/day

It was found that 49 blocks of apartments in Gwacheon are oriented south less than ±40°, 112 blocks, ±40°, which still take advantage of solar gains, and 157 blocks more than ±40°. The proportion of apartment blocks oriented to take advantage of passive solar heating is only 50.6%.

To illustrate how the other blocks might have been rearranged, an alternative layout for one area is shown in Fig. 1.19, thus enabling us to estimate solar gains through redesign of the apartment blocks (Table 1.6).

The proposed alternative layout would increase the solar radiation received by about 30% (67,865 × 100 kcal per day). If it is assumed that all the 157 blocks oriented south more than ±40° could be realigned to face south ±20°, the increase in solar radiation received would be valued at 1522,155 × 10 kcal per day for all 157 blocks.

It can be seen that by considering site selection, building orientation, and spacing, urban systems can be made more energy-efficient in the order of 30% increase of insolation (Fig. 1.20).

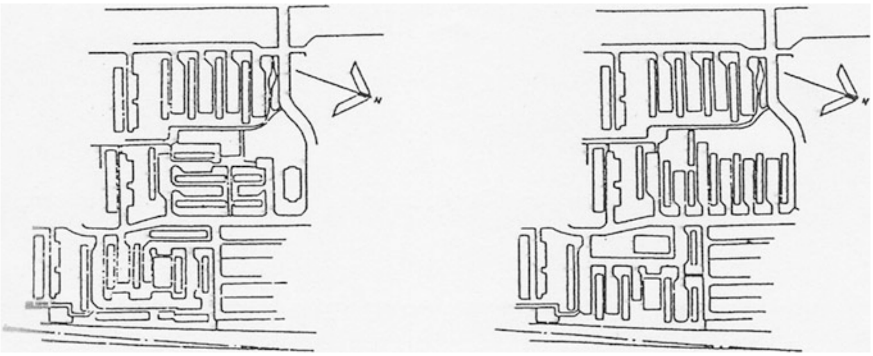

Fig. 1.20 Comparison of existing with proposed

Landscaping

Proper landscaping has a quantifiable impact on energy use, although the amount of heat varies according to the climate (Harwood 1977). It has been suggested that by careful shelter planting and landscaping techniques and selection of appropriate tree species, energy demands of building can be reduced by up to 10%.

Figure 1.21 illustrates how landscaping can allow solar rays to penetrate during the winter and to shade homes from sun in summer. It also illustrates how landscaping protects houses from cold northwest winds in the winter and channels cooling southeast winds toward buildings in summer. Solar "shadow prints" were drawn up showing the solar-based site-planning process.

In order to take advantage of solar heating, it is necessary to obtain data on the dynamics of the sun's apparent movement for given latitude.

Some of the basic considerations in the landscape planning for energy conservation can be generalized using some specific data from this case study as follows:

- Deciduous trees should be used for summer sun-shading effects and for winter sun penetration.

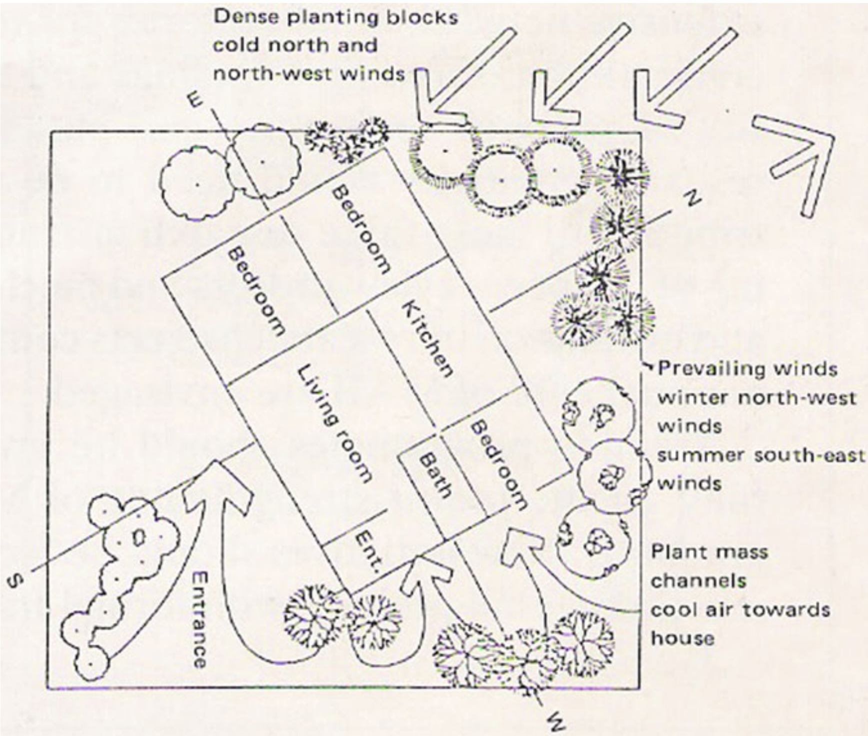

Fig. 1.21 Solar-based site-planning process (functional composite)

- Coniferous (needled evergreen) trees provide shade but generally do not perform as well as canopy plants or shade trees.
- High deciduous trees provide shade for dwellings and outdoor living areas.
- Tall evergreen trees on the south and southwest should be avoided in the cool or temperate regions.
- Windbreaks should be used against winter winds and should be placed close to the structure or area being protected.
- Lawns and grassy materials should be used in the immediate area of the dwelling structure since grass is a material capable or keeping a relatively even temperature throughout the day.

It is important to note that the extent to which a project design process includes energy analysis depends on the political style, the stage of economic development, and the environmental and climatic conditions of each country. Nevertheless, it is possible to make some brief and general indications of what may be the most significant areas facing developing countries:

1. There are at present no standard design methods for integrating energy considerations into urban planning but as the present article indicates, there are ways to incorporate these new ideas into urban design.
2. There is generally minimal participation in energy planning, by the general public or by interest group and governmental agencies. Lack of wide participation usually reduces the effectiveness of implementation.
3. There is generally no political mandate to impose special requirements relating to energy conservation such as energy impact statements for "urban design."

Because energy consumption and especially urban energy consumption is a major financial burden for national governments, particularly in developing countries, it is perhaps surprising that more consideration has not been given to energy efficiency design in urban planning. As this case study shows, relatively simple changes in street patterns and the spacing and orientation of buildings can produce energy savings of 30% or more. The resulting urban environment is also a more pleasant one to live and work in and is likely to produce indirect benefits through greater work productivity, less absenteeism, and lower health costs.

It is recommended that energy conservation should be an explicit objective in urban design, and planning courses should include training in techniques of energy-efficient design. At the same time, appropriate meteorological measurements and monitoring data should be collected for urban areas. Although the amount of energy saving will vary from site to site, depending on both climatic and urban characteristics, it is clear that the energy demands of most cities can be reduced by better urban design, particularly when areas are redeveloped or newly planned.

1.2.5.2 Low-Carbon Green City: The Case of Gangneung, Korea

This section originated from the author's paper (Kim 2010), and thanks are due to the Gangneung low-carbon green city planning team which helped to finance the study. The author was a Master Planner of the Task Force Team.

To address climate impacts, the Korean government designated some municipalities to become low-carbon green cities as part of green growth policy.

Gangneung city is one of those municipalities and takes a leadership role in embodying a green society. The goal of this case study is to introduce tools and green technology examples along with policy recommendations.

Introduction

The Gangneung low-carbon green city development plan includes a method of green growth such as improvements of water systems, ecosystems, transportation systems, and urban culture. The plan has seven chapters which discuss background, vision, objective, implementation plan for each objective, review of international cases, cooperation mechanisms among government departments, and expected results and future plans. This case study is a summary of this plan. This plan can be interesting for other municipalities because it:

1. Discusses cooperation mechanisms among stakeholders including local government, central government, public institution, private sector, and local citizens.
2. Proposes new techniques for low-carbon green city against climate change. The new techniques include adaptive design process, watershed urban planning, eco-cycle approach (considering carbon and water footprint), mitigation and adaptation technology, application of crosscutting techniques in urban planning process, and Urban CDM method.
3. Proposes how environmental assets can be improved in the development process through restoration of water, wetland, forest, and coastal line.
4. Is based on future thinking. It stresses that effort against climate change and ecological restoration should be included and specified in the early development stage for the success of green growth and sustainable development.

Low-Carbon Green City Concept

The low-carbon green city plan in which this study proposed applies eco-balance game based on the water corridor and green corridor to calculate emission and absorption of CO_2 in the low-carbon green city. Also, location and natural resources were considered to create low-carbon pilot complex including renewable energy facility such as solar heat, solar electricity, and waste energy. Also, renewable energy demonstration, training facility, and climate gallery were included in the plan. The ecological elements such as rain garden, earth-sheltered house, wind-corridor residential complex, and eco-village are efficient programs for CO_2 reduction, and they were considered for the final conceptual plan in the shape of water circulation, wind circulation, and resource circulation. Also, new conceptual transportation such as magnetic levitation train was adopted for the road network. Furthermore, the application of green rooftop and ecological corridor would allow the low-carbon green city to contribute for the increase of biodiversity.

Application to Urban Revitalization Site

The below are the proposal for water circulation and wetland structure in Gyeongpo Lake watershed level, which indicates the use of techniques for water and wetland system. The result would conserve biodiversity and natural ecosystem in the Gangneung city and increase the civil amenity through the increase of quality of health along with water and residential complex with functional integration among different urban elements.

Site Characteristics

Gangneung city located in the middle of Gangwon province, the eastern region of Korea, is a central base city for development of industry, culture, transportation, tour, and education (Fig. 1.22). The city is between the Taebaek Mountains and the eastern coast and is relatively less developed compared to many other cities in Korea. Accordingly, the city contains a large area of forest with wild animals and is advantageous for utilizing natural energy sources such as wind energy and solar energy. As it is located to next to the coast line, the city is under direct impact of sea-level rise and experiences shortage of rainfall in the summer time. The city, therefore, is very vulnerable to the climate change impact.

The area was previously agricultural area with freshwater stream and salty water lagoons. The area had already high biodiversity, and the ecosystem survey indicated that several native species were present. There were five passing roads, and a bank to protect farm road and farmland.

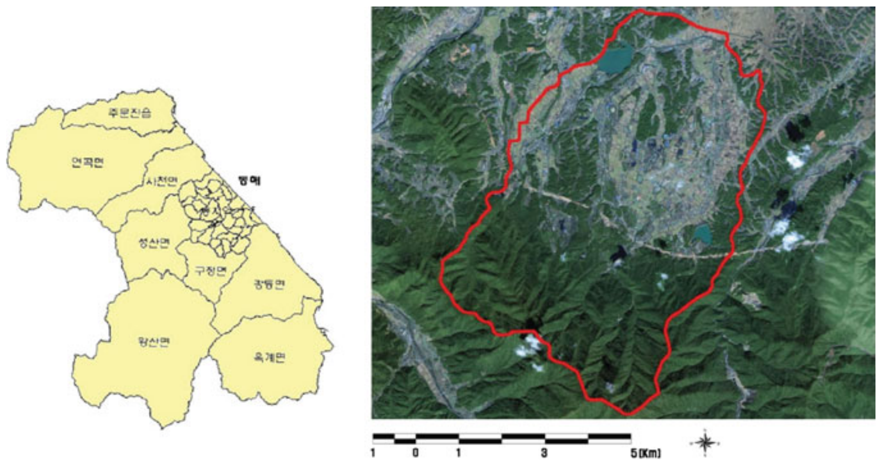

Fig. 1.22 Location of Gangneung city and Janghyeon reservoir

Opportunities and Challenges

With 19,000 inhabitants and an area of 17,545,000 m^2, the study area is a relatively low urbanized area with little development. There is almost no industry, and the site contains historical and cultural assets. Water, wetland, forest, and costal line have been well preserved and tourism flourishes (Fig. 1.23).

Observed and Projected Climate

Before any mitigation or adaptation strategies can be implemented, a sound understanding of the observed and projected climate is necessary. The Figs. 1.24 and 1.25 underneath show the observed trends in annual mean temperature (°C) and annual rainfall (mm) for Gangneung, Korea. Over the given time period, Gangneung has experienced increasing trends for both temperature and rainfall, with increases of 0.1 °C/decade and 35 mm/decade, respectively. The annual temperature and rainfall values for the city were computed using a monthly data set. The months in the data sets that were missing were replaced by the climatologic average for that month over the full time series. The plots of both climate variables cover the period from 1912 to 2008. In addition to the observed trends, a linear trend line along with the calculated trend per decade is included for each of the plots. The data set used for the temperature and rainfall values was the NCDC Global Historic Climate Network (GHCN), Columbia University, New York, the USA.

Fig. 1.23 Land use of the study area in 2010. *Source* Google Earth

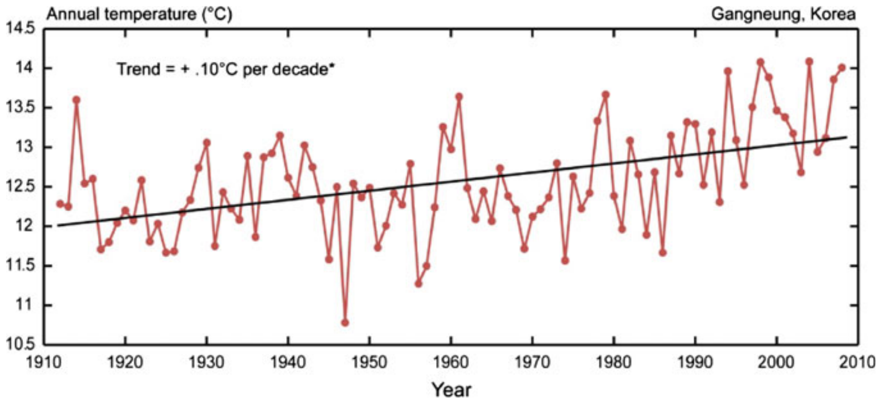

Fig. 1.24 Observed annual temperature in Gangneung, Korea, from 1912 to 2008

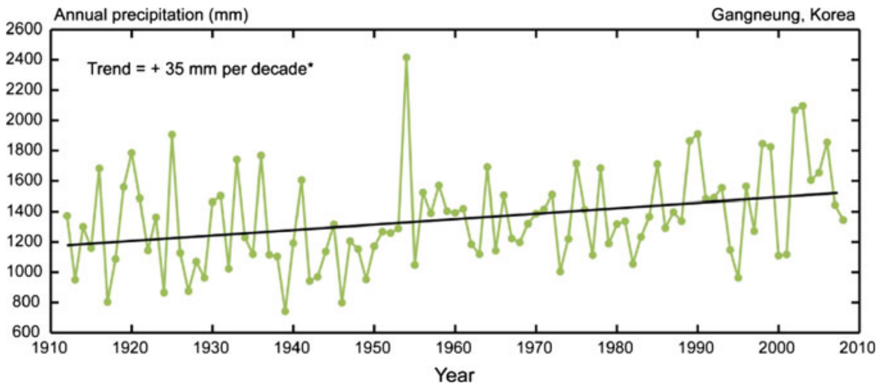

Fig. 1.25 Observed annual rainfall in Gangneung, Korea, from 1912 to 2008

Temperature and rainfall both are expected to increase over the next 100 years. By the 2080s, temperature increases of +2.0–4.0 °C and rainfall increases of +5–20% are projected. These results are continuations of the trends that have been observed during the twentieth century and the early years of this century (Table 1.7).

Figures 1.26 and 1.27 underneath combine the observed climate trend with the model-based projections. On the left hand of the figure, the observed trend is plotted. To the right, the range of projections across all the GCMs and emissions scenarios is shown. A ten-year filter has been applied to both the observed data and model projections to highlight the climate signal and reduce interannual variability. The three thick lines (green, red, and blue) show the average for each emissions scenario across the 16 GCMs; shading shows the central range. The bottom and top lines show each year's minimum and maximum projections, respectively, across the suite of simulations.

Table 1.7 Baseline climate and mean annual changes

Gangneung	Baseline 1971–2000	2020s	2050s	2080s
Air temperature central range	12.9 °C	+1 to 1.5 °C	+1.5 to 2.5 °C	+2.0 to 4.0 °C
Rainfall central range	1400 mm	−5 to +10%	+0 to +15%	+5 to +20%

Note Based on 16 global climate models and 3 emission scenarios (A1B, A2, and B1). Baseline is 1971–2000 for temperature and rainfall. Central range = middle 67% of values from model-based probabilities. Temperature ranges rounded to the nearest half-degree and rainfall to the nearest 5%

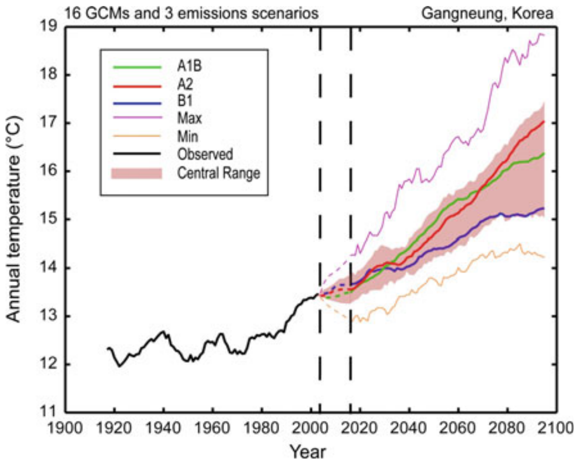

Fig. 1.26 Observed climate and future projections for temperature in Gangneung, Korea

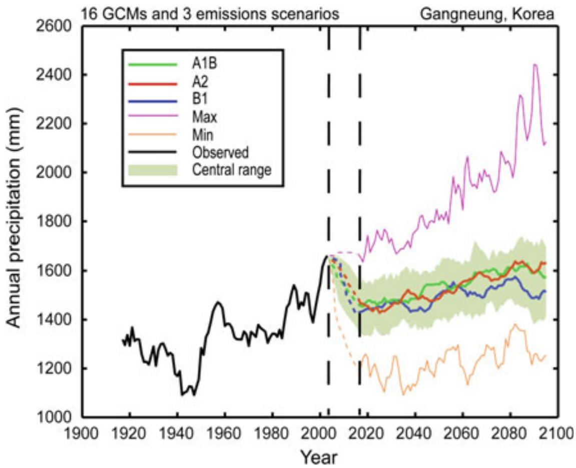

Fig. 1.27 Observed climate and future projections for rainfall in Gangneung, Korea

Projected model changes through time are applied to the observed historical data, resulting in a combined observed (black line) and projected temperature changes. The three thick lines (green, res, and blue) show the average for each emissions scenario across the 16 global climate models. Shading shows the central range. The bottom and top lines, respectively, show each year's minimum and maximum projections across the suite of simulations. A ten-year filter has been applied to the observed data and model output. The dotted area between 2003 and 2015 represents the period that is not covered due to the smoothing procedure.

As shown in Fig. 1.26, rainfall records often display large decadal variability. For example, rainfall in the city was low in the 1920s–1940s and has been increasing since then, with several years later in the period with extremely high above-average rainfall. These high annual rainfall values are higher than the observed mean of the 1971–2000 periods, which is the value to which the model projections are applied. The initial decrease in projected rainfall in Fig. 1.26 is an artifact of these recent high annual rainfall values.

These projected changes are likely to cause impacts on many aspects of the city of Gangneung, including heat stress on its citizens, deterioration of infrastructure, and enhanced flooding. Adaptation to the changing climate should be considered in urban planning for the city, to ensure sustainable growth and development.

Principles

Thirty-eight low-carbon green city planning principles have been developed. They aim to:

Overall

1. Maintain and, where possible, improve the quality of air, land, water, and green space through the prevention and control of pollution, and by applying ZED principle.
2. Consideration of linkage with surrounding area or city.

Air: Energy

3. Convert solar and wind energy into electrical energy or use to heat water.
4. Convert the heat from the treated wastewater into district heating and district cooling.
5. Convert biofuel from nature into district heating electricity.
6. Convert combustible waste into district heating and electricity.
7. Extract biogas from the digestion of sewage sludge.
8. Maintain and create wind path (white network).
9. Utilization of carbon card.
10. Energy recovery from water temperature difference.

Water, Wetland, and Sewage

11. Rainwater from courtyards and roofs is not drained to the wastewater treatment plant, but into communities.

12. Rainwater from streets is treated locally/settled and then drained into communities, not to the wastewater treatment plant.
13. Manage ground and surface water resources to achieve the right balance between the needs of society and the requirements of the environment.
14. Manage and restore wetland, floodplains, and flood risk for the benefit of people and the natural environment and the protection of property.
15. Conserve and enhance the natural, cultural, and historical value of river corridors, their landscapes, and biodiversity.
16. Retain, improve, and promote water, wetlands, and waterside land for the purposes of eco-tourism, navigation, appropriate recreational use, and public access and enjoyment.
17. Use the post-extraction sludge—the biosolids—as a fertilizer.
18. Maintain and create water circulation system (blue network).

Earth: Waste

19. Achieve reductions in waste through minimization, reuse and recycling, and improved standards of handling and disposal.
20. Help the residents to sort their waste at source with an automated waste disposal system with different refuse chutes, block-based recycling rooms, and area-based waste collection points.
21. Convert combustible waste into district heating and electricity.
22. Convert/digest organic waste into biosolids and use as fertilizer.
23. Recycle all recyclable material: newspaper, glass, cardboard, metals, etc.
24. Incinerate or recycle hazardous waste.

Forest, Parks, Green Space, and Habitat

25. Prevention of coastal erosion due to sea-level rise and ecosystem restoration.
26. Biodiversity increase.
27. Diversification of green area and habitats.
28. Conservation of ecosystem, restoration, and diversification.
29. Forest increase as a carbon sink.
30. Selection of indicator species in Gangneung city.
31. Establishment of green network.
32. Promotion of community garden.
33. Increase of approach to green area (trails, etc.).
34. Green rooftop and wall.
35. Utilization of wetland as a pollution purification system.
36. Promotion of green area and rainwater garden in infrastructure design process.

Metals

37. Minimized use of rare minerals.
38. Minimization of impact from abandoned mine.

The principles include land-use plan and environmental, culture and tourism elements to be considered in the infrastructure planning.

Implementation Strategies

The implementation strategies for the creation of low-carbon green city based on the principles are as follows:

- Creation of clean environment through conservation and restoration of natural environmental.
- Creative design based on history, culture, and regional resources.
- Test bed for high-tech green techniques.
- Stepwise improvement of low-carbon traffic, houses, and energy.
- Promotion of citizen participation and green activities.

Low-Carbon Green City Model

Gangneung low-carbon green city model was developed to strategically link elements with principles. This model is based on holistic thinking of "Everything is connected" approach (Fig. 1.28).

Fig. 1.28 Model for Gangneung low-carbon green city: a circular model

Potential Techniques

Various potential low-carbon green techniques are available as shown underneath (Tables 1.8 and 1.9).

These techniques (together with the low-carbon green city model) provide opportunities for mitigation and adaptation for Gangneung city in the beginning stage of planning. Also this model emphasizes the need for identification and assessment of mitigation and adaptation measures in land-use planning.

Targets

The plan has three periods of short-term (2012), middle-term (2013), and long-term (2016). Therefore, major indicators in each term are needed. Table 1.10 underneath indicates the related indicators and foreign cases. In Gangneung low-carbon green city plan, international certification is planned on building level as well as entire city level.

Selection of Interventions (Tools and Techniques)

Table 1.11 below indicates what interventions can be used for Gangneung low-carbon green city. In addition to the climate tools and techniques included in the low-carbon green city creation plan, new climate tools are added in Tables 1.11 and 1.12.

Table 1.8 Mitigation and adaptation technology in each sector

Mitigation (Mitigation)

Sector	Potential Mitigation Techniques
Energy	-Efficiency improvement -Conversion from coal to gas -Renewable energy -CCS (Carbon Capture and Storage)
Transportation	-High efficient and hybrid cars -Clean diesel and biomass fuel cars Conversion from cars to train and public transportation Land use and transportation planning, bicycle and walking, -High efficient airplane
Building	-Efficient lighting, window & electronic devices, insulation -Active & passive solar design -Integrated design and system
Industry	- Heat recovery - Recycle of materials - Management of CO2 emission
Agriculture	-Management of farmland to store carbon -Restoration of damage land -Management of CH4 and N2O reduction
Forestry	-Lodging, minimized forest cultivation -Management of tree production, Biomass -Improvement of carbon-absorption capability in trees -Satellite survey to search carbon-storage potential of plants and soil
Wastes	-Energy production -Compost of wastes

Adaptation (Adaptation)

Sector	Adaptation Option/Strategy
Water Resources	-Increase of rainwater collection, water storage and conservation -Reuse of water, desalination -High efficiency of water use
Security of Agriculture and Food	-Change of vegetation period, multi-species planting -Change of vegetation locations -Efficient land use) -Training for soil and water conservation and management
Residence (including Coastal)	-Relocation, breakwater, sand dune -Creation of land against sea-level rise -Vulnerability survey and assessment
Human Health	-Health care action plan -Emergency medical service, medical exam -Natural hazards management system -Improvement and management of clean water
Ecology	-National forest prevention system -Improvement of carbon storage in forest -Restoration of stream and wetland -Recognition improvement of coastal ecosystem
Energy	-Strengthening of supply system -Renewable energy -Diverse energy sources

Integration(Cross-cutting)

Climate Change as a national policy	Climate Change Planning & Initiatives Promotion	CDM	Survey & Research	Education & Training	Recognition Improvement

Source IPCC

Table 1.9 Ecological restoration techniques

Eco-restoration project	Technique	Eco-restoration project	Techniques
River restoration	Plan, design, construct	Abandoned mine restoration	Eco-restoration, biosolids, greening
Flood control	Setback, off-channel wetland, flood plain management	Landfill site restoration	Vegetation, assessment
Eco-pond	Water speed control, habitat translocation, soil	Slope restoration	Geo-green
Eco-park	Restoration on each habitat type and species	Flooded area restoration	Stabilization of soil, vegetation

Table 1.10 Basic development and application in Gangneung low-carbon green city

Scale	Project	Criteria		Foreign example
		National criteria	International criteria	
City level	Gangneung low-carbon green demonstration city	–	–	Hafel, Germany
Neighborhood or district level	Soonpogae wetland	National wetland conservation site designation criteria	Ramsar site designation criteria	Masdar, UAE Dockside, Canada BedZed, UK
	Raw fish community Motel community Café community	Low-carbon community designation criteria	LEED (Neighborhood development) designation criteria	
Building level	Climate change low-carbon green experience center	National certificate system of green building	LEED (USA) BREEAM (UK) CASBEE (Japan) DGNB (Germany)	All buildings in the dockside (LEED platinum level) Miramar college parking structure and police substation (LEED platinum level)

Comprehensive Plan

Gangneung low-carbon green city comprehensive plan includes 12 specialized projects:

- Wetland ecological park and wetland ecological resource exhibition center with coastal wetland, lagoon, and freshwater wetland.

Table 1.11 Climate techniques suitable for Gangneung low-carbon green city

Climate change	Techniques	Note	Climate change	Techniques	Note
Mitigation	Renewable energy	Existing	Climate design	Climate smart urban basic plan	New
	Heat recovery from sewage treatment plant	Existing		Adaptive design progress	New
	Bioethanol	Existing		Total energy system design	New
	Geothermal energy generation	Existing		Blue network design	New
	LED light	Existing		White network design	New
	Reuse of rainwater and gray water	Existing		Urban greening and green network design	New
	U-bike	Existing		Urban forestry plan	New
	U-eco-city	Existing		Climate smart traffic system	New
	Electric bus	Existing		Water-sensitive design	New
	Subway	Existing		Climate smart design	New
	Biomimicry	Existing		Resource circulation urban design	New
	Heat recovery	Existing		Habitat-sensitive design	New
Adaptation	Biostructural technique			Local identity creation	New
	Ecological conservation and restoration	Existing		Smart eco-city	New
	Greening	Existing		Cultural and ecological tourism city planning	New
	Non-biostructural				
	Ecological conservation and restoration	New			

- Green growth development complex leading solar industrialization.
- Green growth industry complex.
- Low-carbon green hotels and Anhyun Solar ZED Valley.
- Solar building pilot complex (Gangneung Zed Beach Village).
- Green growth experience and learning center, as a landmark.
- Low-carbon green communities.
- Test bed for experimental low-carbon green technology.
- Demonstration areas of ecological restoration.
- Company-owned zed condominiums and a convention center.
- UNESCO designated Urban Biosphere Reserve.
- Utilization of carbon under international standard.

A conceptual map underneath gives a visual impression of the comprehensive plan (Fig. 1.29).

Table 1.12 Climate tools suitable for Gangneung low-carbon green city

Climate change	Tools	Note
Climate tools	Climate prediction modeling	New
	Urban vulnerability and opportunity assessment	New
	Mitigation, adaptation, and crosscutting tools	New
Implementation tools	Environmental management audit system	New
	Economic tools (incentive, etc.)	New
	Climate impact assessment	New
	Low-carbon green city fund	New
	Carbon footprint of city, complex, and building	New
	Accreditation system for building, complex, and city	New
	Zero-carbon credit	New
	Eco-labeling	New
	Green electricity certificate	New
	Green thermal certificate	New
	Biodiversity credit	New
	Emission Trading Scheme (ETS) Carbon banking system Green Climate Fund (GCF)	New

Fig. 1.29 Conceptual map of Gangneung low-carbon green city comprehensive plan

Alternative 1 of wetland design

Alternative 2 of wetland design

Alternative 3 of wetland design

Fig. 1.30 Alternatives of wetland design

By the creation of the water circulation infrastructure through increasing and managing of water system, creek, tributary, pond, and reservoir, this comprehensive plan aimed to create tributary, stream, pond, and water circulation system in reservoir through the use of rainwater, gray water, and waste water.

The several site surveys, conducted with the international experts, in particular, indicated that linkage with the surrounding areas of stream area and wetland area was required in the plan.

Major Site Proposal

This study considered the proposal from Gangneung city in terms of low-carbon green city. Figure 1.30 shows the alternative results after applying alternative methods for the decision-making. The alternatives were derived after analysis of the environmental impact from the Gangneung city's proposal design to balance with the existing wetland, stream, and lagoons. Also, the ecological linkage was to be increased with the linkage of stream and wetland with the Gyeongpo Lake. Accordingly, the shape and slope of the island was to be changed, along with the vegetation on the slope. Also, the length of the shoreline was to be increased while isolating the birds' protected area to create corridor and habitats for wildlife animals, in order to increase the biodiversity along with providing places for studying and learning.

1.2.5.3 Environmental Impacts of Urbanization: The Case of Gwacheon New Town, Korea

This section originated from the author's UNEP report (Kim 1983), and thanks are due to United Nations Environment Program (UNEP) which helped to finance the study. Environment-friendly new town development can help reduce GHG emissions and vulnerability to climate change.

Introduction

Policy Making and the Need to Study the Environmental Impacts of New Town Development

The creation of new towns is undeniably one of the best examples of man's ability to modify both his physical (built) and socioeconomic environments. A new town not only has a physical presence with buildings, streets, and open spaces, which have immediate tangible and visual impacts, but also contains people who use these facilities and generate waste and pollution, the disposal of which creates other impacts often of a wide-ranging nature. There have been increasing public concern in most industrialized and industrializing societies since the late 1960s about environmental quality, and in particular about the wider and long-term effects on the environment and on local communities of such major urban and industrial or large-scale building projects are taken into account, along with other assessment criteria, by policy makers.

It is becoming increasingly desirable, therefore, to be able to establish the impacts and to measure the relevant gains (social benefits) and losses (social opportunity costs) which may result from any given project or course of action. Two of the better-known sets of analytical techniques available: the costs and benefit analysis (CBA) and environmental impact assessment (EIA). CBA procedures attempt to evaluate and compare the costs and benefits which might accrue from the given project or action. EIA, on the other hand, is specifically designed to look at the nature and distribution (the social spread, timing, and effects on particular groups or areas) of impacts which can result from a particular action or policy. Therefore, EIA often deals with effects which are not readily quantifiable nor easily included in a conventional cost-benefit balance sheet (Turner and O'Riordan 1982). This section illustrates how the numerous and varied potential impacts of the development of a new town in Korea can be assessed and, by means of an extended cost-benefit analysis (ECBA), incorporated into an evaluation with a wide base of predicted and assessed impacts.

The case study attempts to show how ECBA and EIA can provide policy makers with valuable assistance in estimating at the planning and design stage the potential impacts, costs, and benefits of new town development. Not only can the impacts, costs, and benefits of various courses of action be estimated, but the economic effectives and, perhaps, the social desirability of implementing various mitigation measures, so as to counter undesirable impacts, can also be estimated. Moreover, alternatives to any proposed developments or components of a new town can be evaluated insofar as individual factors can be identified. The actions of developers —for example, the provision of new residences, utilities, drainage, open space, or streets—can be indicated as having certain positive or negative effects which range from major to minor. The costs and benefits of actions and feasibility of avoiding or mitigating these impacts can therefore be assessed.

The incorporation of various types of CBA or EIA into new town planning is not totally new, but research in the past has often been restricted to assessment of the impact of certain components or features. Giles (1978), for example, provides a useful discussion of the impact year by year of new urban development on agricultural land and farm laborers; other studies might focus on the effects of pollution or transport. In this section, the case study tries to show the value of a wider analysis. The environmental impacts of new town development are varied and can be as important as the social consequences (such as the provision of services, housing, and employment). The provision of buildings and infrastructure has impacts which affect the quality of life of residents both in and around a new town. If planners and policy makers are able to assess these effects prior to development, then it may be possible to identify alternative ways of proceeding which will enhance the eventual functioning of the new town.

The case of Gwacheon new town illustrates how new town developments can provide the maximum benefit using the resources which are available. The initial high costs of the analyses can almost certainly be recouped from the saving accruing from the prevention of mistakes in development. The creation of new towns is expensive and, as suggested, it provides one of the most obvious examples of man's ability to modify his environment. Some form of CBA and EIA is therefore not only appropriate but also probably essential to the sensible planning of such developments. It is widely recognized that the success of environmentally sound development projects depends on the understanding of social needs and opportunities as well as of environmental characteristics (Munn 1979). The case study illustrates how socioeconomic factors, personal evaluation, and other matters can be complementary to more conventional environmental impact assessment, and how they might provide policy makers with a better and more potent yardstick than is usually available to predict and modify the effects of new town development (Fig. 1.31).

The Integration of EIA and the Planning of New Town Development

EIA methods can be integrated with the planning procedures for new town projects. This is relatively simple where the planning procedures and mechanisms are well established and clear. It is perhaps less easy to integrate the two when planning is more piecemeal, weakly developed, or without a strong legal basis.

If proper integration is achieved, environmental impact statements will help to detect, at an early stage, negative environmental effects which may occur, and they can help to avoid costly later plan changes and delays. More importantly, perhaps, the final plans should be more sensitive to all of the needs—social, cultural, and physical—of the people who will live in and around the new town.

Figure 1.31 shows how the sequences of new town planning and design and environmental assessment might be integrated and how links between professionals at various stages can be made explicit (Kim 1984). The basic aims of impact identification, assessment, and evaluation are to provide feedback for improving plan and design, to assist in making a choice between alternatives, and to suggest mitigation measures (to reduce adverse environmental impacts). Measures which are designed specifically to mitigate the often inevitable adverse environmental

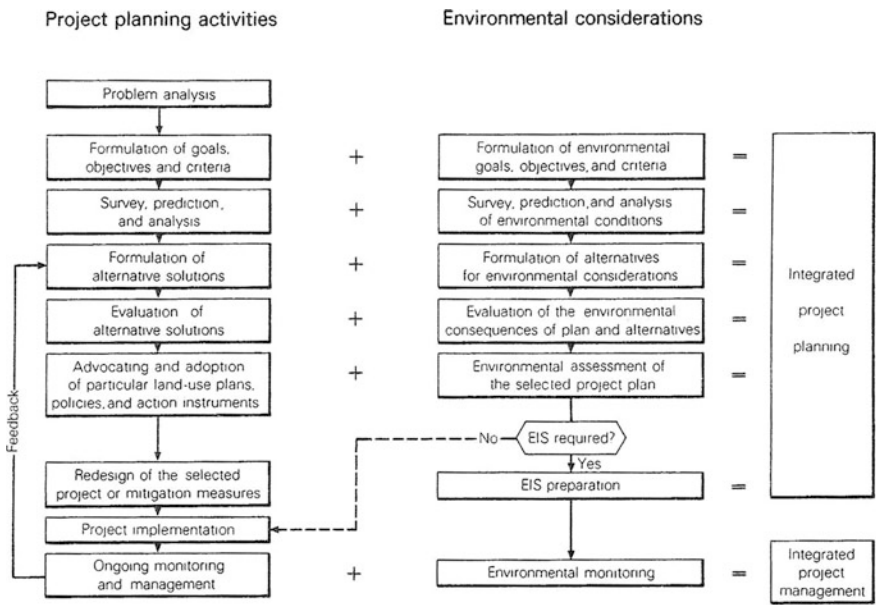

Fig. 1.31 New town planning and design—environmental assessment sequence

impacts of new urban development and to enhance environmental quality should be given special attention in environmental assessment.

Although the stages and links indicated in Fig. 1.31 may appear to be logical and relatively straightforward (e.g., the concurrent formulation and evaluation of alternative plans and their environmental consequences), these are impediments to the implementation of impact assessments and thus to the achievement of integrated project planning (Kim 1984). In Third World countries in particular, poverty puts a premium on short-term, income-producing activities to the detriment of the long-term protection of natural systems. The technical, economic, and administrative personnel and expertise necessary for the planning and implementation of environmental management programs may be inadequate. There may be minimal participation or interest in environmental quality planning, either on the part of the government agencies or the public in any particular country. Data problems may beset the sophisticated calculations necessary for EIA: environmental, economic, and social data may be deficient or non-existent, and there may be little knowledge of past trends and baselines, which inevitably limits the quality and scope of the analysis. Finally, if a wide diversity of cultural values exists, it may be difficult to evaluate the social significance of certain effects on environmental quality. This may also be important when international comparisons are being made between various impact analyses.

In addition, various practical impediments which may hinder the implementation of EIA methodologies, even where they are desired, should be borne in mind.

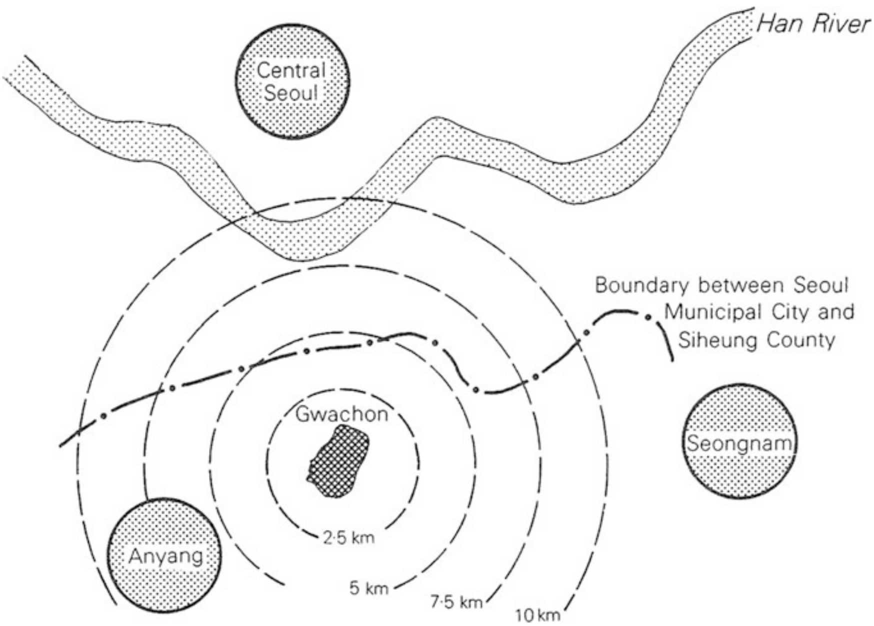

Fig. 1.32 The regional setting of Gwacheon new town

Corruption, group conflicts, a shortage of skilled personnel, administrative weaknesses, the lack of information and consultation, and poor communications and coordination can all prevent implementation.

Korean Responses

In response to the problem of the deterioration of environmental quality associated with rapid industrialization and urbanization during the last two decades, the Korean government has taken legal and administrative actions to meet the challenge of environmental pollution. An important move in coping efficiently with environmental problems (some of which may be associated with new town development) was the promulgation of the Environmental Preservation Law in 1977. An environmental impact assessment system was adopted and, in 1980, the Office of Environment was established.

Despite substantial progress in environmental impact assessment, existing procedures and methods of assessing the impacts of new town development have been found to be inadequate. In other words, the conventional approach to project appraisal and development planning has contributed to the development of new towns, but the undesirable environmental and socioeconomic consequences of new town developments are beginning to demonstrate the demand for a new, sound approach to evaluation (see, e.g., Kelly 1975; McAllister 1980; Bisset 1984).

The principal aim of this study (which was carried out in 1982–1983) was to improve understanding of the impacts which the development of a new town creates and to develop an assessment methodology which would work in practice in the Korean setting. The ECBA model is a practical form of assessment for application in new town schemes. Its application in the specific case of Gwacheon new town is considered below.

Environmental Impact: The Case of Gwacheon New Town

Strong national new towns policies, including new towns legislation (such as the New Towns Act of 1946 in Britain), have not emerged in Korea. In the absence of an explicit new towns policy, the importance of economic influences can be clearly seen when changes over time in the new towns program in Korea are assessed. However, it is still very relevant to look at the application of ECBA/EIA in this context, as the case of Gwacheon illustrates.

Construction of the new town of Gwacheon commenced in 1979, in an area five kilometers south of the municipal boundary of Seoul (Fig. 1.32). The town was planned to accommodate 63,000 residents during the period 1979–1984 and to house the Second Government Hall. It is a project in phases, numbered I and IV. The developments for phases I and II have been completed, and grading for phase III was in progress at the time the study was carried out. The Second Government Hall will be developed by the Ministry of General Affairs, and the new town (the hinterland of the Second Government Hall) will be developed by the Korea National Housing Corporation.

According to the construction plan for the Second Government Hall, Gwacheon will be developed as an administrative new town in order to disperse administrative functions agglomerated in downtown Seoul and to relieve the overcrowding in that city. The facilities designed for the new town include a transport system, high-quality housing, sufficient living space, and a comfortable urban environment, and Fig. 1.33 illustrates in cross section the layout of some of the main features of Gwacheon new town. Some principles which are to be applied in its spatial organization are:

(a) the creation of a convenient living environment through effective and rational spatial organization which takes into account the visual, functional, and environmental aspects of facilities;
(b) the creation of communal space in which people feel a community identity;
(c) the creation of imaginative skyline and spatial patterns which maximize the east–west and north–south axes and related site requirements;

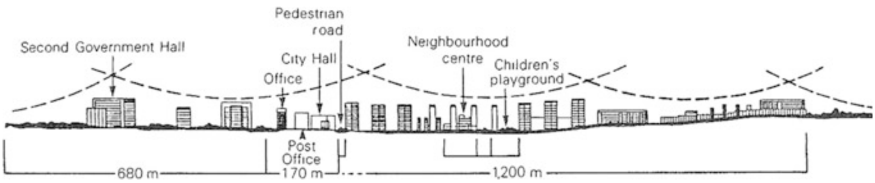

Fig. 1.33 Cross section of Gwacheon new town

(d) a mixture of high-, medium-, and low-density housing areas;
(e) the achievement of visual and functional relationships between higher density housing areas and adjacent design components (such as relationships with the central areas, major arterial roads, park, and open space).

Table 1.13 shows the land-use plan for the proposed new town project; a summary of the proposed housing development plan is provided in Table 1.14. The project covers the construction of 696 single detached dwellings, 644 attached dwelling units, and 12,860 apartments on the 1.06 km^2 of residential area, which comprises 46% of the total area. The figure for single detached dwellings includes 18 solar-heated houses.

Extended Cost-benefit Analysis and Environmental Impact Assessment

A cost-benefit analysis (CBA) attempts to assess the benefits accruing from certain levels of expenditure and costs, including environmental impacts (often called “social costs”) (Canter 1977; Pearce 1983b). Such impacts accompany any new physical development. However, this project was particularly appropriate for the application of extended cost-benefit analysis (ECBA) for a number of reasons. Firstly, the area in which the new town is to be sited is located within Seoul’s green belt. The project would therefore have a significant impact on an existing populated area (if largely agricultural). As a consequence, an important environmental quality problem is involved. This problem is of course quite common in many new town developments in other countries.

Table 1.13 Land-use plan, Gwacheon

Total	Commercial				
	Residential	Business	School	Road	Park
100 (%)	46	6	6	19	23
2,298,540 (m^2)[a]	1,060,103	138,704	132,100	426,023	541,610

[a]This figure does not include the Second Government Hall site (660,500 m^2), without which the total indicated here equals 77.7% of the entire area
Source Korea National Housing Corporation (January 1983)

Table 1.14 Proposed housing development plan, Gwacheon

		Types of housing		
		Detached	Attached	Apartment
Total	14,200	696	644	12,860
Stage 1	1290[a]	228	204	840
Stage 2	6075	235	–	5840
Stage 3	5537	233	264	5040
Stage 4	1316	–	176	1140

[a]This figure includes 18 solar-heated house
Source Korea National Housing Corporation (January 1983)

Secondly, the project would involve various types of environmental effects which permit the application of ECBA, so that the usefulness of the technique can be examined. Thirdly, the project has been fully planned and is still under development. Accordingly, there is good pre-development documentation, including data on actual development costs and benefits, and the actual environmental effects of the project. Consequently, many environmental impacts can be evaluated as costs or benefits by looking at environmental settings before and after the development, with sufficient precision for the application of the methodology suggested in this study.

Method for ECBA

This section outlines the main features of ECBA as a form of EIA. As a technique, ECBA focuses on the incorporation of the CBA tool into EIA techniques for various types of projects. Much of the criticism directed at existing decision-making procedures has come from those who argue that environmental restraints on, and consequences of, urbanization have been ignored.

"Simple" CBA is of limited usefulness in aiding decisions which result in significant environmental impacts. An important reason for this is that CBA does not systematically consider impacts which cannot be described appropriately in monetary terms (Ortolano 1984). In the traditional literature, the concept of CBA is market-oriented, where goods and services are sold at a price. The approach required of CBA in the future could be called non-market-oriented, with the increased public awareness of externalities and social costs, which are not always directly attributable to specific activities and often not directly quantifiable. Another shortcoming of CBA is its failure to account for equity considerations. The emphasis is on aggregate economic effects, not on the question of which groups gain and lose if a project is (or is not) implemented. Such issues pose important questions in new town planning because the developments often occur in already populated locations.

The limitations of CBA have encouraged efforts to extend the approach and to make it applicable to a wider range of evaluation problems and particularly to the assessment of environmental effects. The ECBA developed in this study considers not only profit maximization and economic costs, but also encompasses and measures the physical, chemical, and biological effects of development activities. This evaluation approach to new town development recognizes that most public policy decisions have multiple objectives and embrace social goals which are much broader than mere economic efficiency.

Another criticism of traditional CBA is that it conceals very considerable value judgments behind a façade of value-free objectivity. The ECBA makes provision for the achievement of a wider basis of value judgments and political acceptability. Enlargement of the CBA in this way may enable developers and decision makers to weigh environmental impacts against social and economic demands more realistically than is possible with earlier methods.

A Framework for Environmental Assessment

The ECBA aims to provide policy makers with information which will help them to make a rational decision about a specific project. In principle, the analytical procedure can be divided into six steps or stages:

(a) analysis of baseline data;
(b) summary of total environmental impacts;
(c) suggestion of alternatives to the proposed development;
(d) sensitivity analysis;
(e) identification of distributional effect;
(f) submission of the finished ECBA report and results to the policy maker.

Figure 1.34 presents the same steps, together with human and information resources or requirements in diagrammatic form. The hypothetical impacts of the urban development project and the presentation of results are shown in Fig. 1.35. It will be seen that there are direct and indirect effects identified for any urban development project, and that many direct environmental consequences (such as pollution and erosion) are of the more "traditional" type of impact.

The ECBA model developed in this study differs from some of the earlier applications of EIA. It internalizes the costs of mitigation measures in an enlarged cost-benefit balance sheet, extending EIA to value judgments, while restricting quantification to those areas where it is well based. It develops CBA and conventional EIA as complementary analytical techniques and includes the effects of government intervention on the urbanization process through the use of established standards relating to urban development.

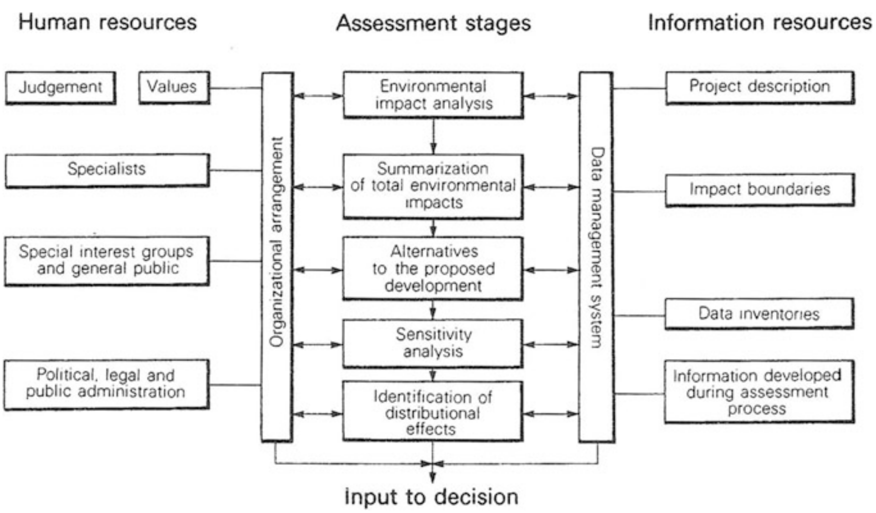

Fig. 1.34 The analytical procedure for the extended cost-benefit analysis (ECBA)

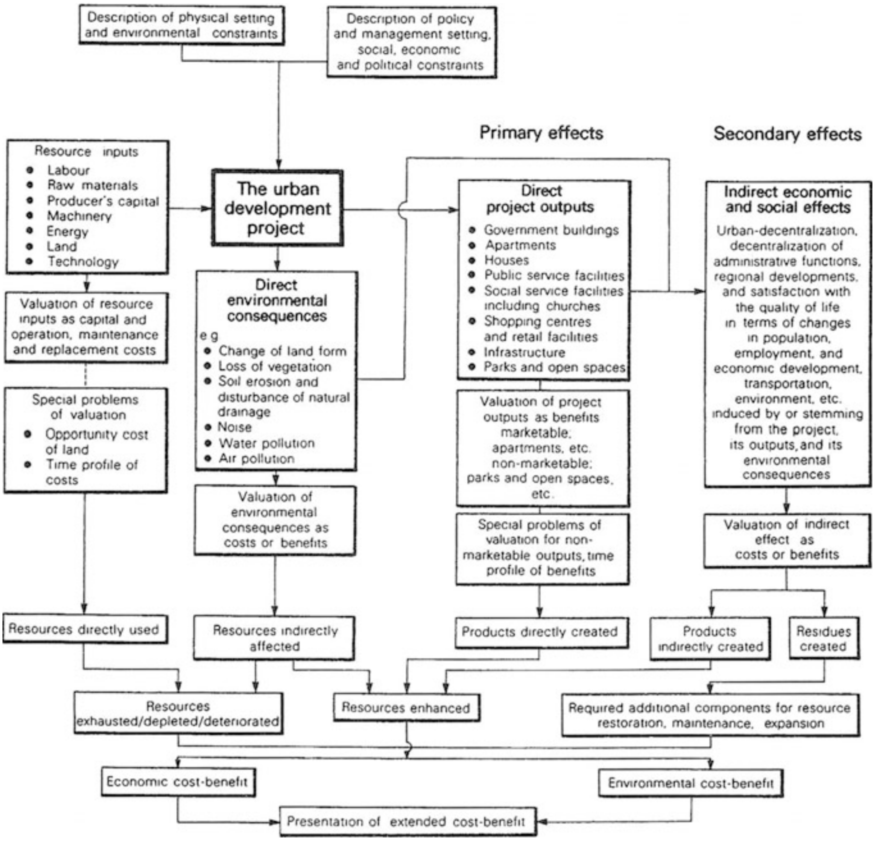

Fig. 1.35 Hypothetical impacts of the urban development project

Pearce (1976) suggests that it is more important to know the costs of abatement than to estimate pollution damage in monetary terms, and that research should therefore be expanded into the costs of abating pollution. In the ECBA model, the costs of mitigation measures, as surrogates for monetary environmental costs (which are considered necessary in this study), are included in the ECBA (measurable). The assumption is therefore made that these mitigation costs will actually be paid. The cost of mitigation measures which have been incorporated in the approved project plans is included in the item of economic cost-benefit in order to avoid double counting.

This study recognizes that an EIA will inevitably entail some subjective judgments. Because objective measure cannot fully describe environmental settings and cannot completely assess all the impacts of the new town, they are supplemented by indicators of residents' attitudes toward the new town and the displacement of (in this case) a village. The data for the subjective evaluation of impacts derive from two social surveys employed in this research project. These surveys include one of the villages which was to be displaced and one set in the new town itself.

It is hoped that the example here will provide an illustration of the ways in which an ECBA can be applied in other circumstances. So as to enable the reader to interpret the results in light of individual experience and to make an informed opinion on the desirability of this new town project, as suggested by Nash et al. (1973), the results of the environmental CBA are presented here in a disaggregated form. Qualitative descriptions show clearly how the environmental costs and benefits (measurable and non-measurable) of each factor involved in the total project are determined. An enlarged cost-benefit will be of use only to those who are familiar with the value judgments, including a single net present value figure (8%), used in this study. Obviously, a person with different importance will be attached to the various components. The key point with regard to EIA methodologies is that their results must be interpreted using varying value sets over time and also probably in different national settings.

To the extent that the CBA and EIA techniques are regarded as complementary, the ECBA technique can be a valuable aid to policy analysis and policy makers. The clear understanding of the nature of the actions and reactions of any specific measure implemented requires the use of such environmental management tools as EIA, which should be considered a prerequisite for the effective application of ECBA.

At the present time, the effects of government intervention on the urbanization process are so great that government and other public institutions arguably play a vital role in the political, decision-making context. Land-use planning, zoning controls, and environmental review procedures have often been the major determinants of urban development. In an environmental context, for example, three categories of government action to manage residuals/emissions can be distinguished: direct regulation, using standards to control discharges; economic regulation, using incentives such as subsidies; and government construction and operation of facilities to collect, treat, and dispose of residuals (Ortolano 1984). In this study, direct regulations to limit discharges (which involve effluent or emission standards) are utilized to compare predicted impacts with established environmental quality standards.

An outline follows of the stages for conducting an ECBA, as illustrated diagrammatically in Fig. 1.34. These generalized stages are then discussed with specific reference to Gwacheon.

Environmental Impact Analysis of Specific Impact Areas

The basic steps associated with impact analysis in specific impact areas include the description of the environmental setting, impact prediction and assessment, and determination of mitigation or control measure. Environmental factors considered in this study are topography, hydrology, climate and meteorology, air quality, noise pollution, energy and utility services, vegetation, animal life and habitat, land use and zoning, dislocation of people and villages, transportation, demography and community identity, recreation and parks, attractiveness of townscape, and regional development.

Description of the Environmental Setting

The environmental setting gives the baseline information against which prediction and assessment can be made. Here, the study focused on both qualitative and quantitative data sources for major environmental factors. For those impacts which are susceptible to quantitative measures, the sources of information were field observation, personal contact, printed materials, assessors' experience, and specific studies. For those impacts which cannot be adequately described or accurately assessed, the data were derived from the two social surveys referred to earlier.

The objectives of the social survey of the village to be displaced were to provide information on some personal and domestic details, business organizations and other behavior in the village, and residents' attitudes and plans. The objectives of the social survey of the new town were to provide information on the characteristics of newcomers, their activities, the status of households and dwellings, and the attitudes, opinions, and beliefs of new residents. In order to analyze the qualitative data for the new town, various cross-tabulations of 37 questions asked in the survey questionnaire were compiled, using a standard social science computational package.

Impact Prediction and Assessment

Impact prediction and assessment were approached in different ways depending on the environmental factors under consideration. For example, scientific approaches and models were used to predict impacts on the air and noise environment. Although predictions of impacts on some socioeconomic factors have technical bases, the results of the two social surveys already described were used more subjectively to understand the issues of social impacts associated with displacement of the existing villages and people, as well as for rating attractiveness of the townscape, and for identifying existing and potential problems.

For impact assessment, this study made comparisons with established quality standards, urban planning and design standards and guide values, professional judgment, and ratings from the survey of citizens. An effort was made to gather quantitative standards which are in use today in Korea. The most important criterion for the selection of standards was that they should reflect planning control principles and practices in this country. Therefore, it is possible to consider this case study in the more general context of what is acceptable and expected in urban development in modern Korea.

The selected assessment standards and guiding values, including predictive demand and land-use conversion ratios, are available from the author. Since many possible standards and guiding values of neighborhood and community development can be devised, the bases of the established standards and their assumed validity may be a source of disagreement among proponents of competing standards and guide values. Indeed, such standards will be the subject of a future study.

Mitigation Measures

Impact prediction and assessment provide the basis for recommendations as to how to reduce or remove the most serious of the impacts measured and socially perceived. In this study, mitigation measures were divided into measures incorporated into the original design of the project by the public authorities responsible for the development of Gwacheon, and other measures which were considered necessary in this study in order to further reduce adverse impacts. For examples, with regard to smoke pollution, the increase in the stack height from 30 to 60 m is suggested to reduce concentrations at ground level and at different receptor heights.

It is important to note that the costs of enforcing mitigation measures were taken into account in this study and were internalized later in an enlarged cost-benefit balance sheet. The implicit assumption is that those mitigation costs will be paid by the Korea National Housing Corporation. Table 1.15 provides some examples of selected factors which may be assessed in EIA of specific areas and illustrates some suggested mitigation measures to reduce impacts. The full details are available in Kim (1983).

Summary of Total Environmental Impacts

After the baseline inventory and mitigation measure have been conducted, it is necessary to assess collectively the results of these specific impact assessments in terms of an overall or summary evaluation. The basic incorporation of CBA tool into EIA summation techniques consists of the following five elements:

(a) tables of benefit-cost (B/C) ratios which provide planners with guidance on how beneficial the development is to the developer in terms of economic CBA;
(b) tables of CBA for development of direct services, implemented by other public agencies concerned;
(c) tables summarizing economic cost-benefit analyses (a) and (b);
(d) tables showing measurable and non-measurable environmental costs and benefits of the project;
(e) tables of the enlarged cost-benefit balance sheet which incorporate the results of economic costs and benefits and the measurable environmental costs and benefits associated with the new town project.

Table 1.16 shows the reduced format for presentation of the environmental CBA. The table allows qualitative descriptions to be made of non-measurable environmental costs and benefits. It therefore accommodates unmeasured impacts alongside impacts which are financially assessed. It also shows how elements are valued so that readers might subjectively interpret the results and give their own weight to the various factors. This is important as individuals might reach different conclusions as to the desirability of a project (as discussed below in the section on sensitivity analysis). The disaggregated impact information may also help to clarify the trade-offs of environmental factors against economic and other considerations (For discussion of these topics, see also Lichfield 1968; Lichfield and Chapman 1970; Lichfield et al. 1975).

Table 1.15 Suggested environmental assessment guidelines for new town development projects (natural/physical factors only)

Factor	Environmental setting	Assessment questions	Analysis methods	Evaluation of impacts	Mitigation measures
Physical site suitability	Soil characteristics and surface and bedrock geological conditions which will have a direct influence on site suitability for development of buildings, sewers, and underground utility trenches	(1) Is there any visible evidence of soil and foundation support problems, etc.? (2) Is there evidence of high side seepage potential when underground utility collectors are to be installed?	(1) Field observation (2) Sources of published information: soil maps and geological survey information (3) Contacts: local authorities, federal and state planners, and engineers	If there are no problems with soil or bearing capacity, there is "no impact." If there are problems, whether minor or not, which will be solved by mitigation measures or modified design, there is a "minor impact." If there are major problems which cannot be solved, there is a "major impact"	(1) Installation of drainage facilities in low areas to make the soil stable for construction (2) Alteration of foundation design, by using pilings, or increasing the bearing areas of spread footings (3) Replacement of problem soil with more satisfactory fill (4) Installation of approved perforated pipe and gravel sub-drains to prevent seepage potential (5) Possible alternative site land-use configurations
Topography	Delineation of the major and minor drainage basins along with their characteristics: slope, elevation, natural and artificial drainage nets, erosion, and deposition	(1) Would the proposed project result in substantial modification of the terrain? (2) Is erosion control included as part of the new	(1) Field observation (2) Sources of published information: topographic maps, soil survey maps, erosion potential maps (3) Further study: conduct a detailed site soils analysis	No impact: an existing erosion or sedimentation problem is demonstrably corrected as part of the project proposal or erosion or sedimentation problems are not present	(1) Phase grading to expose only those areas necessary at each phase in order to limit extent and exposure time of disturbed soils

(continued)

Table 1.15 (continued)

Factor	Environmental setting	Assessment questions	Analysis methods	Evaluation of impacts	Mitigation measures
		town development plan? (3) Is there any visible evidence of sedimentation problems on the site?		Minor impact: erosion or sedimentation problems are present only to a very small degree Major impact: erosion or sedimentation problems are present and severe, or the proposed project will increase the potential for erosion and sedimentation problems, and inadequate mitigation measures are proposed to correct these conditions	(2) Break up slope to reduce runoff; terrace downhill slopes (3) Collect and reuse all topsoil beneath proposed cut and fill areas
Hydrology	Description of the relevant surface water bodies and groundwater aquifers	(1) Is there evidence that supplies are adequate and free from pollution? (2) Will the project involve discharge of sewage effluent into surface water bodies? (3) Will the project involve a substantial increase in impervious surface area?	(1) Field observation (2) Source of published information: storm drainage maps (3) Contacts: the country engineer or other local officials who are familiar with the area	No impact: the project will have no significant effect on either the quantity or quality of water entering the groundwater stratum. A finding of "minor impact" or "major impact" will be based on results of the required interagency coordination procedures	(1) Inclusion of runoff control measures in site design (2) Design of underground spaces to withstand provision to pump out seepage in locations with high water problems

(continued)

Table 1.15 (continued)

Factor	Environmental setting	Assessment questions	Analysis methods	Evaluation of impacts	Mitigation measures
Vegetation, animals, and habitat	Indication of those species which have been designated rare or endangered Description of wildlife habitat or portion there of which might be affected by the project	(1) Will the project damage or destroy existing plant communities listed as rare or endangered species? (2) Will the project damage or destroy existing wildlife habitats?	(1) Field observation (2) Sources of published information: existing list of endangered species (3) Contacts: if an endangered species or habitat may be affected, further coordination with the Fish and Wildlife Service is required	Major impact: (a) Grading, cutting, or filling will take place on locations of protected species or critical habitats (b) Species or vegetation population dependent on the site or preempts a critical habitat	(1) Altering project plans to avoid impact on critical habitat areas (2) Setting aside the critical habitat area as a park or natural area

Table 1.16 The reduced format for environmental cost-benefit analysis (measurable and non-measurable)

Cost							Benefit			
Resources indirectly affected			Residues created		Resource restoration input		Indirect output without extra cost to the original project		Resource restoration outputs with extra cost to the original project to mitigate adverse impacts under a modified project	
Physical/natural factors	Description	Quantity	Description	Quantity	Nature	Value	Nature	Value	Nature	Value
Topography										
Hydrology										
Climate and meteorology										
Vegetation, animals, and habitat										
Air quality										
Noise										
Energy conservation										
Sanitary sewers										
Solid waste										

Alternatives to the Proposed Development

In an ideal EIA, the proposed action should be selected only after consideration of the factors associated with alternatives which might meet the project's needs. For example, alternative land uses may change completely the findings of the extended cost-benefit study. However, if any benefit is to be gained from alternatives, they should be based upon proposals which are realizable in practice, rather than those which are possible but impracticable.

The development and comparison of alternatives are usually presented in order to show the reason for the selection or rejection of specific alternatives. The consideration of alternatives in this study contains a systematic development of alternative land uses for the solution of the identified new town development problems; and a rational comparison of the alternatives, including the identification of critical differences leading to the selection of one (or more) alternative over another.

Sensitivity Analysis

Perhaps the only certain aspect of evaluation is its inherent uncertainty. As a result, the assessment technique described so far will have produced a meaningless answer if no investigation of the associated uncertainty is conducted. Uncertainty in the overall assessment has two components: uncertainty about the accuracy of assessment of the overall project impacts at present and uncertainty about changes in the overall project impacts in the future. This overall uncertainty depends, in turn, on the uncertainties in the discount rates and the underlying value judgments, including changes in tastes and aspirations from one generation to another, policy changes, and developments in technology.

In order to overcome the problem of the unquantifiable nature of some environmental impacts, the study does not attempt to render all values in money terms, and it attempts to make clear the bases on which judgments may be made. It is the decision maker's responsibility to combine, weigh, and judge the information presented to him, and details should therefore be presented as fully as possible.

Distributional Effects

Traditionally, conventional EIA methods have been used to minimize aggregate adverse environmental impacts and to maximize aggregate benefits, regardless of the groups to whom benefits and costs accrue. Consequently, full consideration of the "losers" from projects has not been adequately documented in most environmental impact statements. The priority has usually been to evaluate the project in the interests of the community as a whole. If new towns are to be provided as a benefit both to nations and to individual's residents, the "winners" and the "losers" in any circumstances have to be considered. The concept of fairness (or justice) is therefore relevant to decisions affecting environmental quality because the individuals who enjoy the benefits from such decisions are often different from those who pay the costs.

Two main components of distributional analysis can usually be distinguished (Abelson 1979). One is the analysis of the incidence of costs and benefits on selected community groups (sometimes called incidence analysis). This involves determination of what data are required in addition to those collected in order to calculate the net present value (NPV); of which groups are involved; and of how costs and benefits are borne or passed on between groups. The second and more controversial component of distributional analysis consists of the identification of how the incidence of costs and benefits might affect the project decision and its final form.

Example of Results from the Gwacheon Case Study

Assessment of Specific Impact Areas

Some examples of the main results of the assessment of the selected impact areas are summarized in Table 1.17, which describes environmental setting, impact prediction and assessment, and mitigation or control measures. An example of one type of information which may be forthcoming from an ECBA is air quality, which is discussed below.

Environmental Setting and Air Quality

The specific topography of a new town is of considerable importance in influencing its air quality. Gwacheon's site is characterized by mountains to the north and south which prevent crosswind ventilation, and there is a high incidence of low-level temperature inversions in conjunction with low precipitation during most of the year. The site therefore has great potential for air pollution. It is part of the Seoul–Inchon metropolitan airshed, which causes higher background concentrations of sulfur dioxide and particulates, for example, than are observed in other rural areas outside the airshed.

Impact Prediction and Assessment of Air Quality

The estimated emission rates and the results obtained from the smeared concentration approximation method (SCAM) model suggest that the concentrations of the criteria pollutants are within safe limits and will not exceed ambient air quality standards after completion of the new town.

Concentrations at major downwind locations of heating plant stacks, predominantly in the cold winter months, cause some concern, however, particularly in conjunction with relatively high particulate concentrations exceeding the 24-h annual maximum concentration (150 $\mu g/m^3$) of the secondary US standards. It is anticipated that the particulate concentrations will decrease as soon as all construction activities are completed. Adverse effects on public health due to air pollution are therefore not expected. However, the effects on sensitive vegetation, such as conifers, and visibility impairment resulting from air pollution cannot be entirely excluded. This illustrates the need for awareness of impacts which will accrue even if international standards are not exceeded.

Table 1.17 The reduced format for environmental cost-benefit analysis (measurable and non-measurable)

Factor	Environmental setting	Impact prediction and assessment	Mitigation or control measures
Topography	(1) Elevation between 40 and 125 m above sea level (2) Slope ranging from 0 to 20% (3) Soils containing varying amounts of clay, silt, sand, and gravel, with some organic matter	(1) Altering moderately the existing terrain of the site (2) Significant effects of the change in the orography on the existing local wind flow pattern (3) Removal of the existing soil mantle	(1) Stage grading (2) Collection and reuse of topsoil (3) Planting all fill and cut slopes
Air quality	(1) The specific topography preventing crosswind ventilation (2) High frequency of low-level temperature inversions (3) Low precipitation during most of the year	(1) The estimated sulfur dioxide concentration (12 ppb in 1986) within air quality standards for sulfur dioxide in Korea (2) Significant sulfur dioxide concentrations at major downwind directions of heating plant stacks (3) Effects on sensitive vegetation such as conifers and visibility impairment from air pollution	(1) Increasing the stack height from 30 to 60 m (2) Construction of a mound along the bypass road planted with trees or bushes (3) Traffic light system control
Dislocation of people and village	(1) 6840 people (the 1978 population of Gwacheon) and 1556 households (2) 842 dwelling units and 359 business leases to be affected	(1) Replacement of existing village and people (2) Disruption of community cohesion (3) Creation of community resentment (4) Uncertainty about the future due to the loss of employment	(1) Compensating displaced people for their property and business leases (2) Providing an economic base for displaced people (3) Publicizing fully and well in advance the details of development and compensation

Mitigation Measure Related to Air Quality

In general, it is suggested that the stack height of major single sources—for example, central heating plant stacks or stacks of public bathhouses, where considerable amounts of fuels are burned—should be 2.5 times higher than the surrounding buildings. This requirement is not satisfied in Gwacheon because of the high-rise nature of development. The 15-storey apartment buildings are higher than the 30-m high stacks of six local heating plants. Therefore, it is recommended either that fuels containing less sulfur should be used or that the stack heights should be considerably increased. The latter measure has to be carefully assessed with regard to the topographical conditions, characterized by high mountains to the north and south which are covered with sensitive vegetation. This situation emphasizes the need to consider the total environment in any new town setting.

The planting of trees or bushes so as to create wide buffer zones along roadsides may be recommended. An additional refinement is control of the traffic light system to ensure a smooth traffic flow at reasonable speeds throughout the whole new town area, particularly at major arterial roads, so as to avoid excessive concentration of vehicle fumes. This type of forward planning, in conjunction with traffic circulation design, can enable a new town to minimize atmospheric pollution by vehicle emissions. This is difficult to achieve in existing urban areas.

Summary of Total Environmental Impacts

The results of the summary of the total environmental impacts may be presented in the form of the enlarged cost-benefit balance sheet. Table 1.18 summarizes the economic CBA, and Table 1.19 provides an ECBA, incorporating measurable environmental costs and benefits.

Gwacheon is being developed in phases, and these tabulations allow any changes to be shown in benefit-cost (B/C) ratios as a new town grows. For example, when the fourth stage development is completed and new apartments and other facilities such as shopping centers are sold, the enlarged B/C ratio will be higher than 0.934 as of mid-stage construction (Table 1.19), because most direct services development will already have been completed. In addition, the result may be more

Table 1.18 Summation of economic cost-benefit analysis in million Won, [The exchange rate used is Won 800 = US$1 (1982 prices)] Discounted to 1982 at 8%

Capital cost		Benefit		Net balance	B/C ratio
Item	Value	Item	Value		
The new town development	246,177	The new town development	258,696	+12,519	1.05
The Second Government Hall construction	55,000	The Second Government Hall construction	55,262	+262	1.005
Direct services development	31,163	Direct services development	–	−31,163	–
Total	323,340	Total	313,958	−18,382	0.945

Table 1.19 Enlarged cost-benefit incorporating measurable environmental costs and benefits

Item	Costs	Benefits	Net balance	B/C ratio
Economic cost-benefit[a]	332,340	313,958	−18,382	0.945
Environmental cost-benefit (measureable)	3961	–	−3961	0
Enlarged cost-benefit	336,301	313,958	−22,343	0.934

[a]The cost of mitigation measures which have been incorporated in the approved project plans is included in the item of economic cost-benefit in order to avoid double counting

positive if an attempt is made to evaluate as far as possible the non-measurable secondary and tertiary benefits.

The study found that, although the extra costs of the mitigation measures (Won 3961 million) were added to the original project costs (Table 1.19), the project is justified because the high cost of land and other properties makes these measures economically feasible. It is assumed that these mitigation costs will be borne by the Korea National Housing Corporation.

The costs of mitigation measures can be calculated and totaled (Won 3961 million, approximately US$4.95 million). They include such costs as the collection and reuse of fertile topsoil, the reclamation of new agricultural lands equaling the area of lost land, the extension of bicycle roads, an increase in the stack heights of heating plants from 30 to 60 m, landscaping of the buffer zone, and the construction of a noise protection wall.

Alternatives to the Proposed Development

It is assumed that land-use and transportation alternatives have already been formulated and evaluated as part of the decision-making process, since their selection was made prior the environmental assessment. This section therefore takes account only of the possible consequence of alternative uses of the sites and adjustments to the intensity of residential development. Four feasible alternative land uses are discussed in this study. These alternatives include a “no project” alternative, a change in the intensity in the new town plan, a change to a different type of land-use, and the adoption of alternative sites. After taking these into account, the ECBA model can be used to reach a decision on the mixes of land uses and locations.

Sensitivity Analysis

A standard feature of this type of analysis is an estimate of its sensitivity to financial fluctuations. In this study, an 8% discount rate and a six-year evaluation period from 1979 to 1984 were used. All measurable costs and benefits were discounted to 1982 values at 8%. The present value of benefits from the Second Government Hall project was derived by dividing rent (p) by the rate of discount “R” (8%) in perpetuity. The ECBA results calculated with differential rates, would obviously be important in any full analysis.

Resource inputs released for economic investment as a result of alternative technology and energy development, which in turn may be an environmentally induced cost reduction in the environmental cost-benefit table, have not been credited in the economic cost-benefit table. It has been presumed that alternative technology and energy sources are providing a base for economically efficient urban development as well as environmentally sound activity. For example, the net cost of alternative energy may be less than the released cost induced by, say, coal, which is used as fuel in a substantial number of houses (3100) in Gwacheon new town. Moreover, the identification of precise outcomes from the application of the sensitivity analysis with changes in tastes from one generation to the next is as yet beyond the capability of this research. The limited scope of existing research cannot enable the prediction of future demands and requirements and permits no more than suggestions of possible developments in the field (Pearce 1983a; Haveman 1983).

Some Distribution Effects

Table 1.20 shows distributional effects in terms of the Korea National Housing Corporation, the Ministry of General Affairs, displaced people, local government, and the central government. It is important to note that a municipal government of Gyeonggi province will take over the public assets of Gwacheon new town from the Korea National Housing Corporation after completion of the development, and will therefore be responsible for the management and administrative supervision of the town. The current Gwacheon Office of the Gyeonggi Provincial Government does not provide for any capital cost, due to the lack of financial resources and an inadequate institutional mechanism. Total local government benefits were estimated at Won 15,700 million (Table 1.20). In Gwacheon, the Ministry of Construction will pay for bypass road construction and central main road enlargement, while the costs of a new sewage plant have been included in sale prices of houses.

One possible conclusion to be drawn from this case study is that, through the development of Gwacheon new town, people who live in the new town will be much better off environmentally than the population residing in congested Seoul. Indeed, a social survey of the households which have already moved into the Gwacheon new town showed that a large number of people claimed a more acceptable quality of environment since moving to the town from the congested capital city. Nevertheless, based on the findings of the city, the Office of Environment has requested that the Ministry of Construction take the necessary actions to implement mitigation measures identified in the study so as to reduce environmental impacts. These measures will ensure that environmental standards

Table 1.20 Distributional effects in million Won at 1982 prices

Organization	Capital cost	Benefit	Balance
Korea National Housing Corporation (KNHC)	250,138[a]	258,696	8558
Ministry of General Affairs (MOGA)	55,000	55,263	263
Displaced people	NA[b]	76,300[c]	Displaced people may not have been the true beneficiaries of the development area policy
Local government	None	15,700	15,700
Ministry of Construction	24,858	–	−24.858

[a]This figure includes Won 3961 million mitigation measures
[b]Precise cost figures are not available
[c]This figure includes payments for compensation and special land sale price

and quality are maintained as much as possible as Gwacheon grows. However, in terms of the apportionment of costs, a population migration from Seoul to Gwacheon would cause the transfer of the costs for items such as solid waste disposal and sanitary sewage treatment from Seoul to Gwacheon new town. Therefore, some transfer of funding may become necessary to provide equity and balance.

Implications of the Gwacheon ECBA Study for New Town Planning and Development

The first step of the study was to develop a general EIA methodology applicable to other countries as well as Korea. The methodology was then applied to a specific new town development, the town of Gwacheon, Seoul metropolitan area, Korea. Environmental impact assessment is a valuable aid in the selection of which alternatives are to be preferred and/or is an effective tool for determining, in the production of development plans, the acceptability of proposed action. However, because of the totality of new town construction, the EIA of the creation of such projects requires somewhat different methodological approaches than are necessary in the case of smaller or piecemeal developments.

This study has developed an ECBA model to determine the acceptability of a single proposed plan. It can be used for determining final project design and for allocating limited resources to selected projects so as to obtain the maximum overall social benefits with minimum overall social costs, by employing integrated new town project planning and development. Mitigation or control measures which are specifically designed to reduce adverse environmental impacts, to enhance environmental quality, and to help the optimal use of resources can reduce the total social costs by anticipatory rather than remedial actions. This is, of course, very important in many new communities in attracting population and in maintaining an economic base.

The need for the incorporation of environmental considerations into the planning stage of new town projects was discussed earlier. The Gwacheon case study illustrates that, in integrated project planning, after all of the alternatives to the proposed development have been taken into account, the ECBA model can be used to help in reaching a decision and to obtain feedback for improvement of planning and design. It can assist in making a choice between alternatives, and it can help to suggest mitigation measures. However, the method employed in the case study is not designed to identify large differences between plans at the strategic level. It depends heavily on detailed planning and design of developments at the local level. At this level, the method makes it possible to assess adequately many vital aspects of the plans. Therefore, while ECBA is adequate for local plans, it may not be suitable for strategic plans. This is because, by their very nature, the effects of many mutable aspects of development are often relatively localized.

Although the ECBA is specifically designed to determine the acceptability of a proposed plan, it can be a valuable aid to the selection of "socially preferred" alternatives, to the extent that traditional plan evaluation methodologies and the

ECBA technique are regarded as complementary. In brief, in the Gwacheon case, the following impacts were among those identified:

(a) Adverse impacts include traffic problems, loss of agricultural land, cumulative degradation in air quality, short- and long-term noise impacts, disruption of existing community cohesion, non-achievement of self-containment and socially integrated, balanced communities because of cross-movement and turnover of population, and higher population than planned resulting in pressure on public services. Land acquisition and compensation, initial site clearance, grading, and construction had major negative impacts in this project.
(b) Beneficial impacts include factors such as the availability of new housing, the Second Government Hall, additional park land, employment during grading and construction, increased tax revenues, and decentralization of the urban base.

A summary of the total environmental impacts showed that the project would be economically sound, and supplementary subjective evaluation of the new town showed that a large number of people had a better quality of life since moving to the town from the capital city, Seoul. However, the authorities responsible for the development of Gwacheon should consider controlling growth in the area surrounding the town by maintaining the green belt policy, incorporating mitigation measures, adopting an area-wide approach, encouraging public involvement, and monitoring changing conditions. When control or mitigation measures which are essential conditions to the planning approval are implemented, the overall benefits of the proposed project would exceed the overall social costs. The results of this study have already led to government measures to alleviate some of the adverse impacts of the new town development project.

In conclusion, the ECBA developed in this study provides for more efficient new town development than was possible under existing methodologies. In addition, the ECBA methodology may usefully be applied in other contexts, in developed as well as developing countries. However, an important limitation is data availability and, in general, countries which adopt ECBA must be aware that its application requires considerable resources and the availability of well-trained personnel. Such resources are often in limited supply in Third World countries, but it should be appreciated that the timely application of these methodologies can save considerable future remedial expenditure or help to prevent losses from poorly designed projects, and increase the both technical and non-technical additionality of the proposed projects for the Urban CDM.

1.3 Emergence of Climate Resilient and Low-Carbon Smart Urbanism: City Climate Urbanism

Sustainable development is a specialist field. A thorough review of on it is required for understanding the emergence of resilient and low-carbon smart urbanism. Furthermore, the new image of the city sought by (1) the eco-city, (2) sustainable city, and (3) the conventional low-carbon green city discussed in the previous sections should be injected into the climate resilient and low-carbon smart cities. In addition to efficiency, sustainability, connectivity, circularity, and resiliency have become increasingly influential in the emergence of climate resilient and low-carbon smart urbanism.

Smart city planning, climate action, and disaster reduction are all influencing urbanization patterns that can lead to more sustainable and resilient cities.

1.3.1 What Is Smart Climate Urbanism?

Smart climate urbanism aims to reform all aspects from sustainability, connectivity, circularity, and resiliency perspectives. It involves new development, urban retrofits, and suburban infill.

It affects city, town, neighborhood and the corridor, and building. Since climate change has become a critical issue in the city, smart climate urbanism is a new tenet of climate change for cities. It differs from new urbanism which is urban design movement originating in the late ‘80s—early ‘90s in many ways:

- It supports urban planning for climate smart urban development, climate change mitigation and adaptation planning, and green infrastructure development.
- It can reduce GHG emissions, increase the circularity and resiliency of the vulnerable cities, and, therefore, ensure the sustainability of cities.
- It covers nexus issues such as energy, transport, industries, land use, livelihoods, health, food and water, infrastructure, and ecosystems in a connected manner.

1.3.2 Why Do We Need It?

We live in the era of climate change and digital age. Pope Francis issued a stark warning on the “grave implications” on climate change on Thursday (June 18, 2015) and called on wealthy countries to pay their “debt” to poorer nations and support mitigation and adaptation efforts (Francis 2015).

The Pope warned of an “unprecedented destruction of ecosystems, with serious consequences for all of us” and said developed, industrialized nations were primarily responsible and should help poorer states tackle the crisis.

The encyclical states that climate change presents an “ecological crisis” and is a “global problem with serious implications”. The document addresses a wide range of topics, from urban planning and agricultural economics to conservation and biodiversity. Similar arguments were also made in COP21, UNFCCC in December 2015. UN HABITAT III also has the leverage on these issues stated in the New Urban Agenda. Smart climate urbanism is economically rational and can contribute to the Post-2015 Development Agenda and Sustainable Development Goals.

There are several reasons for why we need climate urbanism:

- Cities are main sources of global GHG emissions and a major pollutant. Fifty percentage of the world’s population now lives in cities. By 2050, three out of four people are expected to live in urban areas, due to urban migration.
- Urban areas currently use 67% of the world’s energy and account for over 60–70% of global GHG emissions (World Bank 2011).
- Due to financial vulnerability of developing countries, efforts to reduce GHG emissions and investment in environmental protection are economic burden for cities in developing countries. The impact also is marginal.
- Clean energy generation, carbon reduction, and green business have become critical issues to find out how investors and businesses are benefitting and what countries have to do to enable green growth.
- Decoupling has been proven to be possible in Europe and Korea for economic growth and GHG reduction.
- Far from expensive technological dreams, we need a “down-to-earth” vision: a future city integrated with a sustainable lifestyle for us all. Whether old or new, future city will need to employ life-support systems, materials, and spatial designs that meet the health, conservation, and spiritual criteria. More and more people are turning to such lifestyles, and we need cities that support, rather than hinder, these new aims and priority for living.
- Land has been consumed without regard to local climate and global climate change.
- Climate change mitigation and adaptation strategies must also factor into restoration planning and be an integral part of restoration projects.
- Increasing intensity of typhoons and flooding need storm-resistant housing and evacuation of flood zones.

1.3.3 Principles of Smart Climate Urbanism

The only way we can make a real difference in our impact on the global environment and climate is through a holistic approach to policy, planning, technology, and governance where in all work collaboratively toward the common goal.

Based on the concept of smart climate urbanism defined in Sect. 1.3.1, the following principles of the smart climate urbanism are singled out:

1.3.3.1 Urban Sustainability

- Principle 1: Manage cities' resources sustainably for demonstrating long-term environmental sustainability.
- Principle 2: Design with nature.
  - Adopt new climate planning and design approaches which favor more innovative solutions based on biological productivity of natural systems, cycling of resources, or demand management to reduce need for new services.
- Principle 3: Consider global and cumulative effects.
  - Secure local climate successes with larger regional and global improvements.
  - Adopts much longer and broader perspective that includes attention to off-site, cross-boundary, intergenerational, and cumulative climate effects.

1.3.3.2 Urban Efficiency

- Principle 4: Create energy-efficient city and transportation planning in the climate context.
  - Adopt transit-oriented development.
  - Demonstrate how urban energy grid system can play an important role in addressing climate issues.
- Principle 5: Try to have a net effect on our environmental footprint which requires an interdisciplinary approach.

1.3.3.3 Urban Connectivity

- Principle 6: Adopt an interdisciplinary approach to information.
  - Entails a greater scale of information gathering for big data, more integration of information and greater cooperation among information providers, both amateur and expert (Figs. 1.36 and 1.37).
- Principle 7: Develop interdependent enabling factors which are all critical elements in facilitating the rapid connection.
- Principle 8: Encourage zero-carbon lifestyle that is connected with the connect-tech.

Fig. 1.36 Digitalized real-time temperature measurement in the outdoor hot bathtub in the aqua-world, Sol Beach Samchok, Gangwon province, Korea

Fig. 1.37 Installment of CCTV cameras for safety and surveillance information in the aqua-world, Sol Beach Samchok, Gangwon province, Korea

- Principle 9: Interconnect street grid network which disperses traffic and eases walking and use blue, green, and white networks. Build the capacity of institutions to embed new connect-tech into the local institutional and social context. Proper relationships or connection between man and machine have to be established.

1.3.3.4 Urban Resiliency

- Principle 10: Adopt a precautionary but positive approach to development that aims not just to avoid further climate change but also to reduce risks and enhance the resiliency of ecosystems and communities.
- Principle 11: Make our cities more resilient to climate change, while accommodating higher population densities.
  - Require planning to protect, maintain, and enhance the multiple and interdependent benefits and ecosystem services offered by the total greenhouse neutrality.
  - Develop a strategy which is built around diverse water sources and a mixed water infrastructure with smart water grid system. It will allow cities the

flexibility to access a portfolio of sources at least cost, in terms of environmental impacts and other externalities.
– Develop uniform standards and engineering procedures for designing climate adaptation measures.

1.3.3.5 Urban Circularity

- Develop the circular model which stirs the economy and has the ability to create the job as well (Refer to Fig. 1.28 for a circular model).
- Set a goal to increase the waste diversion rate.
- Facilitate public–private collaborations that promote efficiency and restorative use of natural resources.
- Support improvements in material effectiveness and transition to renewable energy and a circular economy.

1.3.4 Benefits of Smart Climate Urbanism: Value Added

If any city is regarded as a smart climate city icon, the city can benefit from it in the area of planning, in particular, resettlement planning based on the smart climate urbanism.

Resettlement is often unavoidable consequence of natural disasters—some caused by climate change—that leave, for example, many coastal and low-lying communities homeless, jobless, and outside developed social networks. Innovation following the principles of climate smart urbanism in resettlement design can also replicate to some extent pre-damage livelihood, such as that from farming, fishing, and tourism.

Smart climate urbanism can develop and deliver innovative design solutions for post-disaster reconstruction and the rebuilding of resettlement communities in specific, as well as for humanitarian and community projects throughout the world in general.

When the concept and principles of smart climate urbanism are properly applied in urban planning and design, the benefits of smart climate urbanism could contribute to:

- Digitize access to information.
- Build strong, well-informed, and livable communities.
- Reduce risks and enhance the resiliency of ecosystems and communities by connecting people, natural process data, and buildings.
- Optimize the use of resources, including land, water, energy, buildings, and even waste by embracing IoT technology.

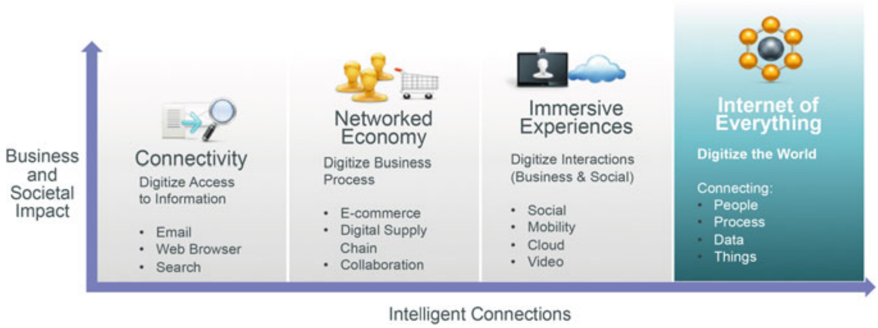

Fig. 1.38 Business and societal impact of intelligent connections. *Source* Fellor (2016)

- Entice the best and brightest businesses within their borders by incorporating smart technology into municipalities.
- Implement smart initiatives, including the Post-2015 Development Goals, Paris Agreement, and New Urban Agenda.

Business in particular flocks to cities that take care of their smart infrastructure because it lowers operating costs. One study predicts the global business community will spend more than $18 billion incorporating smart technology into buildings in 2017—which far surpasses the $5.5 billion it spent back in 2012 (Horn 2016). When cities operate in line with the principles of smart climate urbanism, their cities, industries, communities, climate, and environments all thrive.

Figure 1.38 summarizes the business and societal impacts of intelligent connections which could be associated with climate smart urbanism in terms of connectivity, networked economy, digitized interactions, and Internet of Everything. These changes may be beneficial.

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Chapter 2
Planning Models for Climate Resilient and Low-Carbon Smart Cities: An Urban Innovation for Sustainability, Efficiency, Circularity, Resiliency, and Connectivity Planning

Abstract This chapter provides planning models for climate resilient and low-carbon smart cities as an urban innovation for sustainability, efficiency, resiliency, circularity, and connectivity of cities. The models incorporate strategic urban growth while keeping under control (or reducing) GHG emissions and vulnerability to climate change, bringing about growth benefits, in particular with the use of automation and Internet control system technology development. The complexity of a low-carbon smart urban development can be addressed and managed through connected networking and information sharing with ICT applications in areas such as transport, land-use planning, energy, water, and waste management under an integrated holistic approach.

Keywords Planning models · Reverse carboning · Sustainability · Efficiency · Resiliency · Circularity · Connectivity · GHG emissions · Vulnerability · Internet · ICT · Connected networking

2.1 Context and Relevance of ICT and Urban Form

The global warming is considered as a serious threat to the very survival of mankind and other living creatures. The full complexity of the carbon-smart urban development can be addressed and managed in the areas of transport and land-use planning, energy, water, and waste in an integrated holistic manner. This type of development can be done through connected networkings and information sharing with ICT and sustainable technology applications.

ICT helps city build resilience to adapt to changing conditions as we move into the era of rapid climate change. The need for a climate resilient and low-carbon smart city

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with Intelligent Digital Connections (IDC) has been demonstrated by existing World Bank programs. The World Bank has an active work program in the areas of cities and climate change, ICT, and also more broadly in the areas of sustainable cities.

2.1.1 A Package Program for Low-Carbon Smart City Development Plans

Cities can serve as living laboratories for innovative techniques and complementary climate policy package. While low-carbon smart city innovation can have significant impacts on economic growth, the ICT applications for low-carbon city in many developing countries are very limited. Many inspiring smart city ideas never make them into their comprehensive low-carbon city development plans which include climate action plans.

Therefore, it is necessary for them to understand why this is the case, and how to improve the situation in a total holistic manner. At the same time, it is necessary to ensure that a complete package is developed for humanware, infoware, and orgaware for a healthy, easy, simple, practical, and structured technology transfer and diffusion.

2.1.2 Reverse Carboning (RC)

Ideas such as reverse engineering (RE) and reverse mortgage have been implemented, respectively, in new product design and rescheduling of acute financial amortization. Similar possibilities can be explored for the development of low-carbon smart cities as it is impossible to destroy all the cities and rebuild them again from scratch. Reverse Carboning (RC), a new concept introduced in this model, can be defined through appropriate methods, procedures, planning, and development (MP^2D). The MP^2D, therefore, entails supplemental and advanced research studies. The MP^2D for RC differentiates the low-carbon smart city from the existing smart city in a practical manner in that transdisciplinary systems-of-systems (TD_SoS) approaches are considered vital.

The current version of MP^2D for smart cities lacks these approaches. Furthermore, the existing methods or projected approaches considered “what” it is and “how” to deal with the situation, but do not address “why” the steps to be taken. As a matter of fact, we currently have a less-awareness society. Needless to say, only a small percentage of global population knows “Why.” All should critically think about the endangered situation ahead: not just for thinking about it on a 4/5-year governmental term basis but for sustainably global term basis, say 100 years, 500 years, or 1000 years. By appropriate MP^2D, we should be able to decarbonize the globe the way we want.

The “Why” variables in the proposed TD_SoS approach are distinct as compared to the existing approach.

2.2 Model for Comprehensive Climate Resilient and Low-Carbon Smart City Planning

2.2.1 Definitions

This is the digital age. Due to the breath of ICTs that have been implemented under the smart city label, it is difficult to distill a precise definition of a smart city. The Smart City Council defines a smart city as one that has simple, easy, and practical digital technology embedded across all city functions.

A smart city is defined by Dr. S. Himesh as follows:

> A smart city is an intrinsically sustainable city which recognizes the physical limits to its growth without compromising the quality of life of the present and future generations.

In the context of climate change, planning processes have to recognize the need for ongoing adaptation, flexibility, and resilience.

Resilience is defined by Walker et al. (2004) as the ability of an ecosystem to withstand or recover from disturbance or stress. Disturbances such as drought, heat, cold, flood, and disease and changes in species all influence or impair an ecosystem's capacity to perform specific functions and provide ecosystem services.

Climate resilient and low-carbon smart cities can be defined as ones that have digitalized connections of all sectors and functions, in which everything is connected, supporting sustainability, resiliency, circularity, efficiency, and connectivity of the city. It incorporates climate change mitigation and adaptation policy goals at each stage of planning process and in urban policies.

2.2.2 Connectivity of Climate Change Actions and Plans

Though cities and communities around the world have elaborated a wide variety of climate change actions and plans, their development and implementation often follow a project-based approach with no networked connections between projects. The increasing number of urban responses to climate change highlights the need for carbon-centered comprehensive (3Cs) smart planning model which incorporates climate change mitigation and adaptation policy goals at each stage of the process.

Such a model aims for digitalizing solutions for individual actions and viability decisions in a holistic manner, and, therefore, the model needs to combine a very high number of different ICT uses that are relevant to climate change mitigation and adaptation measures which will be described in this book later. Lots of institutional capacity is needed in installment of execution of smart ICT uses networks.

In order to visually show efficient development of GHG reduction technologies with ICTs, it is essential to use digital overlay technique and carbon overlay technique as well in the model. The carbon overlay is a quantitative index of the relative importance of individual credits associated with the construction and operation of buildings and various infrastructures based on the carbon footprint (Figs. 2.1 and 2.2).

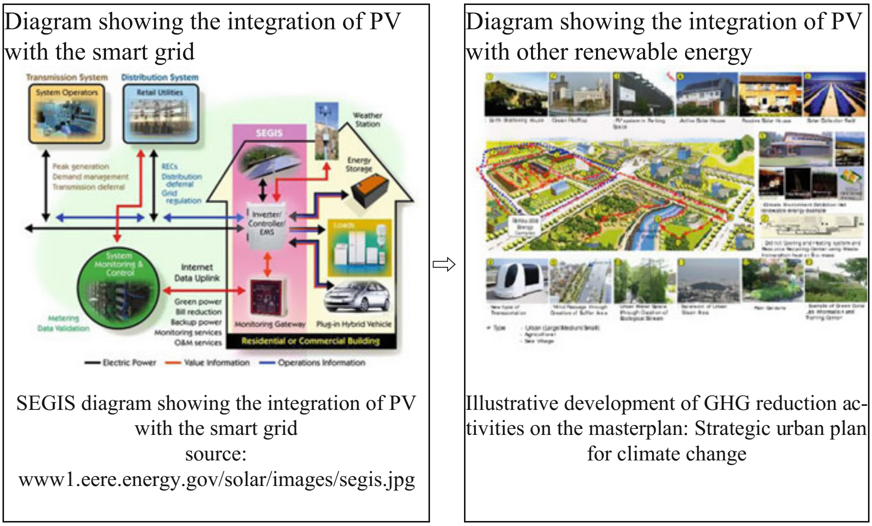

Fig. 2.1 Illustration of the package program for the digitalizing connections of smart city and low-carbon city

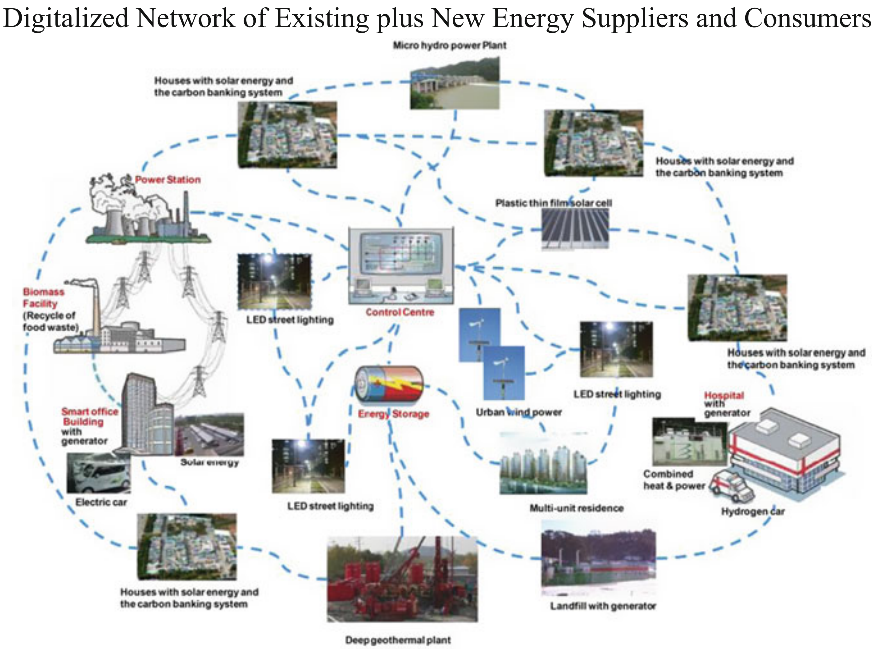

Fig. 2.2 Conceptual urban 100% renewable energy grid system which can be expanded to include carbon capture and utilization, and carbon sink technologies: to become a low-carbon smart city to switch to 100% renewable energy

These figures show the future direction of the digitalized connectivity from information and ICT perspective.

The features of a digitalized network of existing and new energy suppliers and consumers (Fig. 2.2) are as follows:

- Integrate new renewable energy sources into the existing energy system with ICT;
- At present, the energy system in many cities already has a relatively high share of renewable energy and plans for further large-scale integration as clean natural energy sources are available. The large-scale integration of renewable energy is shown in Fig. 2.2;
- The system is an example of flexible energy systems, in which many cities decide to make each building energy independent and carbon neutral through the use of renewable energy, primarily solar but also geothermal and wind power, as well as storage devices and distributed renewable solar thermal energy system, while other buildings, private businesses, and homes are connected to central power grid through the control center; and
- The design of future 100% renewable energy system with ICT is a very complex process. However, the variety of benefits both to the city and to the citizens makes it worthwhile. A cost-benefit analysis may be needed to justify this idea.

Figures 2.1 and 2.2 are illustrative examples of the deployment of GHG reduction technologies. Some technologies are practical for deployment in the near future.

These conceptual development plans show how to achieve the ultimate goal of the "climate resilient and low-carbon smart cities". The actual deployment of GHG reduction technologies for innovation is presented in Fig. 2.3.

Fig. 2.3 GHG reduction technologies for innovation for a better life. *Source* LG Group blog (lgblog.co.kr)

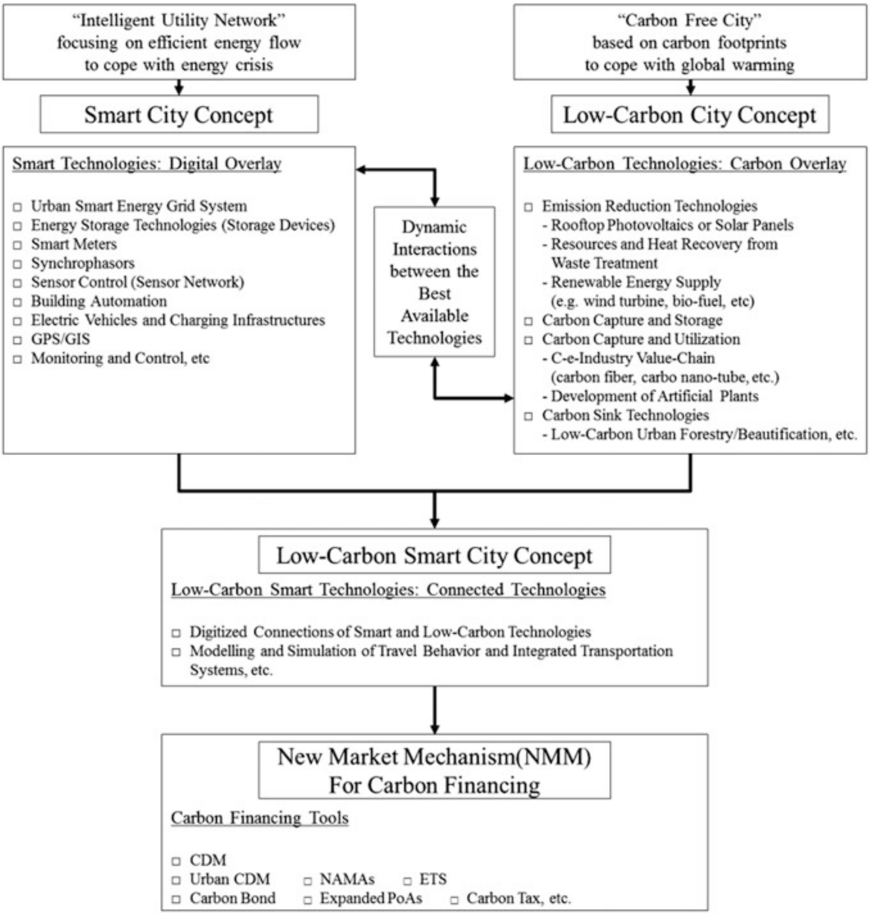

Fig. 2.4 Technologies for the digitalizing connections of smart city and low-carbon city

In Fig. 2.4, the carbon overlay is a quantitative index of the relative importance of individual credits. The score for each LEED credit is estimated based on the carbon footprint for a typical LEED building. A building's carbon footprint is the total greenhouse gas emissions associated with its construction and operation, including the following:

- Energy used by building systems;
- Building-related transportation;
- Embodied emissions of water (electricity used to extract, convey, treat, and deliver water);
- Embodied emissions of solid waste (life cycle emissions associated with solid waste); and
- Embodied emissions of materials (emissions associated with the manufacture and transport of materials) (US Green Building Council).

Fig. 2.5 Image of a smart/connected city. *Source* Gordon Fellor, Internet of everything: revitalizing cities, citizens, and urban systems, June 6, 2016, unpaged

On the other hand, the term "smart grid" defines a self-healing network equipped with dynamic optimization techniques that use real-time measurements to minimize network losses, maintain voltage levels, and increase reliability and improved asset management (Momoh 2012). The smart grid environment requires the upgrade of tools for sensing, metering, and measurements at all levels of the grid (Fig. 2.5).

Climate resilient and low-carbon smart cities and the digital and carbon technology behind them hold much promise and other interesting opportunities for new markets, services, and practices to the cities' stakeholders. These opportunities will be discussed in Chaps. 5 and 7.

2.3 Low-Carbon Smart Sectors with ICT Applications: Sectoral Platform Planning Models

2.3.1 Low-Carbon Smart Transportation System and Land-Use Planning

Energy consumption in the transportation sector in the city of developing countries currently is not monitored via technology systems. As a matter of fact, no information (past, current, and predicted traffic) is available to maintain and control GHG emissions. There is no control of usage of vehicles from any categories, although energy consumption in the transportation sector in the city of developing countries currently accounts for more than 10% of total GHG emissions. There are lots of benefits of smart transportation.

Urban authorities make decisions that influence the transportation systems which may have negative impacts on the sustainability of the city. Hence, actions have to be taken to get solutions through ICT application that help more environment-friendly and sustainable transportation networks, change the human behavior for the use of mode of transport with low-energy demand, reducing GHG emissions, decrease operational costs, move toward better congestion, parking lots and traffic lightings, and integrate new transportation systems. ICT coverage allows individuals to travel less and be more protective via communication.

Land-use zoning and land adjustments in many countries are very critical issues. Although cities only make up 2% of the earth land surface, they are responsible for 67% of global energy consumption and 60–70% of the global GHG produced. Many cities in developing countries are associated with unbalanced growth, fragmental spaces, social segregation, lack of infrastructure, and lack of access to key resources which are quite often related to urban land use.

Therefore, there is great necessity for innovative solutions to maximize the operational performance of transportation and environmental infrastructure, and to move toward more sustainable flow of energy and materials through better land-use planning with digitalized connections based on GIS/GPS techniques.

2.3.2 Energy

Urban energy flow and distribution in many countries are not analyzed as part of urban knowledge base. Hence, it is necessary to understand the interrelations between energy suppliers and consumers, and energy flows between built form, urban infrastructure, and open spaces, as described in section "Design for Energy Conserving Cities".

Another key area is an innovation in the urban smart grid system which is integrated with low-carbon green technologies in a total holistic manner.

The low-carbon smart city requires an urban renewable energy grid system which can be expanded to include carbon capture and utilization, and carbon sink technologies.

2.3.3 Water Supply

The water industry is one of the fast-growing energy users which is a main source of CO_2 emissions. With the rise in water demand, there is a great necessity for innovations driven by ICT applications, with the potential to achieve significant system efficiency improvements.

New technologies are crucial for securing water resources and sustainable integrated management systems that enhance public safety, health, and quality of life in all its communities. Such a utility as water needs to be produced and delivered more efficiently with well-connected networks in terms of electricity used to extract, convey, treat, and deliver water. New technologies for treatment, and processing of “wastewater” streams would recover heat and energy, and valuable raw materials for agriculture and manufacturing, further reducing carbon use.

Water authorities must consider connecting water companies with energy producers to create more effective partnerships for tackling emissions based on the water and energy nexus.

2.3.4 Solid Waste

With urban concentration, cities use a significant proportion of the world’s material goods and produce an increasingly large proportion of global solid wastes.

There are many opportunities for us to reduce our GHG emissions, including reduction of waste volume at landfills and the promotion of waste-to-energy may also, in the future, offer potential revenues from the sale of renewable energy credits and carbon credits in emerging new carbon financing mechanisms, including the Urban CDM and emissions trading programs.

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Chapter 3
Integrated Planning Approach to Climate Resilient and Low-Carbon Smart Cities: Process and Methods

Abstract This chapter examines an integrated planning approach to climate resilient and low-carbon smart cities in terms of process and methods. Management of urban areas and their growth and spatial planning require incorporating disaster risk management and the climate change agenda as essential components of urban development. Only by merging these components and utilizing the sustainable smart planning tools available to us can adaptation and mitigation for global climate change be integrated into our future urban plans. The introduction of digitalized and knowledge-based connection of sectors or elements of a city reduces energy and other resource demands and increases safety and security. It is expected that a new wave of climate action and smart city activities powered by big data and analytics will be emerging. While many "smart" approaches can be introduced into urban planning, the use of smart grids in the planning system, by connecting the dots and creating greater synergies among all the available tools, will increase efficiency, maximize the use of resources, and bring about enhanced benefits.

Keywords Integrated planning approach · Digitalized connection · Smart technology · Innovative thinking · Knowledge-based connection · Big data · New data capital economy · Berkeley · Green connectivity · Smart grid system · Smart ecosystem grid · Sustainable environmental and ecological planning · Smart energy grid · Smart water grid · Smart heat grid

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3.1 Operating System of Climate Resilient and Low-Carbon Smart City Planning: Steps and Actors for Each Step of the Planning Process Involving Wide Range of Stakeholders Effectively and Openly

Planning in the face of climate change requires us to analyze and evaluate a complex set of variables, including:

- Sea-level rise;
- Changing trends in precipitation patterns, storm frequencies, and storm intensities;
- Temperature variability and future trends;
- Water supply (from snow stores, glaciers, and groundwater, for example) now and in the future; and
- Increasing pollutant levels and concentrations of contamination.

There are important linkages between the sustainable development, climate change impacts, and disaster management issues each city confronts. Dealing with climate change has initially been focused on national or regional plans to reduce the contributions to global warming.

But reducing GHG emissions is only one of the important efforts cities must understand. Disasters that result from and/or can be made worse by climate change can undermine decades of growth through a single catastrophic event.

The management of urban areas and their growth and spatial planning require the consideration of disaster risk management and the climate change agenda as essential components of urban development. Climate change will increase the frequency of disasters in cities, and effective disaster risk management is an important component of climate change adaptation (World Bank 2008).

The interconnected nature of these variables requires an integrated planning approach with meaningful collaboration among many disciplines, bringing together planners, architects, engineers, scientists, and technology specialists versed in the context of planning, as well as language of climate change.

Only by merging these various practices and utilizing the sustainable smart planning tools available to us can adaptation and mitigation for global climate change be integrated into our future plans.

A comprehensive climate change approach means several things as follows:

- Integrating government responses to mitigation into existing policies and actions across all levels of governance;
- Combining mitigation responses with adaptation responses;
- Integrating sectors;
- Integrating policy approach with planning, governance, technology, and innovative regulations and fiscal instruments or new market mechanisms (NMMs);
- Interfacing climate science with ethics and policies; and
- Providing opportunities to talk about green and blue infrastructure.

The main opportunities lay in a planning approach that takes climate change mitigation and adaptation responses into account. In Dhaka, Bangladesh, for instance, a Clean Development Mechanism (CDM) project shows that combining mitigation and adaptation responses can yield great economic, social, and environmental benefits. Organic waste is diverted from landfills, where it usually generates high volumes of methane gas (one of the most important GHGs) through anaerobic processes.

By composting the organic waste, these anaerobic processes do not occur, thus resulting in less emissions of methane. The compost produced is used as a fertilizer of soil in rural areas. The effect is that farmers produce more and better crops and become less vulnerable to drought: Farmers are thus better adapted as a result of a mitigation strategy.

On the other hand, many high-income countries have already positioned themselves as leaders new "green" or "eco-friendly" technologies. For example, the methane gas from landfills is collected and used for generating electricity. However, for many urban communities in low- and middle-income countries, these technologies are too capital-intensive or complex.

Urban communities should be included in planning processes and capacity building workshops so that their needs for appropriate technologies are clear and they can take actions themselves. Social community connections are vital to disaster recovery.

Figure 3.1 shows two comprehensive climate resilient and low-carbon smart city planning process in terms of adaptive planning process. It shows an evolving dynamic integration process of city planning, ICT and climate change which are three pillars of climate smart city shown in Fig. 3.2.

Elements of planning are shown in Fig. 3.1. The figure provides a framework to incorporate land development, adaptation, mitigation measures, and physical infrastructure which will be described more in detail later on in this book.

3.2 Digitalized Connection of the Elements in Climate Resilient and Low-Carbon Smart Cities

The digitalized connection of sectors or elements of a city reduces energy and other resource demand and increases safety and security.

3.2.1 Shift in Urban Planning Approach

Throughout history, the construction of great gathering spaces has always pushed the limits of technology. The Crystal Palace, a vast, soaring structure of iron and glass built in London's Hyde Park, was no exception. The brainchild of Joseph Paxton, a master gardener and architect of greenhouses, the Crystal Palace was a stage for one of the most celebrated international expos of all time, the Great Exhibition of 1851. It was the architectural expression of Victorian England's fast-growing industrial mighty (Townsend 2014).

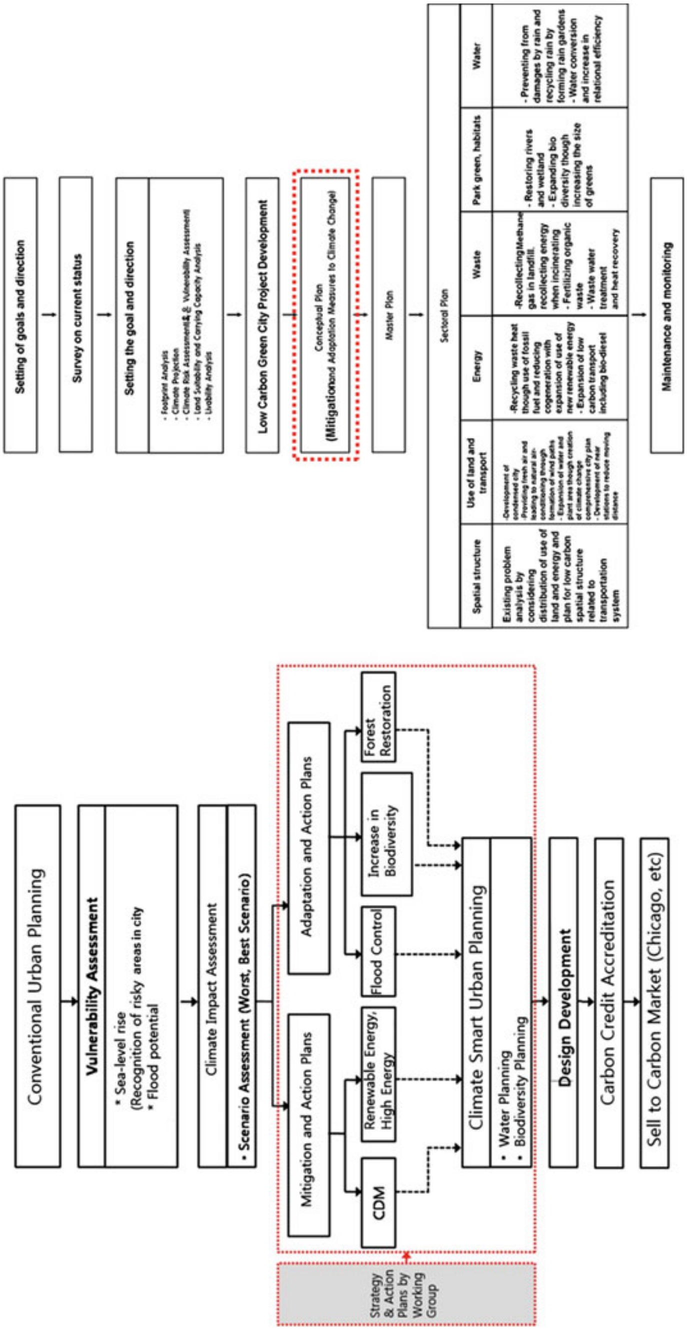


Fig. 3.1 Climate smart comprehensive urban planning model for super-connected cities

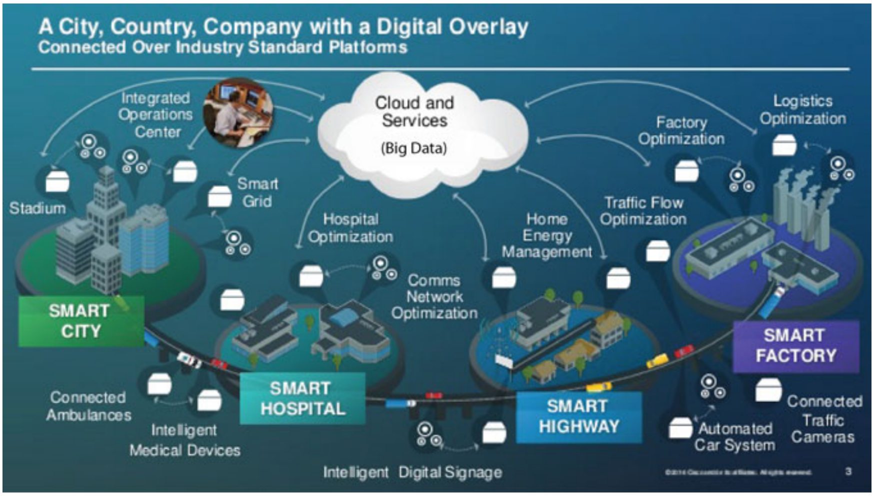


Fig. 3.2 A big data image for a city, country, company with a digital overlay connected over industry standard platforms. (*Source* Cisco 2014)

Nowadays, technology is getting ubiquitous for infrastructure. It means that technology spreads over everywhere. Smart technology brings together powerful new practices and innovative thinking in urban planning.

The innovative process is driven by global warming challenges at the very foundation of the world we have created.

Urban planning discipline is transforming at a rapid pace, interacting with innovation technology and climate change.

As space is getting smarter, the hardware approach to urban planning has been shifted to software-based one, focusing on computing environment with many sensors, meters, and CCTV cameras. A soft and cohesive smart city is getting possible even through mobile techniques and IoT-driven features of life which require Internet connections all the across built environment. Sensors are used for touch-sensitive elevator buttons and a room temperature thermometer for buildings, outdoor solar lightings, and many other aspects of our day-to-day life.

Furthermore, together with outdoor positioning system techniques, indoor positioning system (IPS) techniques are being developed, as can be observed in building information modeling (BIM). Global positioning system (GPS) phones can able real-time positioning.

3.2.2 Knowledge-Based Connection of the Elements of the Built Environment

Knowledge is becoming a database. Big data is a popular term used to describe the exponential growth and availability of data, both structured and non-structured.

And big data may be as important to business—and society—as the Internet has become (SAS 2015).

Big data Imaged for Data Revolution has been developed to show how to connect technology-enabled infrastructure: roads, power grids, security, water, and sanitation.

Cisco has developed a big data image for a city, country, company with a digital overlay connected over industry standard platforms (Fig. 3.2).

In this figure, we can change lightings and colors of coffee shops through a mobile phone. Homes are getting smarter. If a room is empty, the lightings should be off. We can control them remotely with a smart lighting system. For smart parking, if we open the mobile web, we can find a parking space. The shift in shopping behavior makes more online shopping possible. Offline shopping is displaced by the digital home shopping.

In a smart city, an important thing is how to integrate IoT in space. Smart solutions include connected plant, connected rail, connected machine, connected vehicle, connected factory, and connected grid as shown in Fig. 3.2. The IoT allows objects to be sensed and/or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human interaction (Wikipedia).

Although there are huge opportunities for IoT in space, there must be security and privacy issues with sensors and backing/failure of IoT devices. Software architects increase digital affordability for visualizing, monitoring, and analyzing of data. Very recently, the Korean Government has established the big data Center for Creative Economy and Innovation with the Naver Internet Corporation in Chuncheon, Gangwon province. It is one of the 17 centers throughout Korea. They focus mainly on the data for tourism, medicine, and medical treatment and smart sustainable agriculture. However, it has been known that they have an interest to expand their big data to include the data to combine cities and IoT with CCTV, sensors, and meters.

3.2.3 Big Data, Climate Change, and Smart Cities

Cities around the world are facing a triple challenge of a growing population, climate change, and flooding of information and knowledge. In tackling with these challenges, big data and analytics are being put to use.

It can be said that we live in the age of big data. For most planners and companies, their data are considered to be their single biggest asset for "New Data Capital Economy". Big data refers to collections of data that are so enormous in size, so varied in content, and so fast to accumulate that they are difficult to store and analyze using traditional approaches. The three "Vs" are the defining features for big data:

- Volume: Data collections can take up petabytes of storage and are continually growing.
- Velocity: Many data sources change and grow at very fast speeds.

- Variety: Relational databases are very efficient for structured information stored in tables, but businesses can benefit from analyzing semi-structured and unstructured data as well (Wallace 2015).

Climate scientists and climate planners have been gathering a great deal of data for a long time, but analytics technology's catching up is comparatively recent.

Big data and the IoT are going to work with other software and hardware to lead the vision of smart city to fruition (http://www.kdnuggests.com/2015/10/big-data-smart-cities.html).

The idea of "smart cities (http://www.forbes.com/sites/bernardmarr/2015/05/19/how-big-data-and-the-internet-of-things-create-smarter-cities/)" is central to the concept of the IoT—the idea that everyday objects and tools are becoming increasingly connected, interactive, and intelligent and capable of communicating with each other independently of humans. Many of the ideas put forward by smart city pioneers are grounded in climate awareness, such as reducing carbon dioxide emissions and energy waste across urban areas. Smart metering (http://data-informed.com/utilities-executives-cite-need-for-analytics-skills-smart-meter-data-integration/) allows utility companies to increase or restrict the flow of electricity, gas, or water to reduce waste and ensure adequate supply at peak periods. Public transport can be efficiently planned to avoid wasted journeys and provide a reliable service that will encourage citizens to leave their cars at home (http://data-informed.com/how-big-data-is-helping-to-tackle-climate-change/).

In terms of big data technologies, databases without boundaries are part of emerging disaster relief. Online databases can help victims find missing family members, organize volunteers, or link people who can provide shelter to those who need it (Wallace 2015).

Infalia (http://www.infalia.com/blog/31-smart-cities-big-data-and-urban-technologies) has suggested the 25 technologies that every smart city should have, as follows:

- Open-data initiatives and hackathons, like New York City's BigApps competition, which produce useful and resource-saving apps to improve cities and keep citizens informed. Things such as air quality, restaurant sanitation scores, building inspection scores, and impending legislation should be readily available for all citizens.
- Parking apps that show drivers where the nearest available parking spot is. These will save commuters time, gas, emissions, and money, while also easing the flow of traffic. They can also adjust price of parking dynamically to raise revenue and encourage walking/transit.
- Apps that let users "adopt" city property—trash cans, call boxes, trees, fire hydrants, etc.—so the city does not have to spend money sending personnel to tend to them. Boston and Honolulu already have something similar in place, through Code for America, and these projects make citizens feel more invested in their neighborhood.

- High-tech waste management systems—Pay As You Throw (PAYT) garbage disposal would encourage people to recycle more and waste less, while using tools like RFID could improve sorting and parking so recyclable plastic bottles do not end up in landfills. Manufacturing companies should also purchase waste as they produce the packaging objects.
- All-digital and easy-to-use parking payment systems—think EZ-pass for parking. We do not want to put receipts on the dashboard or be confined to time limits that make us run out to put more coins in the meter (if you're going to keep money meters, at least let us add money via an app). It is fine that you charge for parking, but improve the system.
- A city guide app, with information about museums, parks, landmarks, public art, restaurants, and real-time traffic data. These apps, like the ones in Baltimore, Ottawa, Charlotte, and New Orleans, help citizens and tourists alike improve their experience in the city.
- Touchscreens around the city—whether it is a kiosk to buy a MetroCard or the TVs in taxis—should be bacteria-resistant.
- Wi-Fi in subway stations and on trains, along with weather information at every station.
- Sustainable and energy-efficient residential and commercial real estate.
- Dynamic kiosks that display real-time information, concerning traffic, weather and local news, like Urbanflow in Helsinki (Fig. 3.3).
- App or social media-based emergency alert and crisis response systems—every citizen should have access to vital information. Whether it is an alert about a crime that just happened or advice for a storm approaching the city.
- Police forces that use real-time data to monitor and prevent crime.
- More public transit, high-speed trains, and bus rapid transit (BRT) to help citizens traverse the city with speed and low emissions.
- OLED lights and surveillance in high-crime zones, like the 24/7 system coming to Kolkata
- Charging stations, like the solar-powered Strawberry Tree in Serbia. They also function as bus stops and Wi-Fi hot spots (Fig. 3.4).
- Roofs covered with solar panels or gardens. You could even generate solar energy on bike paths, like Amsterdam's SolaRoad (Fig. 3.5).
- Bike-sharing programs, like in Paris, Washington, D.C., and the ones coming to Los Angeles and New York. And bike parking would be nice, too—maybe even underground and machine-driven, like the Eco Cycle in Japan.
- A sharing economy, instead of a buying economy. If we share or rent from each other, we each need to buy and store fewer goods—think Rent the Runway, Netflix, Airbnb. On a similar note, there should be apps to help you find charities that actually need the stuff you want to toss, such as Zealous Good in Chicago.
- Smart climate control systems in homes and businesses.

	
Sub-way station: Arrival and departure information	Sub-way station: Ticketing and traffic card charger

Bus stop with information terminal (BIT): Citizens have access to real time, information concerning temperature, air quality and arrival time of buses

Fig. 3.3 Digital signage, digital city of Seoul, Korea

Fig. 3.4 Electric vehicle (*EV*) charger (charging station), Munster Electrochemical Energy Technology (*MEET*), Munster, Germany

Fig. 3.5 Photovoltaic module, Hongcheon, Korea

- Widespread use of traffic rerouting apps, such as Greenway and Waze. The average person spends 60 h in traffic each year, according to Greenway; these apps calculate the best route for each driver to speed up traffic flow and reduce CO_2 emissions. They also ensure that a traffic jam on one boulevard does not just get displaced to another area.
- Water-recycling systems, because while water covers 70% of the earth, we are not preserving the resource the way we should.
- Cloud-sourced urban planning.
- Broadband Internet access for all citizens—maybe Google Fiber?—which will reduce the digital divide and spur economic growth. This is backbone of all the other techs on this list.
- Mobile payments—everywhere—for food, apparel, and public transportation.
- Ride-sharing programs: To reduce the cost and gas to have two cars go the same place when neither is filled to capacity.

However, the ride-sharing can increase emissions if it substitutes for public transit.

Deloitte has summarized the value proposition of big data to the city:

- Cost saving through the consolidation, monitoring, and optimization-shared ICT assets and services.
- Stimulating business by creating a city-wide digital strategy for economic growth through access to broadband and Wi-Fi services.
- The driving of efficient citizen relationship systems geared to resolving their requests and complaints on first call and benchmarked call closure times, and with more satisfied citizens.

- Lowering costs by providing for an analytics capability to monitor and optimize city processes and resources that can be benchmarked against international standards.
- An ability to provide for enhanced second-tier, cross-department, and agency support to the citizen and moving away from operations that work in silos.

There is every indication that the impact of big data to our lives is set to continue. Citizens can look forward to more transparency and improved service levels from both private and public organizations that make use of their data assets to support and enable new forms of services that innovate on the past.

As such, it is expected that a new wave of climate action and smart city activities powered by big data and analytics will be emerging (Fig. 3.6).

Figures 3.7 and 3.8 show an illustrative positioning and installation of monitoring sensors for IoT in a climate smart city. It is a spatial interpretation of ICT infrastructure for control and measurement based on digital sensor overlay. This map can be used to gather data and compare how well the public authorities communicate with their citizens compared to other cities and towns.

An actual appreciation of sensors and smart-tech will be shown in the next section.

Fig. 3.6 Agricultural drone used for pesticide, Incheon, Korea. *Source* Chosun Daily News, No. 29715, July 22, 2016

Fig. 3.7 Positioning of sensors in climate smart cities (1)

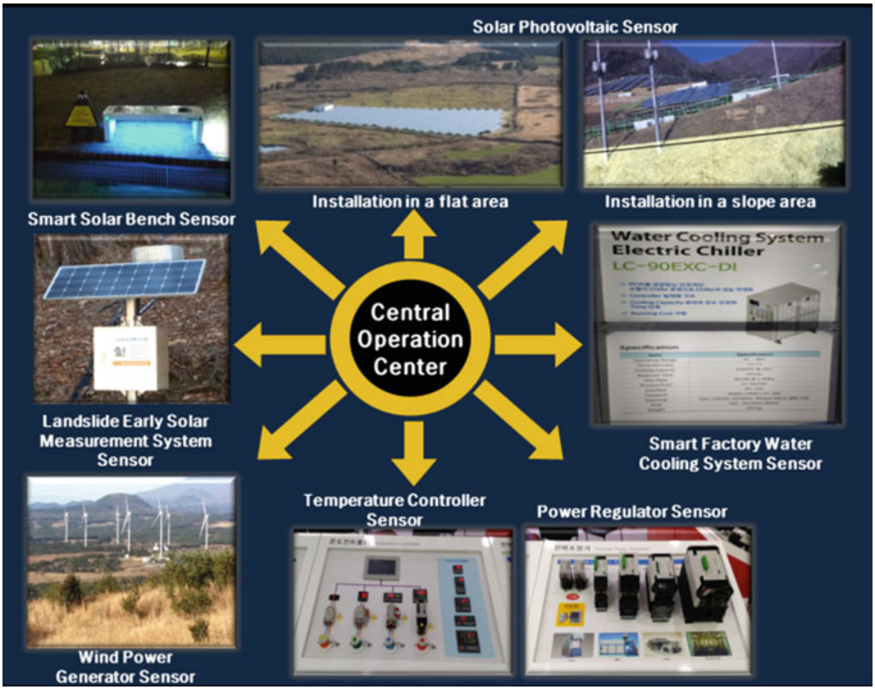
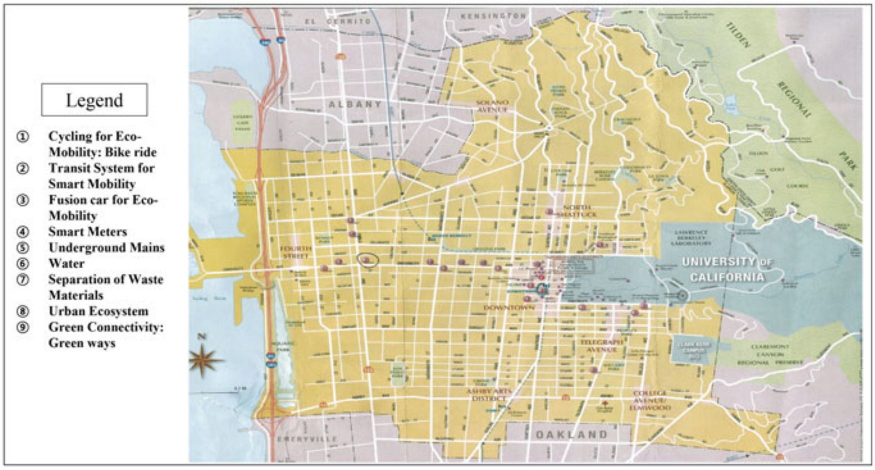


Fig. 3.8 Positioning of sensors in climate smart cities (2)

3.2.4 *Application of IoT and Smart-Tech in Climate Smart Cities: The Case of Berkeley and San Francisco, California, USA*

Berkeley is an inspirational and progressive city. IoT and smart-tech applied in the city are illustrated below in a pictorial way.

3.2.4.1 Location of Smart-Tech

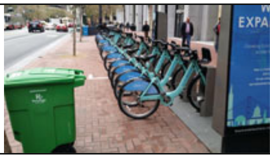


3.2.4.2 Types of Smart-Tech

Cycling for Eco-Mobility: Bike Ride


Bicycle boulevard

Bike racks (1)



Bike racks (2)

Bike racks (3)

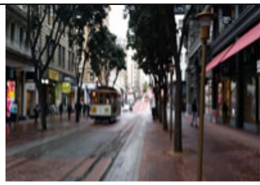
Walk bikes

Bike station

Bike priority area

Transit System for Smart Mobility

Transit routes



Electric train

Hydrogen fuel cell bus

BART system map

Fusion Car for Eco-Mobility

Private electric charger for fusion car

Electric vehicle charger

Mini-electric car

Toyota i-ROAD

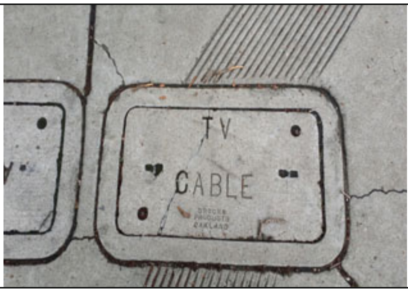
Smart Meters

Parking meters

Energy meter

Meters for gas, electricity and water

Underground Mains



TV cable

Gas valve

Street lighting

Drains

Water meter

Traffic signal

Sewer meter

Water

Use of rain water for home gardening

Irrigation system

Rain garden

Energy-saving garden

Rainwater collection pipes

Rain garden

Separation of Waste Materials

Collection of paper & cardboard

Collection of cans & bottles

Separation of paper & cardboard, cans and bottles and containers and bottles

Collection of plant debris

Urban Ecosystem

Creek restoration

Log housing: Eco-architecture

Urban farming

Vegetable garden

Native plant garden

Wildlife habitat garden

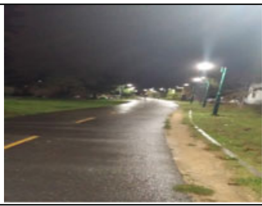
Permaculture garden

Crop garden

USDA organic garden

Green Connectivity: Green Ways

Entrance control



Road in nature

Public park

Common

Neighborhood security scheme: Camera watch

Green corridor

3.2.5 Smart Grid City System for Climate Smart City

The smart grid is an advanced digital two-way power flow system capable of self-healing, and adaptive, resilient, and sustainable, with foresight for prediction under different uncertainties. It is equipped for interoperability with present and future standards of components, devices, and systems that are cyber-secured against malicious attack (Momoh 2012). As an example, a smart grid allows the grid operator to inform customers about their usage of energy. Such a system avoids the need to send personnel out to read actual meters and monitor lines and other components of the energy system. The grid integrates intermittent renewable energy sources with conventional energy to lower carbon.

Considering the smart grid features, smart grid cities for climate change are exciting opportunities to expand further out the smart grid approach, at a much faster rate and on a greater scale than we have seen before. A smart grid city system aims to make outages easier to predict and/or prevent, manage power flow throughout the infrastructure, and give customers greater access to energy information and more control over how much they use.

Many smart grid city, models, and images have been developed with different digital connect-techniques (Google 2015).

3.3 Ecological Planning Approaches to Grid System for Climate Resilient and Low-Carbon Smart Cities

This approach can be used as a tool for decision making and guide targeted investments in key urban priority areas for sustainability, resiliency, connectivity, efficiency, circularity, and prosperity. The approach should be tailored to the specific needs and contextual priorities of cities, responding to current threats and weakness and using available strength and opportunities.

3.3.1 Carbon Overlay to Combine Ecological Mapping Overlay and Digital Connect-Tech Overlay

Figure 3.9 shows the importance of smart grid for building a digital overlay of smart city components.

Due issue is how to connect the real world with the digital overlay with smart ambient media. Carbon overlay can be a product of connecting ecological mapping with digital connect-tech through ICT.

Table 3.1 shows components of ecological mapping overlay and digital connect-tech overlay (Fig. 3.9) which can be superimposed on the carbon overlay.

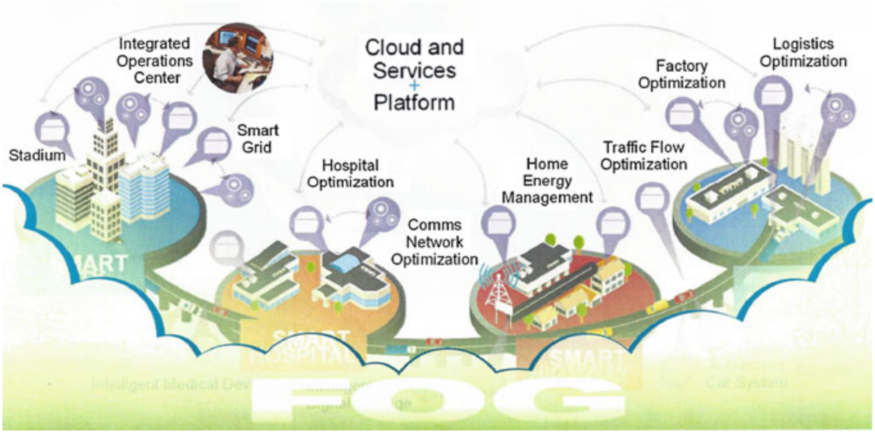


Fig. 3.9 Building a digital overlay of smart city components. *Source* Gordon Fellor, internet of everything: revitalizing cities, citizens, and urban systems, June 6, 2016, unpaged

Table 3.1 Components of overlay approach to climate resilient and low-carbon smart cities

Ecological mapping overlay	Digital connect-tech overlay	Carbon overlay
• Land Development – Land-use zoning – Protected areas – Flood-prone areas • Mitigation – Renewable energy – Carbon capture and utilization – Carbon storage – Carbon forests • Adaptation – Natural ground surface (natural wetlands) – Mangrove plantation – LID (Rain gardens) • Physical Infrastructure – Drinking water – Wastewater – Landfill site – Food waste treatment – Other solid waste infrastructure	• Mobile Techniques – iPhone – Smart phone • Sensors – LED lighting sensor – CO_2 sensor – Car navigation system • Intelligent CCTV – GIS-based CCTV monitoring for crime • Safety – Disaster (natural and human-induced) – Automatic disaster – Water-level perceiving system – Flooding • Meters for metering – Electricity consumption – Water consumption – City gas • Energy and heat density mapping • Monitoring for operation and maintenance (control tower)	• Smart housing carbon footprint • Shopping carbon footprint by social media (Internet: behavioral change) • Smart connected factory carbon footprint • Smart parking carbon footprint • Smart hospital carbon footprint • Traffic flow organization carbon footprint • Intelligent digital signage carbon footprint
Integrated superimposed synthesized map	Integrated superimposed synthesized map	Total amount of carbon footprint and carbon reduction Risk reduction

GIS maps can be used to integrate outdoor and indoor digital overlay map. They can be used to manage and control energy for the whole urban system. This is smart building and city platform process. The use of 3D maps is another advantage for the smart city. Virtual camera for coverage can be put to see a bunch of information. It is a kind of game with all scenarios. As an example, a well-known algorism is available for sunlight simulation and virtuous energy cycle can be simulated.

Questions to start such projects include:

- How easy the project is technically?
- How much money is involved in the project?
- How long the project is? and
- Whether a big data for the project is available?

3.3.2 System Dynamics for Smart Grids

How do land-use decisions effect greenhouse gases? While the simulation efforts of the 1960s had to cope with severely limited computers and data-collection capabilities, with virtually limitless processing power and vast stores of digitalized data at its disposal, IBM developed a computer model of Portland that dwarfed Forester's:

> System Dynamics for Smart Cities, as the apparatus was blithely named, wave together more than three thousand equations (Townsend 2014).

In urban climate systems modeling, there are many sectoral dynamic models described in the previous chapters whose simulation must be based on customized software if their space–time properties are to be explored effectively.

GIS/GPS data inputs, owing to data revolution outputs and related functionality, offer the software designed to generate effective urban simulations associated with climate change.

Models of complex systems with geographic properties, such as cities and ecology, usually involve spatial and temporal processes which are difficult to embed within proprietary GIS. Operational urban models are often built around the link between land use and transport, while models of the urban economy invariably simulate the linkages between different industrial sectors (Batty et al. 1999).

Smart grid can be used for integrating various goals in a consistent decision-making framework. For climate questions, existing integrated urban dynamic models are not sufficient to take account mechanisms relevant for climate issues. There is a need for developing a new integrated urban model to address mitigation and adaptation parameters with the smart grid systems based on the concept of artificial neural network.

3.3.3 Climate Change and Urban Smart Grid System in Climate Resilient and Low-Carbon Smart City Planning

There is the need for viewing the role of smart grids in future ecosystem, energy and water, and heating and cooling systems in urban environments as part of the planning, managing, and operating quantitatively and qualitatively new complex economic–sociotechnical system in cities. The desire is to innovate and deploy new smart technology and design a new climate governance framework for the whole city so that the objectives to contribute significantly to a sustainable world will be met.

At the same time, important public values should be addressed as sustainability, resiliency, efficiency, connectivity, and circularity for making the most out of the smart grid technologies.

3.3.3.1 Smart Grid Concept

Figure 3.10 shows a smart grid conceptual model.

Smart grid is a system tied together with large, wide-area feedback loops. These feedback loops constitute the basic behavioral operating unit of a system of

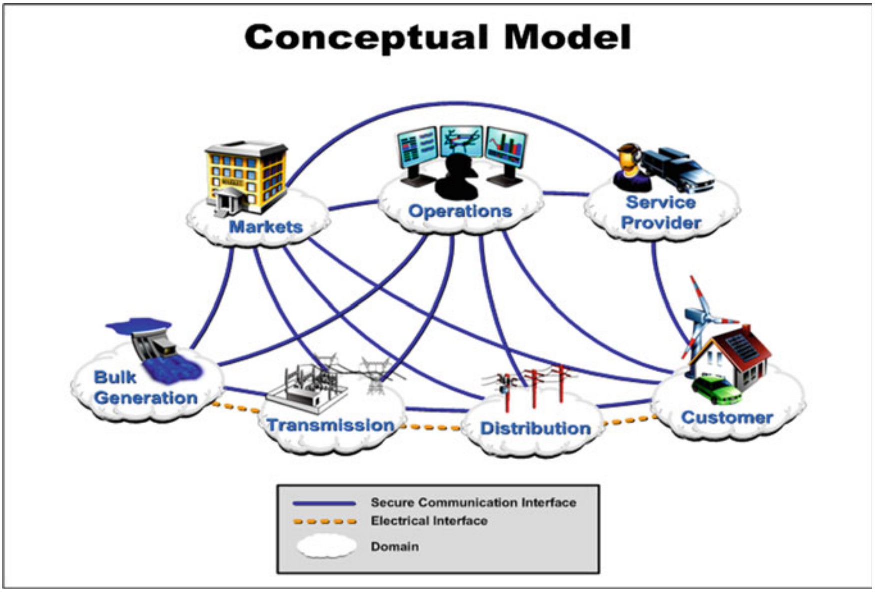


Fig. 3.10 Smart grid conceptual model. *Source* http://www.intechopen.com/books/energy-management-systems/smart-grid-and-dyna…2015-08-05

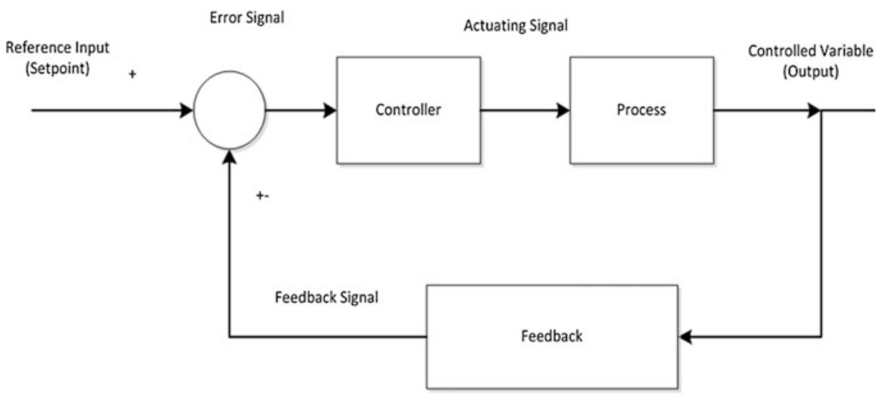


Fig. 3.11 Balancing feedback loop. *Source* http://www.intechopen.com/books/energy-management-systems/smart-grid-and-dyna…2015-08-05

systems. They can bring either stability or instability to the system. They can create growth or shrinkage of the system (Fig. 3.11).

An example of a simple on/off balancing loop is the home thermostat. The desired balance point is the temperature set point. The feedback signal is the room temperature. When the room temperature reaches the set point temperature, the heater is switched off until the temperature decreases below the set point. This digital loop inherently oscillates and relies upon the high capacity and slow response of the room and heating system to achieve acceptable results.

3.3.3.2 Schematic of Proposed Power Line and Wireless Control Connections Between Electric Vehicles (EV) and the Grid

Environmental impact mitigation described in Sect. 2.5.3 is a major driver of smart grid development (Momoh 2012).

The integration/facilitation of the use of renewable energy resources for generation and the move toward the use of plug-in hybrid electric vehicles (PHEV) are two critical aspects of the environmental implications of the smart grid.

One example of smart grid techniques can be illustrated in Fig. 3.12. In this system, each PHEV is equipped with a connection to the grid for electric energy flow, a control or logical connection necessary for communication with the grid operator, and onboard controls and metering.

It will be critical to study the trends of daily PHEV power usage and the average power consumption over one day to determine the impacts on the grid, market, environment, and economy.

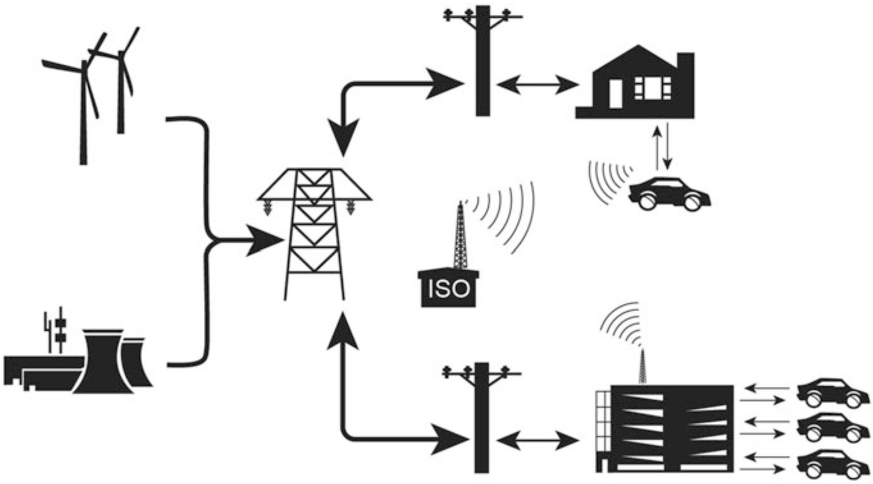


Fig. 3.12 Schematic of proposed power line and wireless control connections between electric vehicles and the grid. *Source* James Momoh, ibid, p. 152

3.3.3.3 Energy Storage Technologies

Energy storage is important for utility load leveling, electrical vehicles, solar energy systems, uninterrupted power supply, and energy systems in remote locations. Energy storage has always been closely associated with solar installations, including solar heating and photovoltaic (PV). Storage options are particularly essential when variable sources are used in islanding and standalone power systems.

Energy storage needs better storage technology and smart grid connections.

Figure 3.13 presents a sample topology for a microgrid system.

Storage options can be evaluated based on the characteristic of the application, for example, whether the application requires portable or fixed storage methods, the duration when storage will be operational, and the maximum power needed for the application (Momoh 2012).

A simple, easy, and practical example of energy storage system (ESS) is shown in Fig. 3.14. In this system, energy from a wind farm, a solar power park, a biogas plant, and a biomass composting plant is stored in a stationary storage system and distributed to housing, e-mobility, and e-grid.

The Bioenergy Park is able to generate 29 MW renewable energy power:

- The wind farm totals 7 wind turbines of 3-MW each.
- The solar power park features 24,000 PV panels installed in 2012 on the bunker walls. The park has a capacity of 5.7 MW peak (can supply 1700 households)
- The biogas plant receives input of 300 ha of corn fields of 17 local farmers, and the technical support is provided by local biogas firm Envitec.

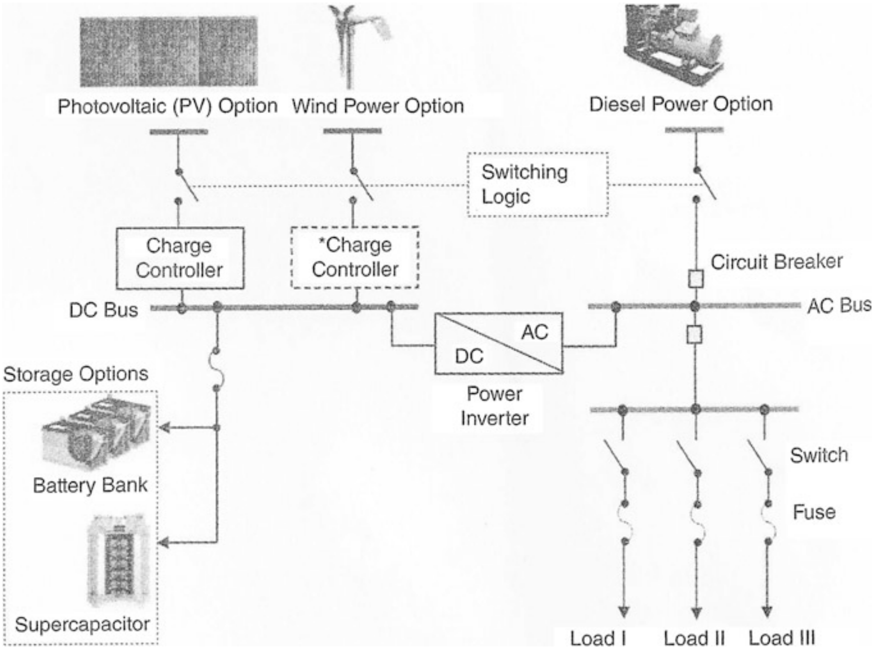


Fig. 3.13 Microgrid topology with storage technologies. *Source* James Momoh, ibid, p. 154

- The composting plant takes care of the fermentation of all biological waste of Region Steinfurt (45 K tonnes/year), and it has a cogeneration capacity of 1 MW heat and has its own wind turbine (one of the seven) (Climate Community Saerbeck 2014).

3.3.4 Types of Smart Grid System for Climate Resilient and Low-Carbon Smart City

The innovations are key outputs of the smart cities. The smart grid system aims to accelerate the development and market deployment of energy and resource efficiency and low-carbon and resilience technology applications in the urban environment. The emphasis will be on their integration, which is a key challenge particularly for smart cities' technologies. The smart grid system aims to bring together technology providers, financiers, and specialists in implementing smart city strategies at local level.

Different types of smart grid system have different impacts on city structure, city function, and city life (such as change of behavior, environment, social inclusion) and hence different levels of impact on climate change. For each type, the

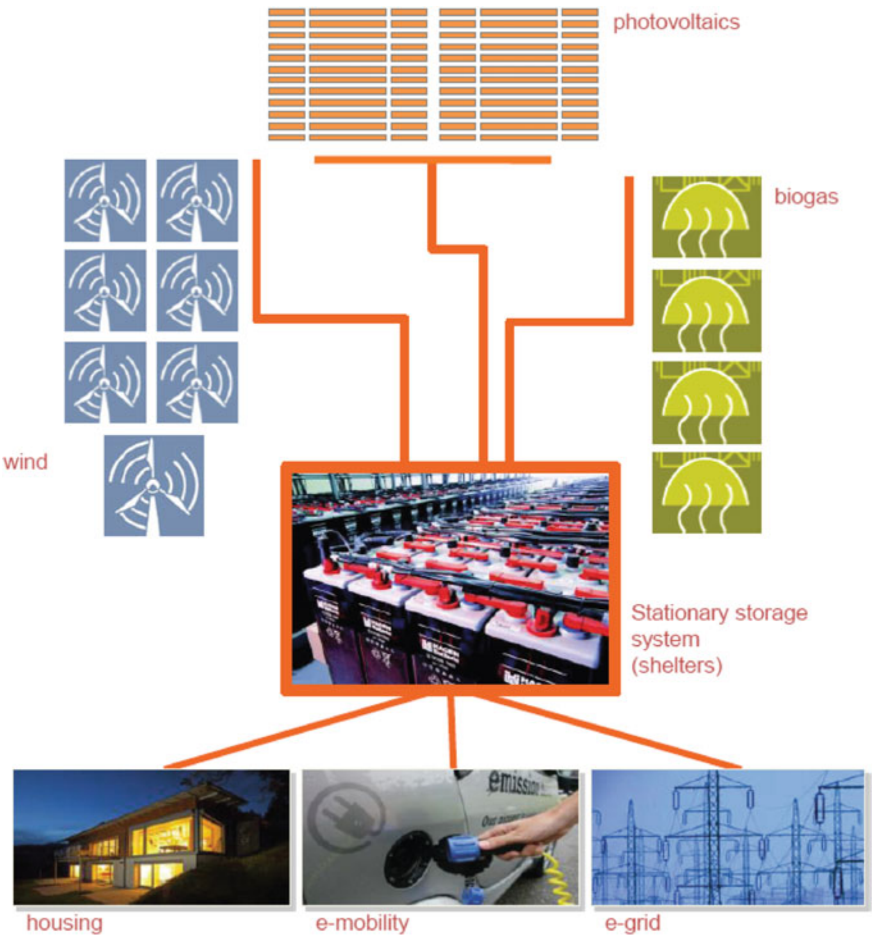


Fig. 3.14 Energy storage systems. *Source* Climate Community Saerbeck: Biogas as contribution to local climate protection, 2nd German-Japanese Biomass Day, Tokyo University, November 7, 2014

methodology to deploy it, including the technical requirements and the necessary framework condition, such as existing infrastructures, technical expertise, regulatory requirements as well as the financial costs involved, is described.

Each type of smart grid system will become an integral part of a carbon-centered comprehensive plan for climate resilient and low-carbon smart cities.

This section addresses four types of smart grid as follows:

- Smart ecosystem grid,
- Smart energy grid,
- Smart water grid, and
- Smart heat (or thermal) grid.

Table 3.2 Types of smart grid by sector at the different scales

Space	Sector				
	Integrated smart grid system	Smart ecosystem grid system	Smart energy grid system	Smart water grid system	Smart heat (or thermal) grid system
City					
District					
Neighborhood					
Building					

Table 3.2 assists for cities to identify potential smart grids and understand their context and implementation needs at the different scale.

3.3.4.1 Smart Grid for Eco-City

The smart grid for eco-city aims at increasing urban connectivity in terms of energy and ecological network including water and green corridors, and wind path (Fig. 3.15).

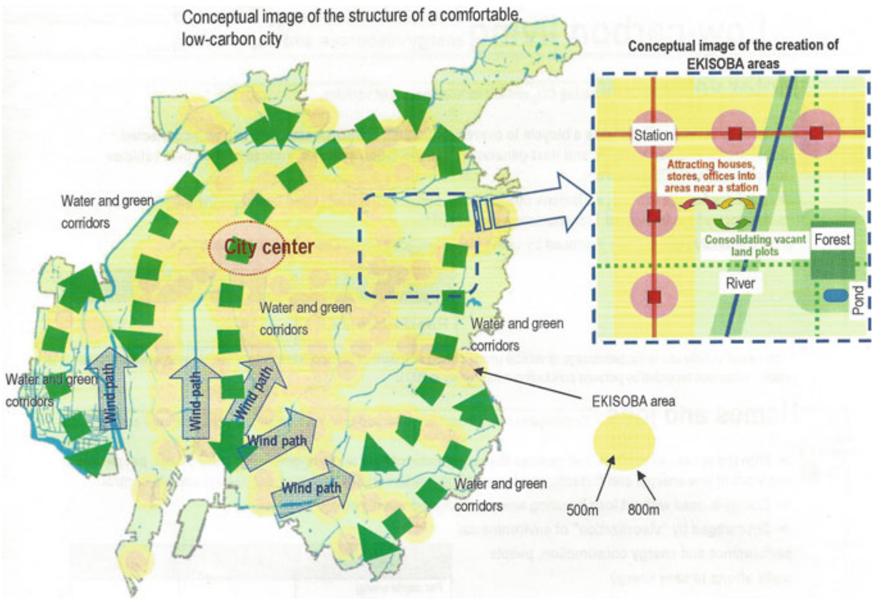


Fig. 3.15 Conceptual image of the structure of a comfortable, low-carbon city: water and green corridors, and wind path in cities. *Source* City of Nagoya, The 2050 Nagoya Strategy for Low-carbon City (Summary), Working on transforming Nagoya into a comfortable low-carbon city-

Smart Ecosystem Grid for the Innovation

In the smart grid, integration of the resources generation, transmission, distribution, and end user components is a critical feature.

Central to urban ecosystems is the idea that links are in existence, and a balance (dynamic equilibrium) exists between inputs and outputs that enables an ecosystem to function effectively. The energy and water balance of urban ecosystems consists of a number of elements divided in natural and man-made.

Complex systems of systems are affected by large numbers of interacting feedback loops. As described in Fig. 3.11, some of these loops have little effect on overall system behavior, while other loops can dominate system behavior. In this context, an important and dominant smart grid feedback loop is the one that connects variable, renewable generation, such as wind and solar energy, with the power consumption of the customer, as described in the previous section.

The smart grid for eco-city focuses specific promising ecological innovations based on the ecological planning concept and approach to promote smart structure and function of ecological resources and their infrastructures which interact with other resources and infrastructures in cities.

The 2050 Nagoya Strategy for Low-carbon City (City of Nagoya 2009) provides four perspectives toward the creation of a low-carbon city based on the structure and functions of eco-city as follows (Table 3.3):

Figures 3.15 and 3.16 show conceptual image of the structure of a comfortable, low-carbon city and conceptual image of the ideal situation.

The main features of the Nagoya strategy are to use natural climate control and land-use systems instead of air-conditioning systems, thus restoring the natural environment.

The author emphasizes the importance of ecological principles such as stability, self-sufficiency, diversity, and circularity in low-carbon technology applications for sustainable environmental and ecological planning.

The next section deals with this issue more in detail.

Sustainable Environmental and Ecological Planning: An Ecological Way to Increase Urban Connectivity—The Case of Songpa-Geoyeo, Korea

Introduction

Although urbanization is a rather positive process that promotes economic growth of nations as well as opportunities for individuals to increase their own value (UN-Habitat/UNEP 1998), the decrease in quality of urban environment raises always question generally accompanying urbanization. In order to mitigate

Table 3.3 Four perspectives toward the creation of a low-carbon city

City development	Shifting toward a compact city in harmony with nature	• Creating communities around station (EKISOBA areas to live in) • Creating a city that uses natural climate control systems instead of air-conditioning systems, thus restoring the natural environment • Shifting from vehicles to public transportation, walking, and cycling
Quality manufacturing	City with the latest environmental technology and wisdom	• Upgrading all systems and vehicles for super energy conservation and fuel efficiency • Promoting comfortable buildings with natural climate control • Promoting next-generation transportation systems
Energy	Shifting from fossil fuels to natural energy sources	• Using natural energy sources, such as solar light and heat • Using an area energy network for the efficient use of energy • Efficiently using underutilized energy resources, such as waste and biomass
Social system	Spread of low-carbon lifestyles and business practices	• Visualizing environmental activities throughout society • Achieving wide-ranging cooperation among cities and the Ise Bay area • Shifting toward low-carbon lifestyles by the active involvement of residents

Source City of Nagoya, The 2050 Nagoya Strategy for Low-carbon City, 2009, p. 10

and address problems of urbanization, interest in sustainability and environmentalism of national land and city planning is increasing. A new market is emerging to increase connectivity of green space and parks in the form of green, blue, and white networks.

Within such trends, the systematization of environmental and ecological planning for the construction of recent new urban and site development area is being sought. The Ministry of Environment of Korea has prepared National Land Environment Planning Guidelines (Ministry of Environment 2006). Within the framework of these guidelines, an environmental and ecological planning system has been established on a large scale for nationally financed new urban area development projects above 2,000,000 pyong (6,611,600 m^2). Such changes are expected to create a space for sustainability and environmentalism to be placed at the center of planning; however, more efforts in various related areas are required for the establishment of systematic methods and techniques through laws and amendments to the system.

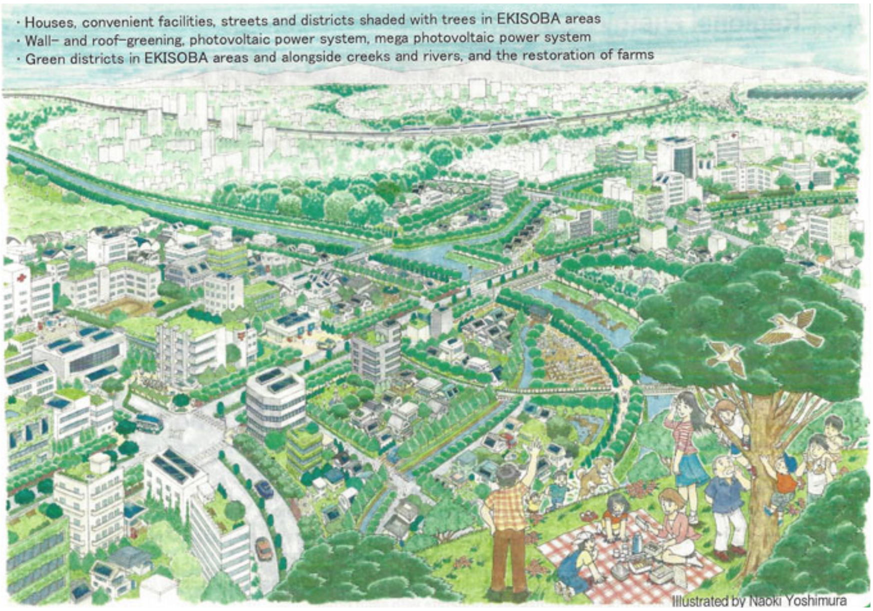


Fig. 3.16 Conceptual image of the ideal situation in low-carbon city. *Source* City of Nagoya, The 2050 Nagoya Strategy for Low-carbon City (summary), Working on transforming Nagoya into a comfortable low-carbon city

What is Environmental and Ecological Planning?

Environmental and ecological planning, in effect, has the objective to provide life to cities in which human beings and nature may coexist in a sustainable and climate smart way. The planning as a first step recognizes that destruction of environment lead to the destruction of human society. This has been discussed extensively since the 1980s when global environmental problems have arisen. The need for such planning is becoming greater because of international movement for sustainable development, energy-use techniques, improvements in nature restoration techniques, and development of environment industries.

The introduction of environmental and ecological planning is an important approach to increase services provided by urban ecosystem and its ecological value. Environmental and ecological planning can be generally defined as "aspiring for a sustainable city" and as a pre-planning process before land-use planning to maximize services of urban ecosystem and its ecological value based on a detailed study and analysis of natural environmental factors and urban ecosystem.

The result of comparison and analysis of current city planning and new urban environmental and ecological planning is summarized in Table 3.4.

In this study, after introducing the environmental and ecological planning model co-developed by the Environmental and Ecological Planning Research Center of the Seoul National University and Korea Land Corporation, the application of the

Table 3.4 Comparison of current city planning with new urban environmental and ecological planning

	Existing city planning	Urban environmental and ecological planning
1. Theological standards	Determinism/comprehensive rationalism	Totalism/organism/circularism
2. Ethical value	Human focused/self-focused	Coexistence of humans and nature/life for future generations
3. Major planning factors	Form/function/structure/space/materials	Humans/other species/place
4. Conceptual understanding of planning problems	Understanding as a process of problem-solving/fitness survival theory of Darwin	Understanding of evolving process of ecology and cultural system/coevolution
5. Planning object	Planning of form and space	Planning looking at place, experience and city as a one ecosystem
6. Process of planning	Linear process	Circular, repeating process
7. Planning principles	Master planning principle	Principle of sustainability/principle of ecology
8. Equity	Equity within a generation	Equity within a generation/intergenerations
9. Post-assessment	Social, economical effects	Ecological, psychological effects

model in a case study town is described. Finally, a simple conclusion was drawn and several proposals were made in terms of urban connectivity.

Development of Conceptual Model of Urban Environmental and Ecological Planning

Characteristics of environmental and ecological planning model

The main characteristics of the environmental and ecological planning model co-developed by the Environmental and Ecological Planning Research Center of Seoul National University (SNU) and Korea Land Corporation (KLC) are as follows:

Firstly, the core of environmental and ecological planning is a concept of pragmatism or practicality. Therefore, in the environmental and ecological model, ecological factors and natural landscape must be given attention. Although ecological factors will be the main focus, because ecological factors are related and reviewed comprehensively with social and economic factors, this planning is a coordinated planning of ecological and socioeconomic aspects of cities.

Secondly, it is an advanced planning. The environmental and ecological planning has the characteristics of advanced planning which applies practical and scientific method in decision process of land use. It is different from the traditional method in that it structures a comprehensive land-use planning by considering in advance the wind, water, air, soil, green area, and slope to divide areas of conservation, restoration, and creation.

Thirdly, it is an equality planning approach that emphasizes the distribution of resources with consideration of interested parties. The environmental and ecological planning accepts the differences in values, attitude, and desire between individual and local community, and within and among generations. Therefore, although this planning needs to be a technical and legal process, it also incorporates sociopolitical dimensions. As such, the environmental and ecological planning is the political response to the social conflicts regarding city planning and its management.

Fourthly, it is a strategic planning contributing to the continual urbanization. It assesses the environmental and ecological gains and losses through strategic environmental assessment (SEA) for each land-use scenario and helps select the optimal planning policy from a strategic perspective.

Fifthly, it is a flexible planning system. As the planning system that has been practiced until now is quite rigid, it is difficult to use it in the environmental and ecological planning model provided in this model. Therefore, it is necessary to induce a flexible planning system which makes the induction of innovative techniques possible.

Sixthly, it is necessary to secure an adaptive urban management system. After the new towns developed by the Korea Land Corporation or the Korea National Housing Corporation, they are transferred to local autonomous authorities. These local autonomous organizations manage the public sector of the new towns. It would be necessary to prepare systematic legal devices for adaptive urban management system, in particular, in case of restoration areas.

Types of urban environmental and ecological planning

Environmental and ecological planning can be categorized into environmental and ecological basic planning, environmental and ecological detailed planning, and environmental and ecological construction planning. The types in spatial hierarchy are reviewed in Fig. 3.17.

Procedures of urban environmental and ecological planning

The procedures of urban environmental and ecological planning are not yet clear from a legal perspective. Different proposals are made by different researchers. The expectation is to introduce the procedures of the planning model developed by the Seoul National University and the Korea Land Corporation. They were developed through the review of existing environmental and ecological planning examples based on the concepts and principles of environmental and ecological planning described earlier on.

From a long-term perspective, the procedures of urban environmental and ecological planning for land use should be developed through integration of "planning process considering city as a social and economic system" and "planning process considering city as an ecosystem" as shown in Fig. 3.18.

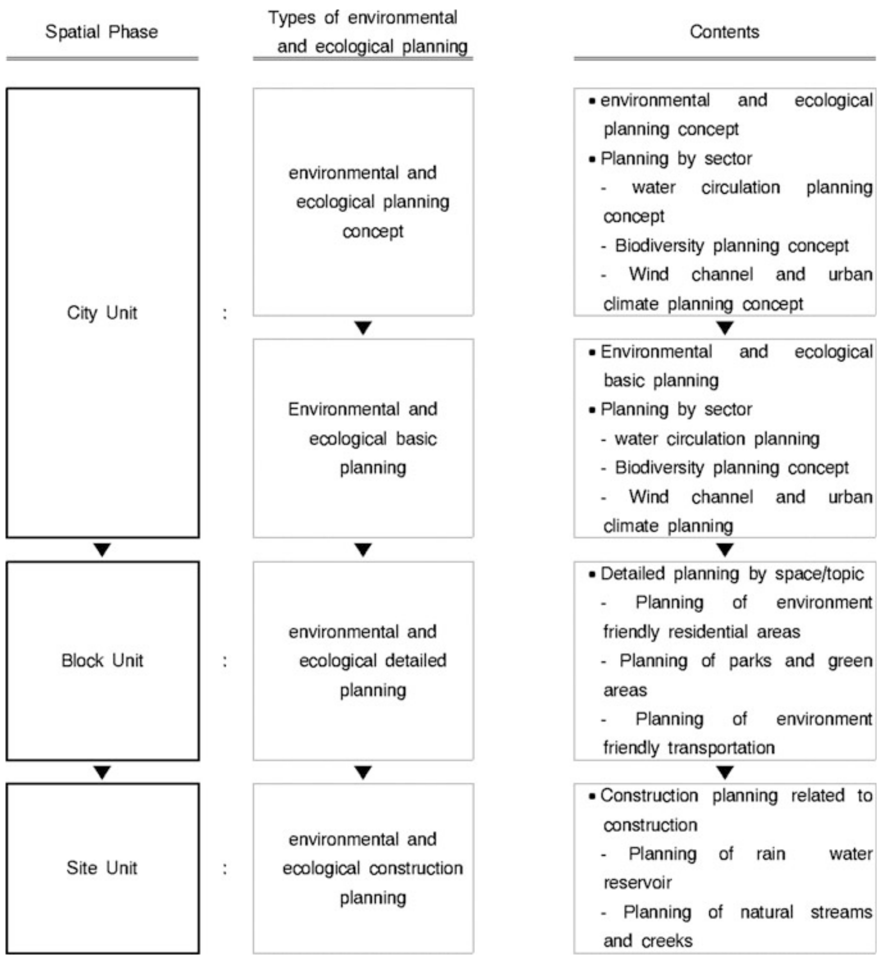


Fig. 3.17 Types of environmental and ecological planning in spatial hierarchy

A strategic assessment of impacts of delineated conservation, restoration, and developable areas on the surrounding environment and ecosystem should be performed, and then, the system of basic planning for each sector and the environmental and ecological basic planning for the city should be established. There should be close hierarchical connections between basic planning, detail, and construction planning.

To summarize, the allocation of land use should be carried out through integrated planning considering the city as a social and economic system and as an ecosystem, and such a land-use allocation should be reassessed and verified through a SEA from the ecological perspective.

The Application—The Case of Songpa-Geoyeo New Town

The SNU and KLC research team led by the author has performed the research related to the environmental and ecological planning used in new town/residential area development projects. The study areas include Pangyo, Paju Unjung, Songnam Yeosu, Poil, Kimchun Innovative City, Songpa-Geoyeo in Korea. The studies have verified the model developed by the research team. The results from the research performed on Songpa-Geoyeo new town are described below. In this case study, the procedure and content in Fig. 3.18 were applied to the method shown in Fig. 3.19.

As a process of environmental and ecological basic planning, (1) planning direction and objective were determined; and (2) on the basis of site survey and evaluation results, a conservation or restoration area was selected on the basis of each ecological factor value. (3) Then, the values assigned to each factor were added to evaluate the aggregated values of the selected conservation and restoration areas by the GIS overlay method in terms of absolute and relative values. (4) A SEA was conducted to evaluate impacts of the original developer's land-use plan on conservation and restoration areas identified in this study. (5) Final conservation and restoration areas were identified through primary consultation with developers in the land allocation process of urban general planning. (6) A new environmental and ecological planning concept including the ecological network concept was developed, and land-use planning proposal was prepared through the consultation meeting and secondary discussion with the developer to apply the proposed concept in the land-use planning.

Thereafter a new environmental and ecological general planning which takes into account spatial scale was established based on the new land-use planning proposal, and sectoral planning followed. Then, environmental and ecological detail planning and environmental and ecological construction planning on each space were carried out together.

The main findings of application of the procedures shown in Figs. 3.18 and 3.19 to a case study area are described below:

(1) Overview of Songpa-Geoyeo New Town

As an administrative division, Songpa-Geoyeo new town includes the areas of Seoul Songpa-gu, Songnam-si Changgok, Bokjung-dong, Hanam-si Hagam, Gamiedong areas with a total area of 6.768 km^2. Generally speaking, fine natural environment, a provincial park, and urban environment coexist. The area has a vast potential for various social, cultural, and environmental conditions. Within the study areas, most areas are being used as military base, golf course, and farmland, and human inference is relatively minimal compared to other areas. Because the city had been expanding due to the development of new town, there were concerns that the phenomenon of conurbation of nearby Seoul and Seongnam areas would take place, and some forest areas within the study areas are already close to the area-wide sub-green axes of the capital region. Therefore, advanced environmental and ecological planning was required prior to Songpa-Geoyeo new town land-use planning (Fig. 3.20).

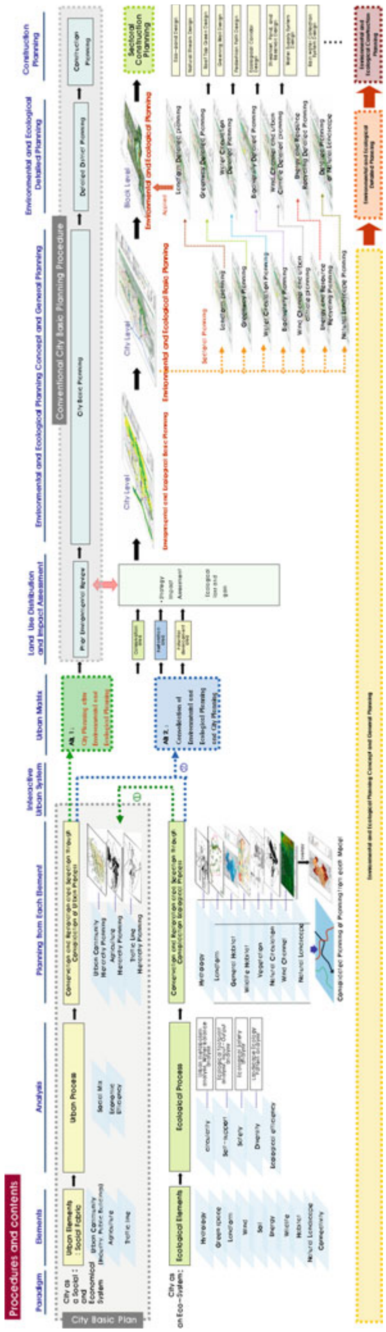


Fig. 3.18 Procedure and content of urban environmental and ecological planning for sustainable land use

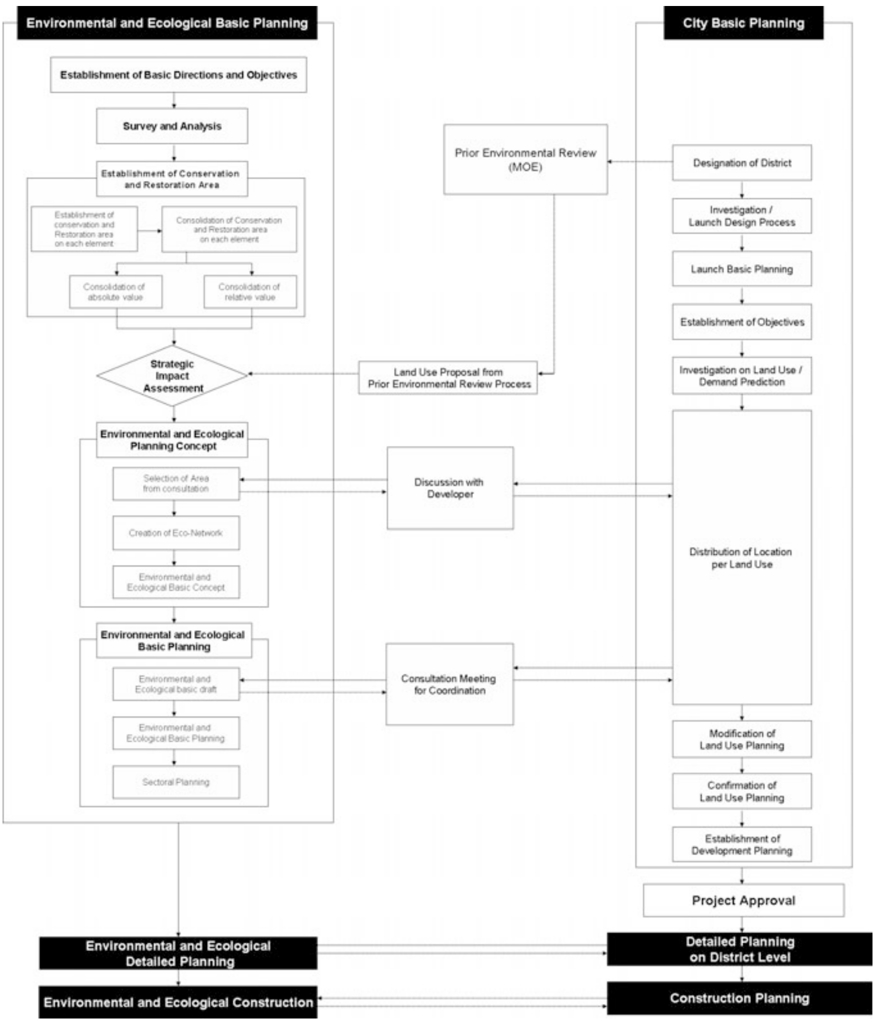


Fig. 3.19 Work flow of environmental and ecological planning model for Songpa-Geoyeo new town: see text for explanation

(2) Establishment of basic directions and objectives

The basic directions and objectives for the environmental and ecological planning of Songpa-Geoyeo new town were as follows:

- Application of a watershed approach;
- Respect of function and value of ecological elements;
- Comprehensive integration of qualitative and quantitative approaches;

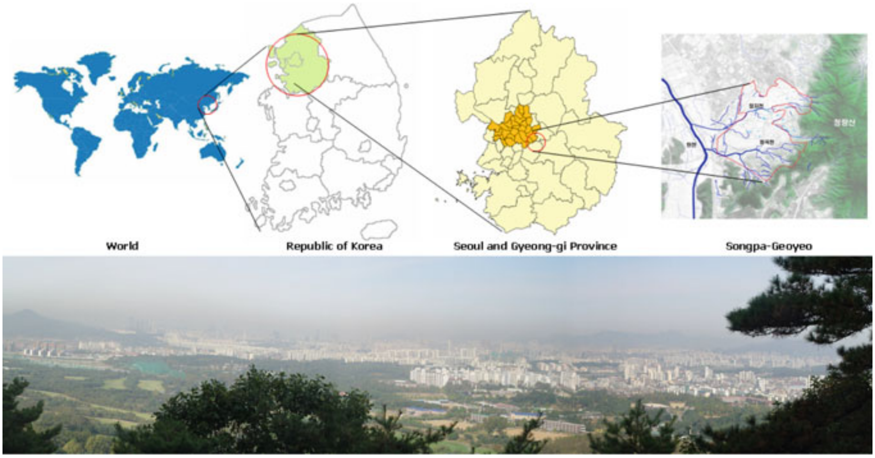


Fig. 3.20 Regional setting (*above*) and whole view (*below*) of Songpa-Geoyeo new town

- Seeking coexistence, commensalism, coevolution of natural ecology and human society; and
- Development of an idealistic ecological city in which all ecological elements are respected and connected.

(3) Civic survey and analysis

In addition to the site survey and analysis conducted by the KLC team, another survey and analysis was carried out for the environmental and ecological planning purposes. The study area was divided into 8 watersheds based on watershed approach. Site survey and analysis of existing ecological conditions were conducted in terms of water utilization, landform, agriculture, and wildlife habitat. Moreover, in addition to the determination of ecological corridor and connectivity of the subject area, the current conditions were analyzed in terms of overall weather and wind channels (Fig. 3.21).

(4) Designation of conservation and restoration areas

For conservation and restoration planning purposes, conservation and restoration principles of 6 elements, water use, landform, agriculture, general habitat, wildlife habitat, and nature circulation, were provided and conservation and restoration areas for each ecological element were selected through a normative and problem-solving approach (Table 3.5).

On the basis of a comprehensive consideration of the ecological processes, the synthesis of conservation and restoration areas by ecological process of Songpa-Geoyeo new town was reached (Fig. 3.22). In synthesizing conservation and restoration areas, absolute (Fig. 3.23a) and relative (Fig. 3.23b) assessments were carried out to designate the conservation and restoration areas in the aggregated way.

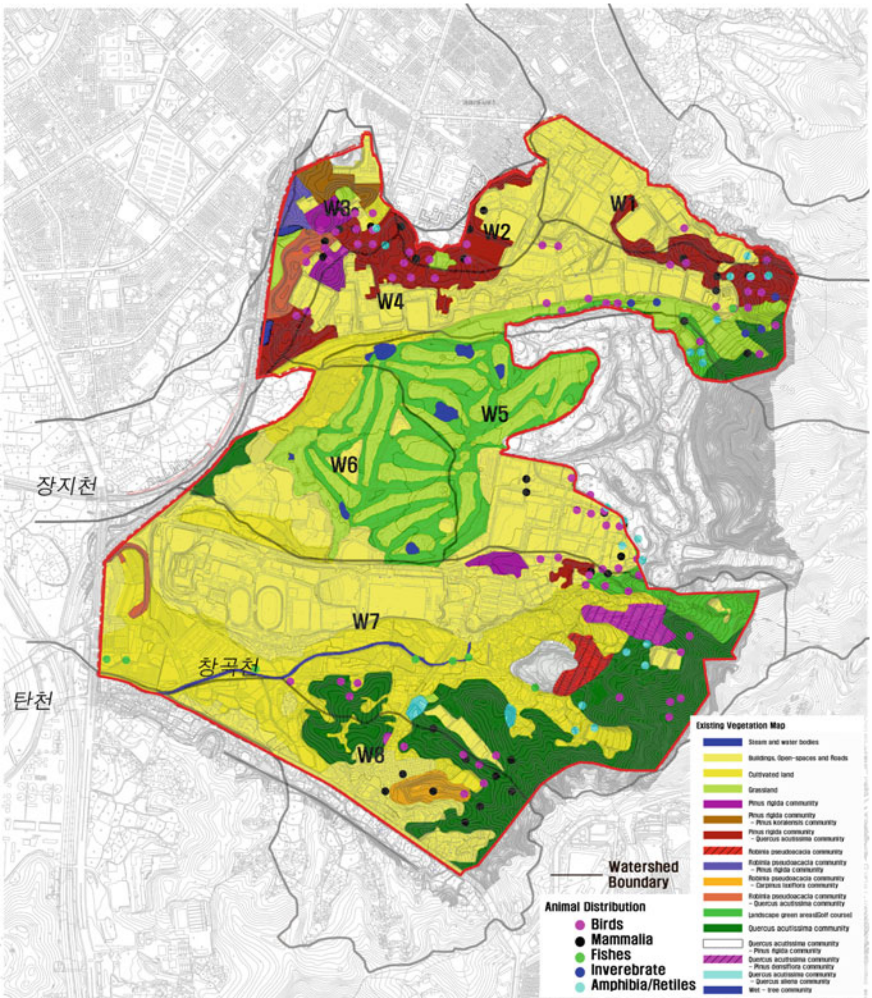


Fig. 3.21 Consolidated results of site profile survey based on 8 watersheds

(5) SEA of the proposed land use

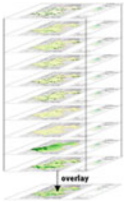
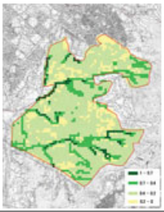
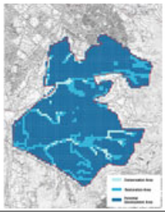
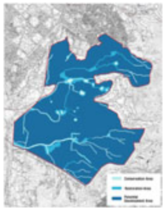
Based on the results of the absolute and relative assessment, a SEA in relation to the land-use alternative proposed by the Korea Land Corporation was conducted.

Proposed land-use scenarios were used in the SEA process which assesses impacts of land-use alternatives on ecological elements.

The proposed land-use planning by the Korea Land Corporation according to the prior environmental review system is shown in Fig. 3.24.

The impacts of the proposed plan (Fig. 3.23) on Fig. 3.22 were assessed as a gain or a loss Fig. 3.25a, b.

Table 3.5 Selection of conservation and restoration areas based on hydrology

Classification	Selection of evaluation elements and standards	Suitability evaluation	Selection of conservation and restoration areas
Normative approach			
Problem-solving approach	Expert standards based on site survey and land-use analysis • Current land-use shape and pattern should be respected to the maximum • The whole hydrological profile including streams should be conserved to the maximum • The disconnected area such as streams in hydrological perspective should be restored • Experts decisions should be taken when selecting restoration areas regarding such areas as wetland and pond • Linkage between green areas should be connected to create networks.		

(6) Development of an alternative environmental and ecological plan

A new environment-friendly land-use plan (proposal) was elaborated in discussion with developer, and ecological network concept was developed to connect the designated conservation and restoration areas.

Conservation and restoration areas were selected based on the results of the strategic environment assessment to improve the positive effects and to reduce the negative effects from the development (Fig. 3.26).

Thereafter, conservation and restoration areas for the environmental and ecological land use were determined in close consultation with the developer and are shown in Fig. 3.27.

On the basis of the selected conservation and restoration areas (Fig. 3.27), an ecological network in Songpa-Geoyeo new town taking into account regional connectivity and linkage was conceptualized in Fig. 3.28.

Then, the overlay of conservation and restoration areas (Fig. 3.27) and ecological network concept (Fig. 3.28) is shown in Fig. 3.29.

The results of the environmental and ecological planning study of Songpa-Geoyeo new town were reflected in the original proposed plan through negotiations and opinion adjustment process for approval by the Korea Land Corporation. The ensuing change in land-use plan proposed by the developer is shown in Fig. 3.30.

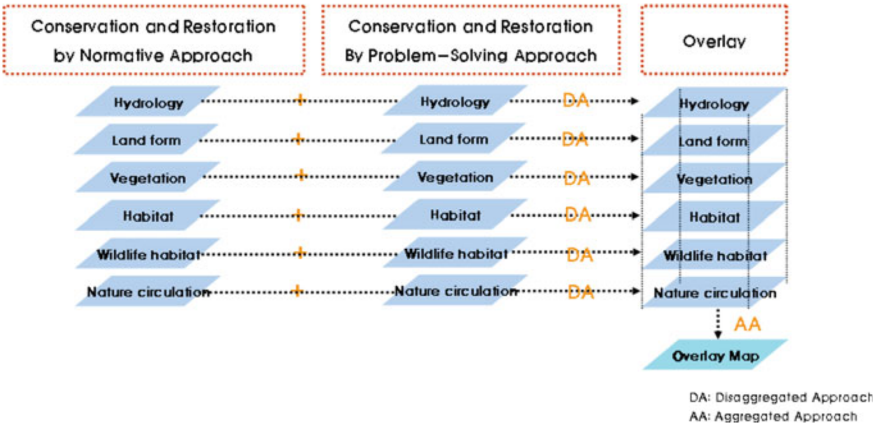
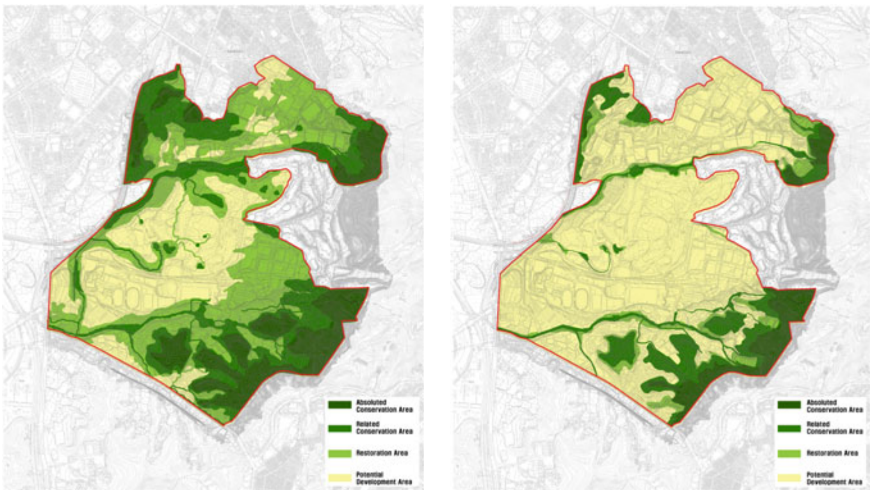


Fig. 3.22 Comprehensive procedure of selection for conservation and restoration areas in Songpa-Geoyeo new town



(a) Overlay of absolute value (b) Overlay of relative value

Fig. 3.23 Selection of conservation and restoration areas through overlay of each ecological element

Table 3.6 shows how much ecological factor values were accepted by the Korea Land Corporation.

The following practical and useful implications can be derived from the application of the environmental and ecological model developed with Songpa-Geoyeo new town model.

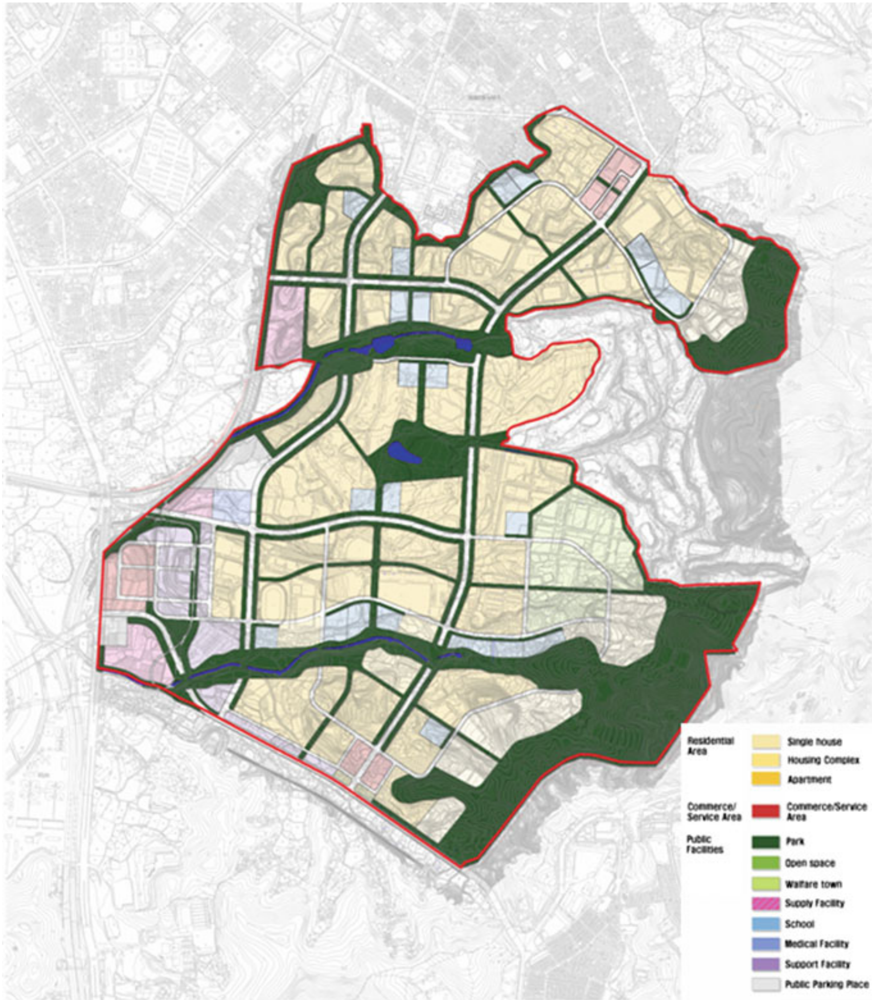
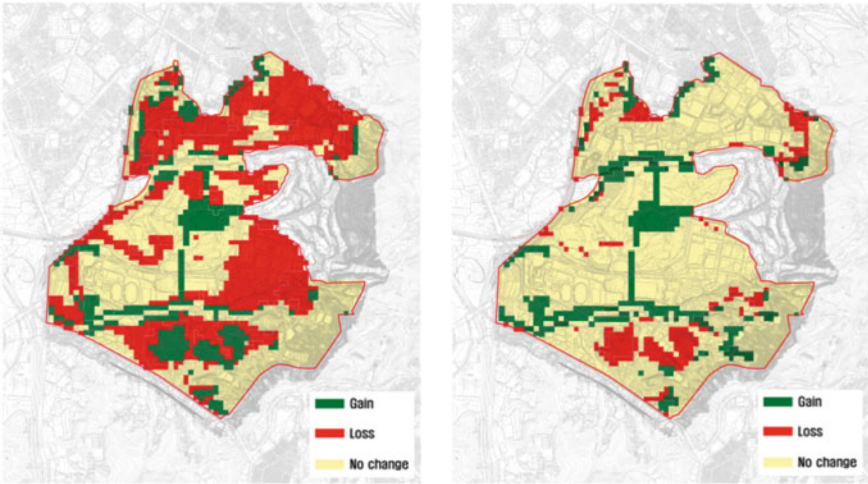


Fig. 3.24 Land-use planning for prior environmental review process proposed by the developer (proposal)

First, environmental and ecological planning is one method of using and creating natural resources and environmental values within the city.

Second, this environmental and ecological model can be applied at city level, block level, as well as regional level.

Third, environmental and ecological planning is a method which increases possibility and potential for the city to provide better ecosystem services and connectivity, and it provides for the increase in the ecological value of the urban ecosystem.



(a) Overlay of absolute value (b) Overlay of relative value

Fig. 3.25 Strategic impact assessment on land-use planning proposal of Songpa-Geoyeo new town, proposed by the Korea Land Corporation

Fourth, environmental and ecological planning can be applied easily by using existing GIS tool, thereby providing for easy repeated application in other areas.

Fifth, by carrying out a SEA, the environmental and ecological planning can assess the impacts of urbanization and suggest mitigation measures and can be used as a tool for opinion adjustment and negotiations of various related parties.

Sixth, the planning can be an effective governance method to resolve conflicts among related parties for "Inclusive City."

It is important to note that a good big data is required for databases of Environmental and Ecological Profile (EP) and Environmental and Ecological Management Information System (EMIS) to increase urban connectivity in terms of ecological corridors.

An Illustration of the Smart Ecosystem Grid Design at the Neighborhood Level

As shown in Table 3.2, the smart ecosystem grid system can be established at a different scale. This section addresses how a smart ecosystem grid can be designed at the neighborhood level.

Climate change adaptation and mitigation projects are part of a larger urban eco-system. The neighborhood must be seen as part of the city ecosystem and must be carefully interfaced with the natural and cultural environment and other aspects of the urban fabrics in terms of the evolving process of nature and culture.

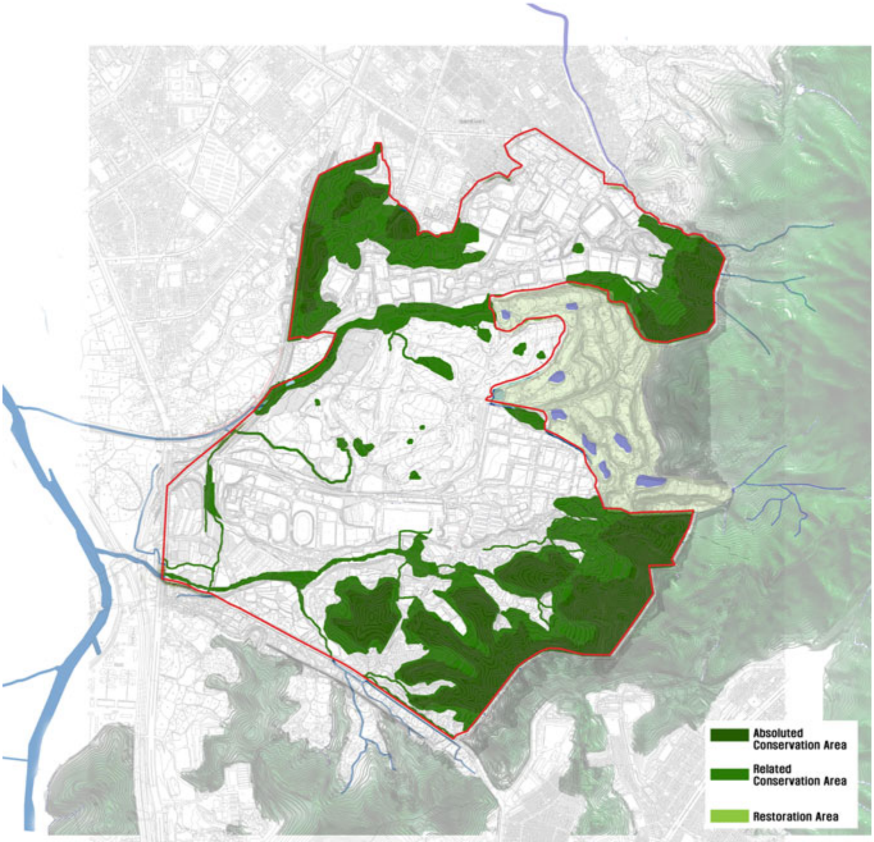


Fig. 3.26 Selection of conservation and restoration area on the basis of strategic environmental assessment

If every street, every neighborhood becomes the city in microcosm, reflecting the full diversity of the city, then a richer range of connection between spaces is facilitated. Even though climate adaptation and mitigation projects take up a small percent of urban space, they have to be efficiently connected with other community facilities, local government offices, and a transit center in terms of materials and energy flow which contribute to reduce carbon footprint.

This neighborhood planning process leads to a specific urban layout including systems for water treatment, energy supply, mobility, as well as the design for resource-efficient open spaces and built-up areas.

This new eco-neighborhood model can be replicated in other areas and can have the following objectives:

- Develop it as a showcase of ICT neighborhood,
- Enhance livelihoods of vulnerable people and communities, and

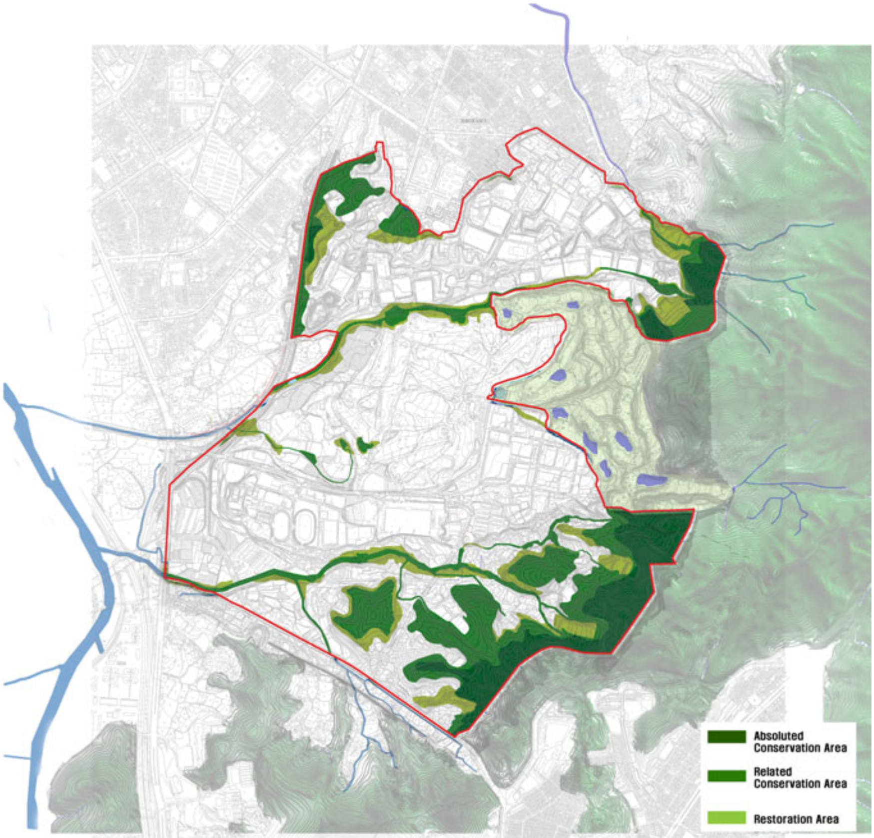


Fig. 3.27 Selection of conservation and restoration areas in consultation with developer

- Increase resilience of health and well-being, energy, food and water security nexus.

Model neighborhood projects could include some or all of the below programs for the master plan and detailed layout plan documents. These facilities can be shown in the form of the virtual world before the master plan is prepared (Fig. 3.31).

A planning process to build a smart ecosystem grid at the neighborhood scale is described below.

(1) **Site selection at the neighborhood scale**

A site that contains options for land use, adaptation (e.g., flooding risk), mitigation (e.g., electricity supply), and infrastructure (e.g., water and waste) can be used in the planning process to (re)build eco-neighborhoods.

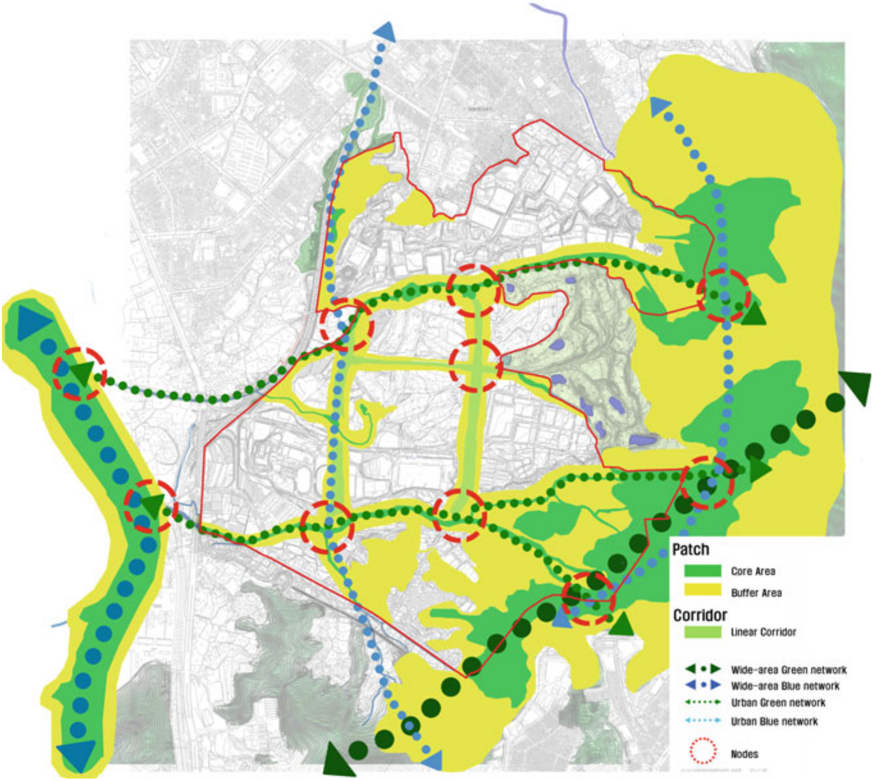


Fig. 3.28 Ecological network concept

Before any new adaptation and mitigation projects take place, the boundaries of the neighborhoods and their center/s must be clearly defined.

Some site selection criteria are suggested as follows:

- Existing plans that very clearly show current situations and state existing policies should be available for the site,
- Distance from the train station and the town center for a number of tasks accomplished by one trip to central location,
- Neighborhoods defined as a complete urban grown units, and
- Neighborhoods with their own internal life.

(2) **Identification of local assessments and needs**

Our experiences show that certain particular conditions on the ground are decisive for determining optimal planning solutions. With regard to eco-neighborhood projects, local needs and assessments are good entry points for interventions in the field of climate adaptation and mitigation.

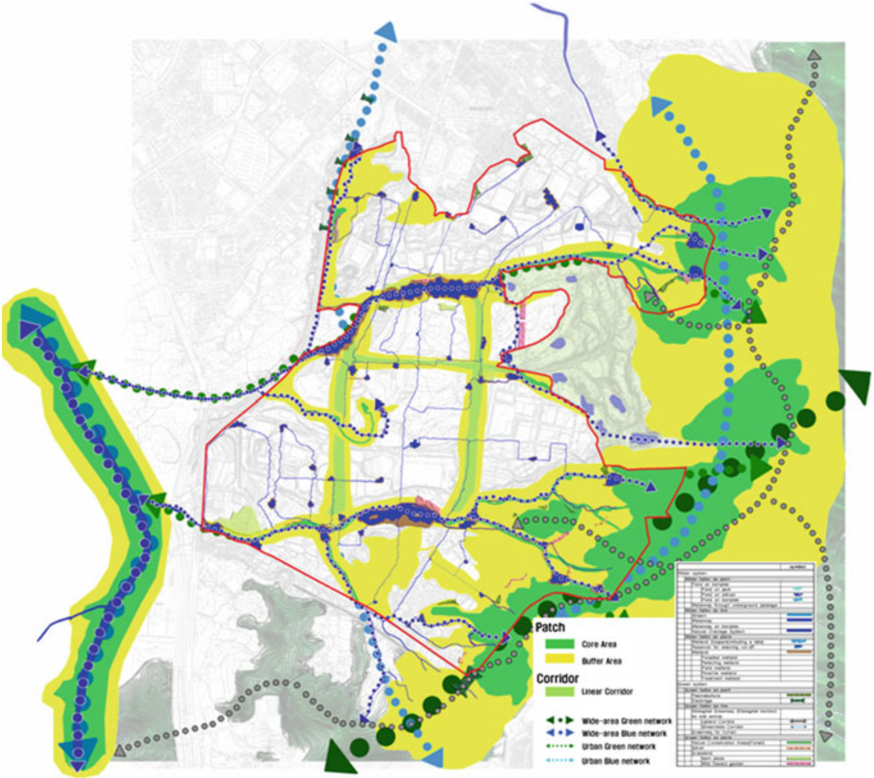


Fig. 3.29 Conceptual environmental and ecological land-use plan of Songpa-Geoyeo new town

(a) Proposal by the Korea Land Corporation in prior environmental review process

(b) Proposal from environmental and ecological planning research

(c) Final land use plan submitted for development permit by the Korea Land Corporation

Fig. 3.30 Comparison of land-use plan in Songpa-Geoyeo new town (proposal)

Table 3.6 Results of applying proposed environmental and ecological plan in Songpa-Geoyeo new town by ecological element

Element	Hydrology	Landform	Vegetation	General habitat	Wildlife habitat	Natural circulation
Conservation area	●	◎	●	◎	●	●
Restoration area	◎	○	◎	○	○	◎

● mostly, ◎ partially, ○ little

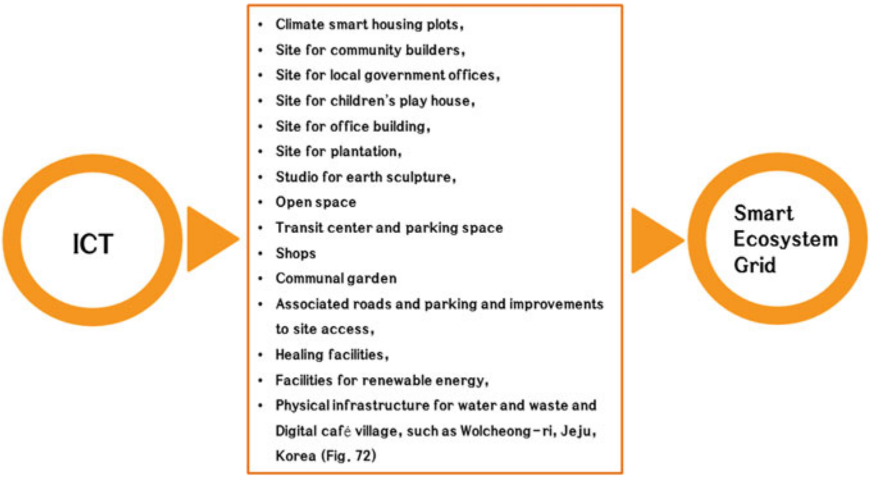


Fig. 3.31 Digital café village, Wolcheong-ri, Jeju, Korea. *Source* Chosun Daily News, No. 29579, 15 February, 2016

Local assessments should include the following: (1) site description for the physical, socioeconomic, and cultural environment; (2) the results of a strength, weakness, opportunity, and threat (SWOT) analysis; and (3) human resources to be engaged in the planning, construction, operation, and maintenance of the projects.

Local needs should be identified by using an analytical framework, including participation and climate governance.

(3) **Design of climate adaptation projects**

Climate change adaptation is defined by the IPCC as "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects."

At the neighborhood level, the hard impermeable areas associated with development can result in undesirable consequences in terms of the rapid runoff of surface water. This can result in poor quality water entering water courses and a risk of local flooding.

The below process is suggested for the design of climate adaptation projects which are important components of a smart ecosystem grid:

- Step 1: Think about the eco-soul:
  - Responsibility to the earth and
  - A new vision for urban living adapted to the climate and resources challenges of our time.
- Step 2: Define neighborhood
  - Natural boundary and
  - Its own internal life.
- Step 3: Promote low-impact development (LID)
  - Water-sensitive neighborhood design, in particular, with rainwater;
  - Distinctively pedestrian with neighborhood feeling;
  - Retention measures;
  - Refreshing presence of nature in the form of generous planting integrated into retention meadows, the stunning lake which is itself a stormwater retention feature, at the heart of the development and the restored adjacent creek into recreational path areas; and
  - Better management of rivers for climate adaptation.
- Step 4: Select appropriate technologies for climate adaptation options and relate them to smart grid
  - Rainwater gardens,
  - Porous pavements,
  - Retention ponds,
  - Buffer zones,
  - Soil stabilization,

– Drainage system's construction,
– Flood-plain zoning,
– Landsliding control, and
– Ecosystem-based adaptation.

(4) **Design of climate mitigation projects**

Climate mitigation projects aims to achieve independence from nuclear and fossil energy through a small neighborhood mitigation project.

As previously described, the term "smart grid" defines a self-healing network equipped with dynamic optimization techniques that use real-time measurements to minimize network losses, maintain voltage levels, increase reliability, and improve asset management. The smart ecosystem grid at the neighborhood level requires the upgrade of tools for sensing, metering, and measurement.

The planning process for the climate mitigation projects is as follows:

- Step 1: Think about transformative climate action
- Step 2: Sensitive urban designing with climate
  – Energy savings,
  – Practicality of the site being 5-min walk to both the train station and the town center, and
  – A variety of architecture types, all of them with low energy and built with sustainable materials.
- Step 3: Prepare digital overlay map and carbon overlay map to visually show efficient deployment of GHG reduction technologies with GIS/GPS techniques
- Step 4: Select appropriate climate mitigation technologies including technologies for "smart city" and "low-carbon city."

Smart technologies for digital overlay may include:

- Urban smart energy grid system (e-grid),
- Energy storage technologies (macro-, micro-, and nano-storage devices),
- Smart meters (Fig. 3.32),
- Synchrophasors,
- Sensor control (sensor network),
- Building automation,
- Electric vehicles and charging infrastructures,
- GPS/GIS,
- Monitoring and control, and
- Digital village (Fig. 3.33).

On the other hand, low-carbon technologies for carbon overlay include:

Fig. 3.32 Smart electric meters

Fig. 3.33 Digital village: drinking water, city gas, and energy consumption metering, solar village, Gwangju, Korea

Fig. 3.34 Logo on the training course on eco-city and low-carbon smart city, IUTC, Korea

- Emissions reduction technologies
  - Renewable energy supply (e.g., solar photovoltaics, wind, biogas, and biofuel),
  - Resources and heat recovery from waste treatment, and
- Carbon capture and storage;
- Carbon capture and utilization
  - Carbon emission industry value chain and
  - Development of artificial leaves; and
- Carbon sink technologies
  - Low-carbon urban forestry/beautification.

Detailed descriptions for mitigation plan will be described at the city scale in the next chapter.

(5) **Synthesis: The package program design of adaptation and mitigation projects with integration of ICT tools**

The full complexity of the climate resilience and carbon-smart development for a smart grid design can be addressed and managed through fast connected networking and information sharing using ICT applications for land-use planning, transport, energy, buildings, water, and waste management in an integrated holistic manner in terms of climate adaptation and mitigation. As described earlier, a carbon overlay can be developed with a quantitative index of the relative importance of individual credits for each infrastructure project.

The process for integrated ICT-supported planning of climate infrastructure can be suggested as follows:

- Step 1: Select sectoral platforms to be connected in the neighborhood,
- Step 2: Connect different sectoral platforms with connect-tech for sensing, metering, automation, and Internet control, and
- Step 3: Prepare the digital overlay and carbon overlay based on the carbon footprint.

(6) **A single project development**

The hierarchical view on climate adaptation and mitigation projects can lead to single projects that divide technologies into segregated parts at the lowest level of a smart grid system with a purpose: to enable maximum output for minimum effort in building a smart grid.

One possible example of a single project would be to use the solar-based LED lighting system for homes and public space, which has combined the green solar energy with low-power LED bulb. The Home and Public Space Lighting Grid System with a ESS provides one option for lighting in the poor surroundings that suffer lack of electricity.

(7) **Implementation plan**

Options should be sought on how to implement integrative plans and PV technologies for lighting, cooling and heating, and home appliances in electrified neighborhoods.

The implementation plan should include laws and regulations, timeline, and financing. The institutionalization will then indicate which organizational arrangement suits the technologies best.

The local-designated lead agency would have to prepare timeline, financing, and vocational education and training for detailed design, technologies, and on-site construction workers for the selected projects which form a smart grid.

A Case of the Kelapa Gading District, North Jakarta City, Indonesia: Toward Ecological and Smart City Planning for Climate Change Adaptation in Reducing the Flood Disaster Risk

With its training priority “Eco-city and Low-carbon Smart City,” the International Urban Training Center (IUTC) is focusing on building the capacity of participants to design smart eco-neighborhoods (Fig. 3.34). The training approach here differs from other forms of training due to its practice-oriented focus that takes into account local needs as a basis for the development of applicable solutions.

Eight workshop outcomes were in different thematic fields within the broad framework of the smart eco-city during the IUTC training course in 2015.

Fig. 3.35 The DKI Jakarta province that is located in north coast of Java island

This section presents an outcome of the workshop, in dealing the background, the issue of the project, and a short overview of the outcome. This case study is an application of eco-neighborhood model described in the previous section.

Background

The project site, Kelapa Gading, is in North Jakarta city, part of the Daerah Khusus Ibukota (DKI) (The Special Capital City Area), Jakarta province, the capital city of Indonesia. The DKI Jakarta, located in north Java coast, is the low land with the downstream of 13 rivers that flow from the south highland, Bogor city (Figs. 3.35 and 3.36).

The Indonesian population is approximately 255 million with a GDP per capita US$3511 (IMF April 2015). The Java island with over 50% of population living in Indonesia is the most densely populated, 1057 people/km^2 (BPS Statistik/Central Bureau of Statistics 2013), and the DKI Jakarta province is the most densely populated province with the 19,968 people/km^2 (BPS Statistik 2013).

Some area of DKI Jakarta has been developed to meet housing needs. Kelapa Gading in North Jakarta, which was a marshland and sparsed agricultural land, was in 1976 by the real estate developing company, Summarecon Agung, developed into an integrated residential–commercial area with a grid-typical urban planning with supporting facilities such as schools and hospitals (Fig. 3.37).

Description of the Kelapa Gading district

The District of Kelapa Gading is 16.12 km^2 wide and its population is 128,729 people, with a density of 10,800 people/km^2. In the west, this area is bordered by the west Sunter River. The Sunter River flows to the sea, the Jakarta gulf. In the south, it is bordered by the south Sunter River and Perintis Kemerdekaan road. In the north, it is bordered by the water drain which ends in west Sunter River. In the east, it is bordered by the Pertukangan River.

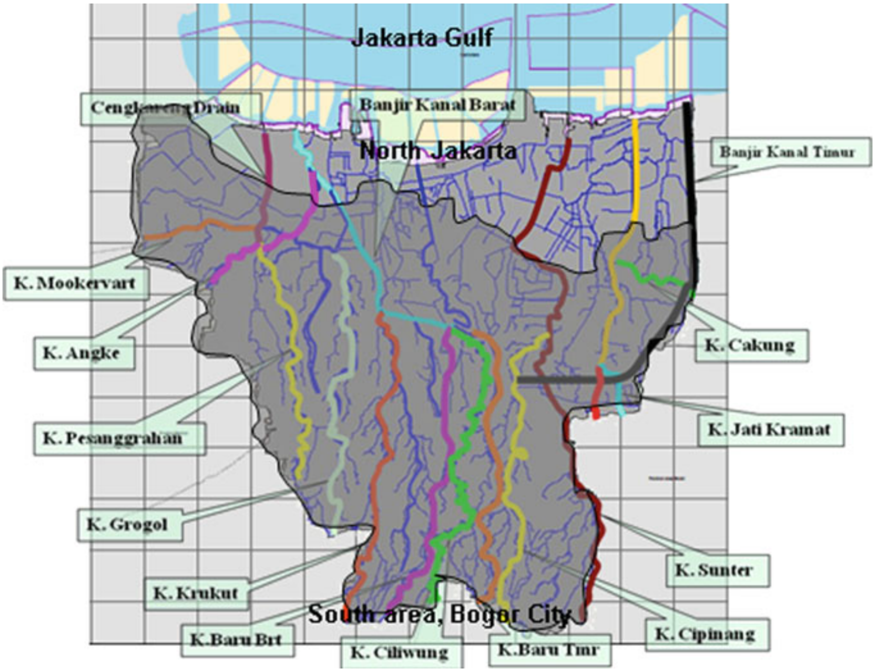


Fig. 3.36 13 rivers that flow the south highland, Bogor city, the DKI Jakarta

The land use of the main road side, Boulevard Kelapa Gading, is for the commercial and business use, consisting of different activities and places such as shopping malls, restaurants, bars, karaoke studios, hotels, stores, showrooms, offices, banks, training and education centers, and gas stations.

The land use of the local road side is for residential area with the landed house type, and in 1990, the vertical house, apartment, and condominium started to be built. At present, there are around seven apartment complexes in Kelapa Gading district. As a commercial and business district, Kelapa Gading contributes the 1/6 of the North Jakata tax revenue (Figs. 3.38 and 3.39).

The issue of the flood

The typical lowland area of Kelapa Gading is 5 m below the sea level. As land subsidence has been reached up to −1.4 m since 1974, at an average of −3.5 cm per year, flooding has become the major problem every rainy season, between January and February. During the rainy season, the rain stormwater flows to the lowland area of Kelapa Gading. It can be worst when the Sunter River overflows to that area. The Kelapa Gading district was the area that was intensively reported on by television media due to the flood disaster (Figs. 3.40 and 3.41).

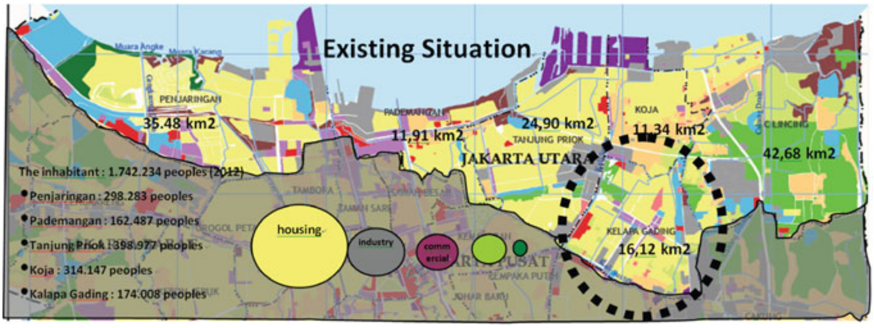


Fig. 3.37 The location of Kelapa Gading district in North Jakarta City of Administration

Fig. 3.38 The borders and land-use of Kelapa Gading district

Fig. 3.39 The Rotund at Kelapa Gading boulevard intersection

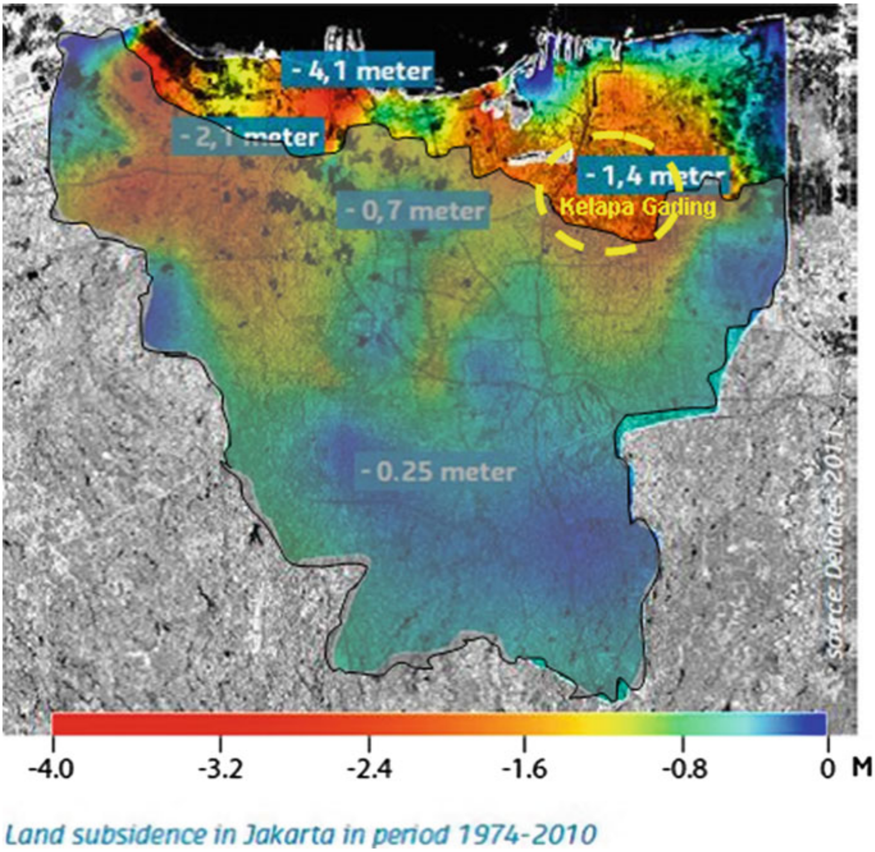


Fig. 3.40 Land subsidence in Jakarta in period 1974–2010: land subsidence in Kelapa Gading has reached −1.4 m below the sea level since 1974 to 2010

Fig. 3.41 Flood Map in January 15, 2014 (DKI, BNPB 2014), pointed the Kelapa Gading district as the area that receives the flood impact (*Top*). The image of flood situation in Kelapa Gading boulevard (*Bottom*)

With the increasing number of population estimated to reach ±215,000 in 2030, the area of Kelapa Gading should be protected from the flooding caused by the rain stormwater and river overflow with green and blue infrastructure.

The vision of the blue and green network

The Kelapa Gading district detail planning has stated that there are four water reservoirs to collect the rain stormwater which was defined as blue zones. The Gendong reservoir in the west, the Pegangsaan Dua reservoir in the north, and the Don Bosco reservoir are existing reservoirs. The Kelapa Gading reservoir in the northwest is the proposed plan reservoir. There are six water pumps in total, and each water reservoir has at least one pump. The water pumps should be turned on at the right time to move the water out to the Sunter River when the reservoir water level at the maximum, as such it needs to be well monitored. The pump receives the supply energy from the gasoline generators. It could be envisaged that the pump should be provided with the alternative supply energy such as wind turbine in case of lack of gasoline supply (Fig. 3.42).

In the west and south area where it is bordered by the Sunter River directly, the riverside wall should be built higher than the maximum river water level in order to protect the area from the river overflow. The wall should be inspected regularly to identify any cracked structure or damage sign and to update the river water height.

An open green space is being planned to be located in the east side of the Kelapa Gading reservoir to absorb the rainwater. There are two other green spaces in Kelapa Gading district that serve as a jogging park and a football small field. It is proposed to have the Kepala Gading reservoir and its green space which serve as an ecological park for recreation and education activities. These three parks will be connected with the schools by the bicycle lines (Fig. 3.43).

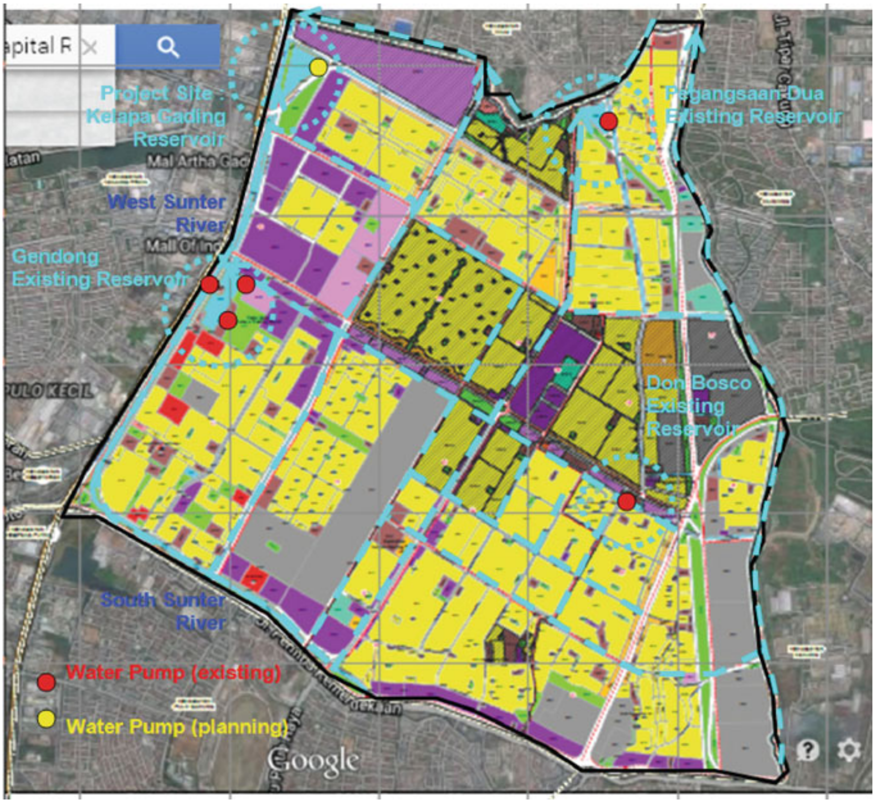


Fig. 3.42 The blue network of Kelapa Gading district connected with the water drain which flow to the north and being collected at Kelapa Gading reservoir (proposed planning)

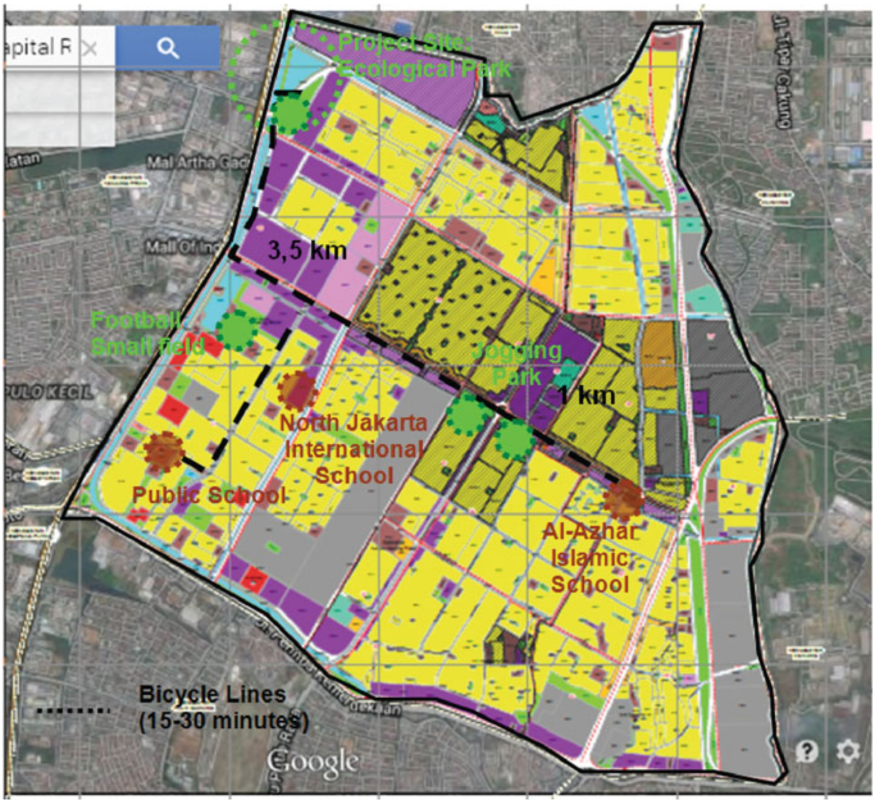


Fig. 3.43 The green network of Kelapa Gading district connected with the schools by bicycle lines. It is around 15–30-min bicycling from school to park

The objective of ecological planning

The Kelapa Gading reservoir is expected to be approximately 0.058 km^2 wide. It is expected that the ecological network can save 5000–8000 houses from flooding. The reservoir will have an organic shape in order to have a pocket to grow the plants and home for animals such as fish and frogs.

The open green space will be planted with canopy trees, and it is designed to be a car-free zone area to provide more oxygen as a recreational site. The office workers from surrounding of Kelapa Gading reservoir will be able to come in the mid-day to spend their lunch hour. There will be a space for educational urban-farming site such as vegetables and fruits vertical garden that will be visited by students from around the district (Fig. 3.44).

Climate smart planning approach at the district level

The technology of IoT will help the local government to manage the blue network such as monitoring the water level in the reservoirs, analyzing the energy

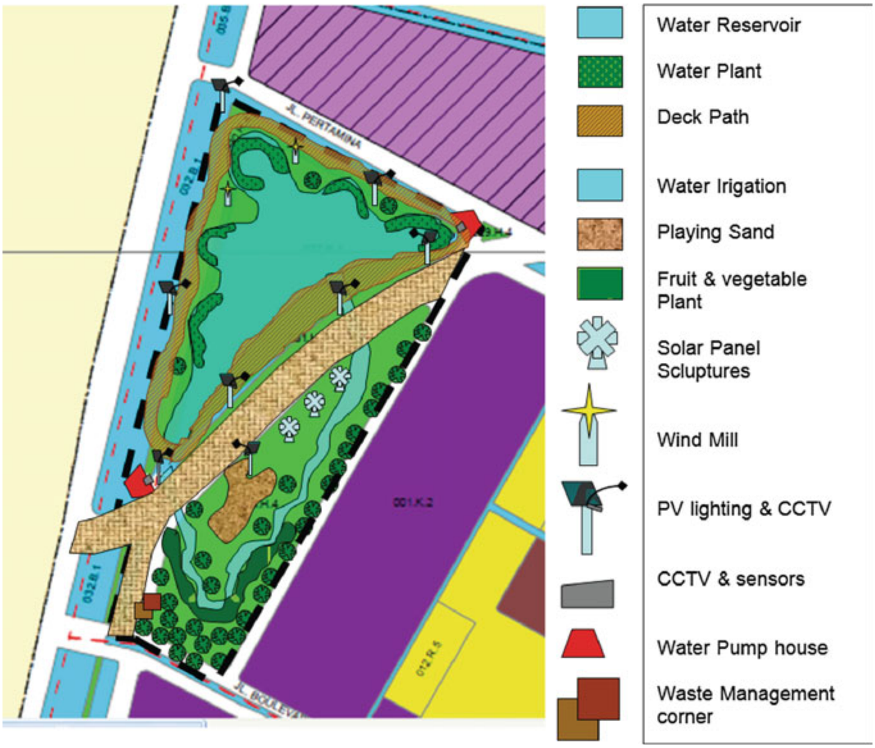


Fig. 3.44 Kelapa Gading reservoir and ecological park planning

supply and time punctuality to operate the water pumps, supervising the river wall structure, and observing the crucial flood area. It will require cameras to monitor the current site situation and sensors to identify the limit of the maximum water level. The cameras and sensors will be connected to a server by the Internet so that the Internet can be accessed to give the information. In the rainy season, the mayor and the governor can easily monitor ongoing situation of Kelapa Gading from the mayor office and city hall which are 5 and 20 km, respectively, away from the site. The public in Kelapa Gading can also monitor the flood situation to prepare actions for saving their assets from flood.

In the green zone, the technology of IoT will help to monitor the safety and security of the people and environment so that the local government can give the responsive protection from vandalism in open green space (Figs. 3.45, 3.46, and 3.47).

The ecological and climate smart city planning should allow the blue and green networks to be well managed so the local government and the public can have a quick respond to flood disaster in order to save the environment and the assets.

Based on the above case study, some principles for digital neighborhoods can be suggested as follows:

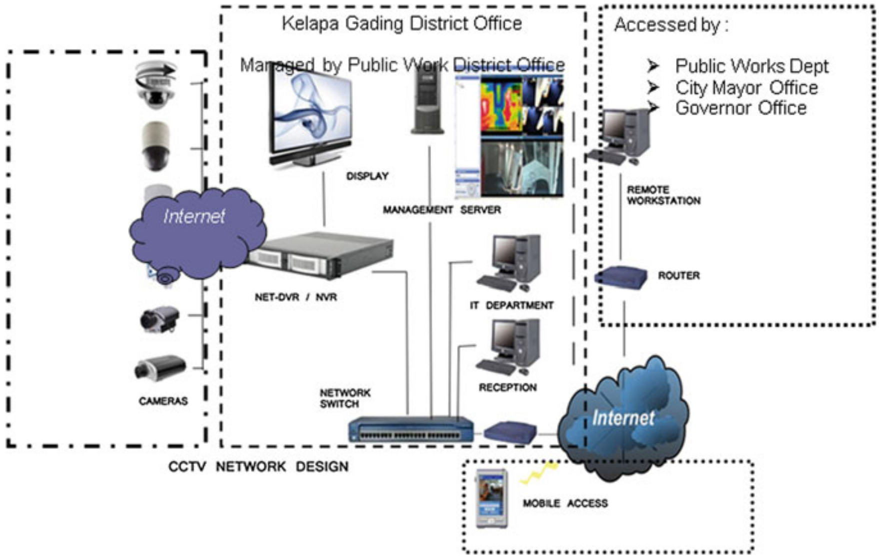


Fig. 3.45 The IoT network for cameras and sensors in Kelapa Gading district

- Separation of incompatible activities, and provision of varied and specialized facilities to support different activities.
- Dispersal of kids' bedrooms to do their homework in quiet and privacy, and with everyone able to retreat to their own spaces with introduction of a heat distribution network, an electricity network, and an air-conditioning network (Fig. 3.48).
- Selective loosening of spatial linkages which allows latent adjacency and proximity demands to manifest themselves through overlay of new transfer technologies and new types of network infrastructure on cities.
- Fragmentation and recombination of established room arrangements, building types, and urban and regional land-use patterns.
- Loosening of the linkages between activities that had previously required face-to-face interaction.
- Necessary access facilities for network connectivity are as follows:
  - Computer,
  - Telecommunications hardware,
  - Appropriate software (Web browsers, e-mail software, and so on),
  - Access to subscription services,
  - Maintenance,
  - Upgrade and repair service, and
  - Advice and technical consulting.

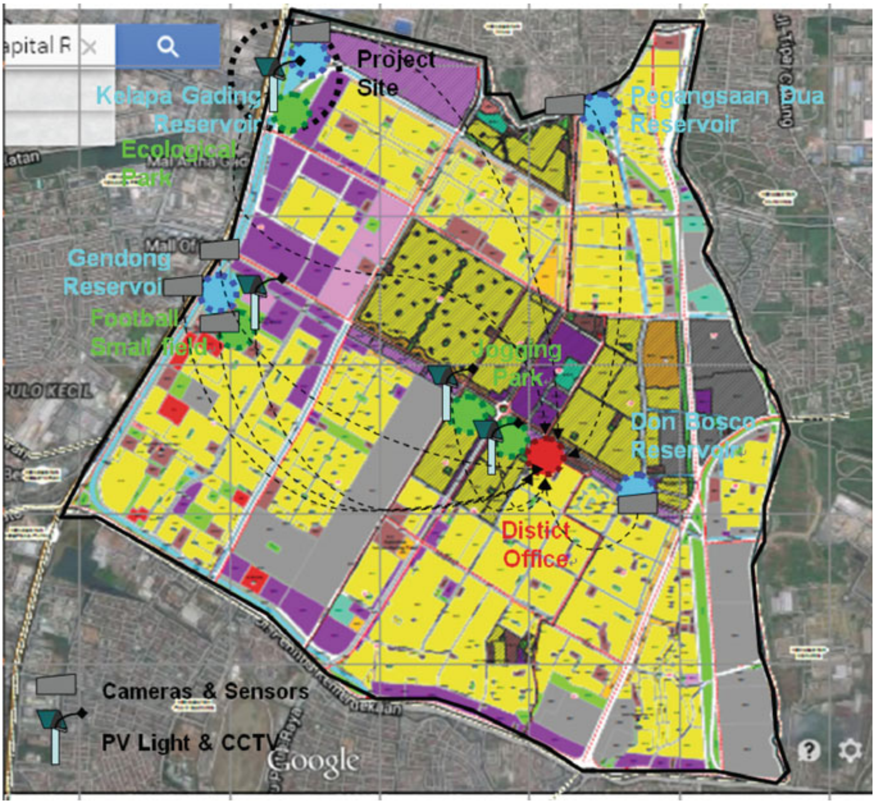


Fig. 3.46 The cameras and sensors in Kelapa Gading district connected to district office through the Internet

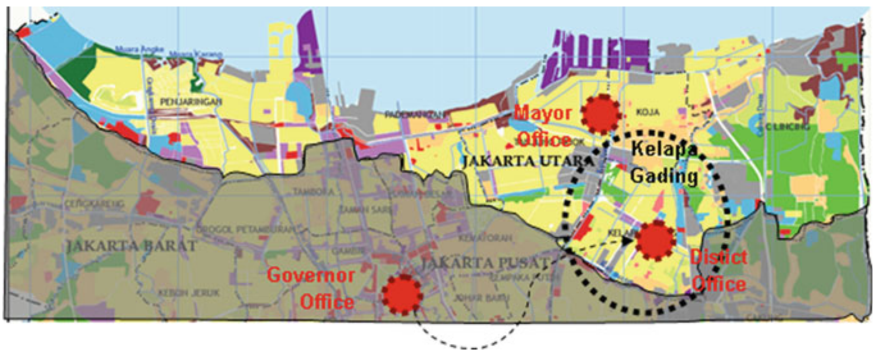


Fig. 3.47 The mayor and governor can monitor the real flood situation in Kelapa Gading district and give the responsive actions to flood disaster

3.3.4.2 Smart Energy Grid and Case of Programs/Projects in Korea

Smart Power Grid Renewable Energy Systems

Renewable energy sources communicate real-time power generation information to utilities. The primary reason for pushing the smart grid is the economies of scale that now make a smart grid affordable as its cost per kilowatt comes down.

Renewable energy demands tighter power grid monitoring and immediate corrections. Solar power production is greater in the afternoon, when people tend to use the most power. However, it produces little power in the winter though people need energy to stay warm. Wind power peaks at sunrise and sunset, when there is relatively little demand. Adding different renewable powers onto the power grid multiplies the variability in the power supply. When the renewable power from local sources suddenly drops due to a thunderstorm blocking the sun, the power grid must compensate by either pulling power from batteries or turning on natural gas power plants.

Renewable energy sources that are good for the environment are coming on line slowly across the grid, while the investors still receive a return on their investment because the natural gas plants are still used in some capacity all of the time. However, more backup power generators will have to be added and kept in synchronization with the renewable energy supply.

A smart grid is the only way to handle many small, personal renewable energy projects that provide most of a consumer's power, and it should allow to alternate between accepting locally produced power and delivering power when local renewable sources fall short (Fig. 3.10).

Figure 2.2 shows a possible network of existing energy supplies plus new energy suppliers and consumers as a model for 100% renewable solutions.

The Case of Korean Carbon-Free Programs and Projects

In a smart grid city, telecommunication technology is used to enable the energy supplier and the consumer to exchange intelligent power grid information.

Korea has the political will to contribute to the implementation of the Paris Climate Change Agreement in Korea through a Low Emission Development Strategy (LEDS) and Nationally Determined Contribution (NDC).

Following the global sustainability trends and the Korean central government's guideline for various energy and greenhouse gas emission reduction plans, local and regional governments in Korea are now working on plans and road maps make their towns and cities more sustainable and climate smart.

Some initiatives, programs, and good practice examples on green urban development and low-carbon economy at different levels in Korea can be summarized in the following:

Fig. 3.48 Dispersal of room arrangements through overlay of new transfer technologies and new types of heat, electricity, and air-conditioning network, The Green, Korea Land and Housing Corporation

At the local level

- Gangneung: Low-carbon green city;
- Suwon: Eco-Mobility;
- Seoul: One Less Nuclear Power Plant to help energy transition;
- Gwangju: Carbon banking system;
- Songdo (Incheon): Smart eco-city;
- Jeju Island: Zero-carbon island with a smart grid system (Fig. 3.49);
- Paju: Water City Initiative;
- Pankyo: Techno-Valley;
- Soeul: Sustainable Energy Action Plan;
- Busan and Goyang city: Smart city; and Hongcheon Environment-friendly Energy Town

In Gyeonggi Province

On June 25, 2015, Gyeonggi Province announced an "Energy Vision 2030" which aims to raise electric energy self-reliance by 2030 to 70% from the current 29.6%. To realize this goal, they have set 3 innovation strategies and 10 core projects.

Fig. 3.49 Water and energy nexus: drinking water purification plant connected with the Jeju Renewable Energy Smart Grid System, Jeju Island, Korea

3 innovation strategies	1. Energy efficiency innovation with citizens and industries 2. Innovation to produce safe and clean energy 3. Innovation of energy new business via applying ICT technologies
10 core projects	1. 100% change of lightings to LED for all public organizations and all high rise apartments 2. All new public buildings to be energy self-reliant buildings 3. Green remodeling on old industrial parks and create eco-industrial parks 4. Energy one-stop service from consulting to follow-up management 5. Turn public buildings, factories, residential buildings, schools, and farms into PV power plants 6. Construct renewable energy town which shares profits from inhabitants 7. Turning next Pangyo (2nd Pangyo) into an IoT and energy combined innovation hub 8. Creation of energy clusters in the northern part of the province 9. Construct energy self-reliant smart cities starting from places where city gas is not provided 10. Raise of hidden champions in ICT and energy field

At the national level

- The 6th Agricultural Industrial Revolution Initiatives with ICT (2016);
- The big data Center of Creative Economy;
- Korea's Evolving Energy Strategy: A Different Shade of Green;
- "Government R&D Innovation Initiative," Ministry of Science, ICT and Future Planning, July 2015;
- "National Forest Plans," Korea Forest Service;

- “The Korea Green Growth Partnership Initiative,” World Bank;
- “Creative Economy Initiative,” Ministry of Science, ICT and Future Planning,
- “Korea National Energy Basic Plan,” Ministry of Trade, Industry and Energy;
- “Korea Climate Change Action Plan Initiative,” Ministry of Environment;
- “Local Adaptation Action Plans of Korea,” Korea Environment Institute (KEI);
- “Low Emission Development Strategies (LEDS),” Ministry of Environment;
- “Nationally Determined Contribution (NDC),” Ministry of Environment;
- Eco-city·Smart city Initiative; President of Republic of Korea at the 9th Trade and Investment Promotion Meeting (17 February, 2016);
- Energy New Business Initiative (zero-energy buildings, eco-friendly energy town, PV module rental business, ESS); and
- Green Remodeling Program.

At the business level

Korea Environment Corporation (KECO): 12 strategic initiatives

- Improvement in environmental monitor quality;
- Optimizing installation and operation of environmental facilities;
- Expansion of foundation for environmental energizing;
- Reinforcement of basis for climate change response;
- Advancement of resource circulation management system;
- Development of environmental pollution diagnosis and analysis service;
- Making healthy living environment;
- Expansion of overseas business;
- Strengthening environmental consultation;
- Advancement of business management;
- Nurturing of top talents; and
- Creation of national sympathy value.

Jeju case studies

Jeju, the biggest island and only special self-governing province in Korea with 640,000 inhabitants and land size of 1874 km^2, has set an ambitious goal to become a “carbon free island” by 2030 (Fig. 3.50).

To this effect, they are considering to install a 2 GW size offshore wind farm around the island and change all the cars (around 385,000 cars at the end of 2014) to electric vehicles by 2030 (Fig. 3.51).

Jeju established so far rough milestones to realize their goal as follows:

Step 1 (2012): Establishment of carbon-free test-bed models

- A satellite island to Jeju called Gapa Island is being equipped to be a carbon-free island

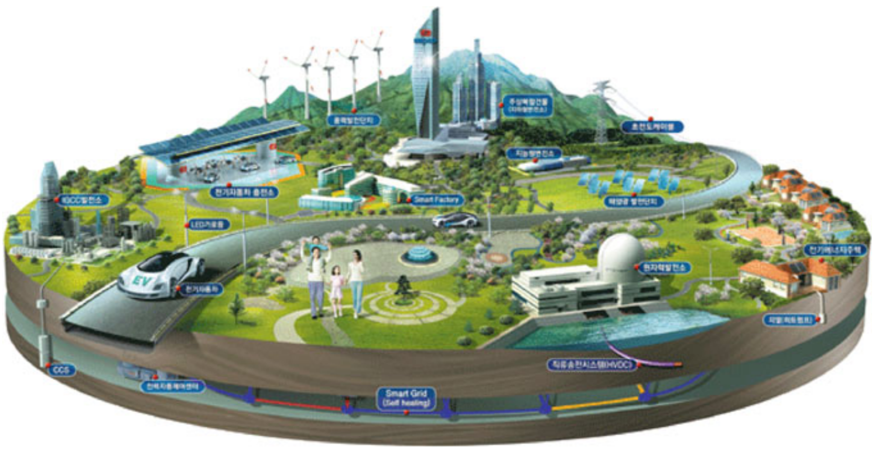


Fig. 3.50 Conceptual miniature of the smart grid island. *Source* Jeju Smart Grid Information Center, undated, unpaged

Fig. 3.51 Gasiri wind power generation complex, Jeju Island, Korea

Step 2 (2020): Establishment of the foundation for a carbon-free island

- For renewable energy supply up to 50%, smart grid shall be installed and more electric vehicles will be used.

Step 3 (2030): Becomes a carbon-free island

Currently, two 250 kW wind turbines were installed in Gapa Island in 2012 and PV panels were provided to 37 households. As of 2015, 1515 electric vehicles were supplied.

3.3.4.3 Smart Water Grid for Climate Change

Climate-driven water scarcity could hit the economy. Water supply, stormwater drainage, wastewater collection and treatment, and quality and quantity management of natural water resources need to be efficiently secured or, where necessary, improved in the line with the water cycle (Fig. 3.52). Only through a paradigm shift from fragmented toward integrated urban water management can economic development, social balance, and ecological integrity be secured.

The Need for Integrated Water Resources Management

The water sector is at the heart of this twenty-first-century challenges, and we need to do a major revision of our approaches and applications of ICT for the management of water resources, flood risk, and pollutions.

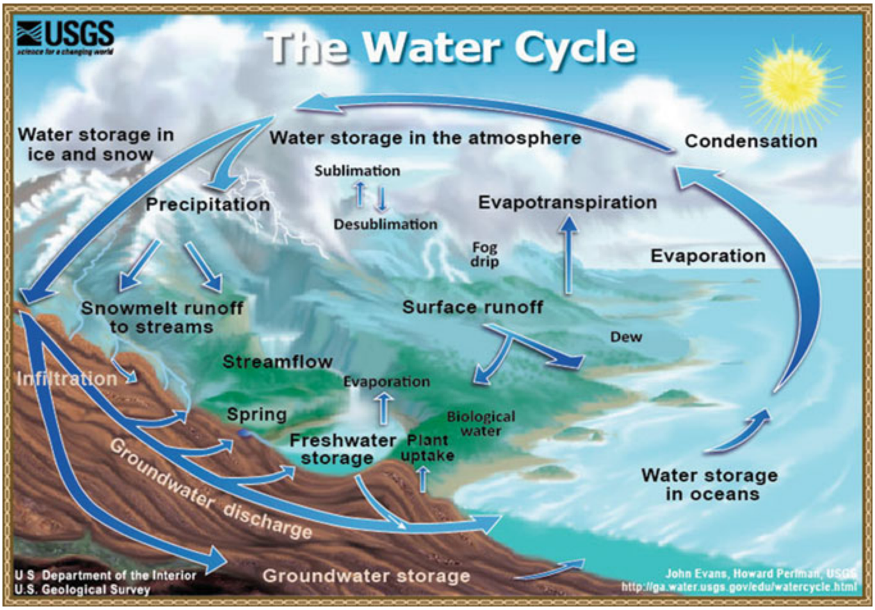


Fig. 3.52 The water cycle. *Source* US Geological Survey (*USGS*)

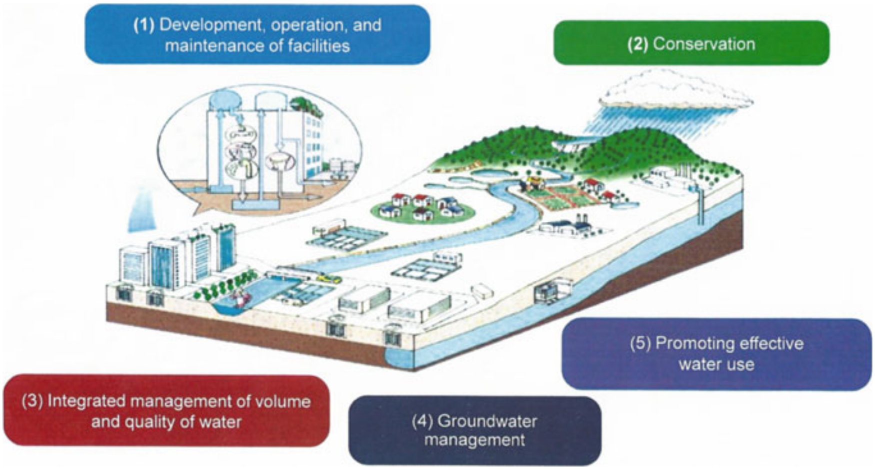


Fig. 3.53 Water resources management at the river basin level. *Source* World Bank, 2014

The new water system management should reflect emerging trends and consider systematic impacts, both upstream and downstream, of new technologies and techniques. By adapting a broad perspective, water system, additional efficiencies, and opportunities can be identified that are not easily seen when water is managed at individual process levels.

Until now, a sectoral approach to water resource management has been dominating and is still prevailing. This has led to fragmented, disconnected, and uncoordinated implementation of policies, planning, governance, and technologies and often leads to inefficient or even unsustainable solutions.

To achieve sustainability, circularity, resiliency, efficiency, and connectivity in cities, we have to apply an integrated and participatory approach also for water resource management.

The purpose of an integrated water resource management (IWRM) approach is to promote the coordinated development and management of water, land, and related resources, in order to maximize the resultant economic and social well-being in an equitable manner without compromising the sustainability of vital ecosystem and to achieve greater efficiency and costs reduction.

These concerns have spawned a number of international research initiatives, programs, and projects related to water resources management at the river basin level as shown in Fig. 3.53.

ICT Solutions for Smart Water Grid System

Growing global populations require constant urban and infrastructure development, while at the same time global warming demands massive investment in adaptation to future climate change and mitigation through reduced emissions.

Some ICT solutions for water efficiency and climate change adaptation and mitigation options include the use of virtual models as a communication tool for water resource management and the use of ICT for leak detection in pipes. There are many non-ICT ways to solve water issues:

– Pricing,
– Fixtures,
– Appliances,
– Landscaping, and
– Green infrastructure to capture rainwater.

It is recommended to use first these and then ICT.

Technology can be applied to water business for water supply and stormwater drainage including flood risks, wastewater collection and treatment, as well as quality and quantity management of natural water resources. These technologies need to be properly integrated with social, economic, ecological, and organizational measures.

A new way to describe the relationship between technology, resource management, and sustainable water infrastructures is the smart water grid (SWG). It combines water and ICT for efficient water resources management including production, transportation, and distribution. It helps to solve problems with water shortage, climate change, and integrated management of water energy and disaster.

The SWG response to a long-term drought can be a network of portable bulk water pipelines connecting areas with an oversupply of water to those lacking water (Fig. 3.54).

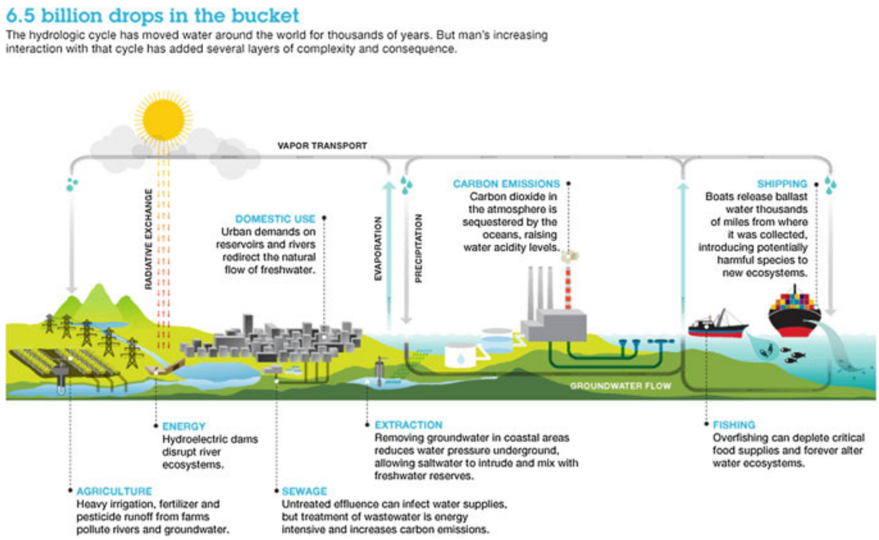


Fig. 3.54 Smart water grid image with the hydrologic cycle

In the USA, the National Smart Water Grid proposes to alleviate freshwater-related problems by mitigating floods along the Midwest's rivers and providing freshwater to ease the arid west by capturing water during flood events at or above regulated surface elevation and transporting it via pipeline to reservoirs in approved destinations.

Very recently, most companies have begun to look at their water footprint, and some agencies predict public companies will soon be required to disclose water efficiency in their annual reports.

The Mediterranean island of Malta received 120,000 smart water meters from Itron in an ongoing effort to build a fully integrated water system. Some 25,000 water meters and communication modules have already been delivered to connect to the existing Ondeo Systems smart metering solutions as part of a large-scale SWG program managed by IBM.

It is believed that putting that data online for customers helps them make better informed choices about how to use water.

Figure 3.55 shows a water grid platform with fresh and reclaimed water cycles with zero water discharge, and bidirectional data flow for water and energy within the water grids and between grids, and the central management structure is shown in Fig. 3.56.

The roll of a system of smart management technology across the water network including water suppliers, water treatment facilities, and distribution networks has contributed to effectively form a SWG. Huge advances in water management and water conservation can be achieved by the system (Fig. 3.57).

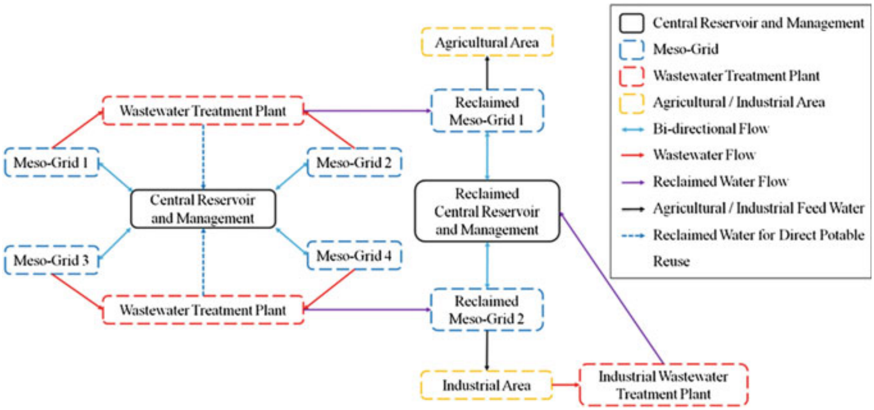


Fig. 3.55 Water grid platform: fresh and reclaimed water cycles with zero water discharge. *Source* Seung Won Lee, Sarper Sarp, Dong Jin Jeon, and Joon Ha Kim, Smart water grid: the future water management platform, Desalination and Water Treatment, 55:2, 339–346

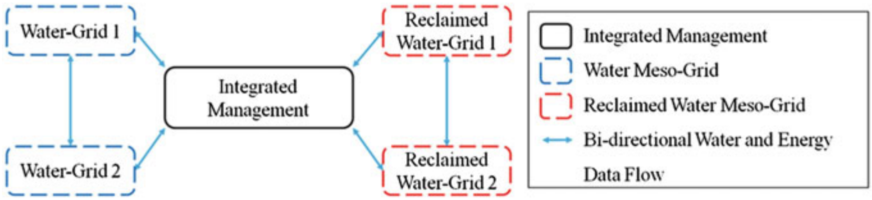


Fig. 3.56 Bidirection data flow water and energy within the water grids and between grids and the central management structure. *Source* Seung Won Lee, Sarper Sarp, Dong Jin Jeon, and Joon Ha Kim, Smart water grid: the future water management platform, Desalination and Water Treatment, 55:2, 339–346

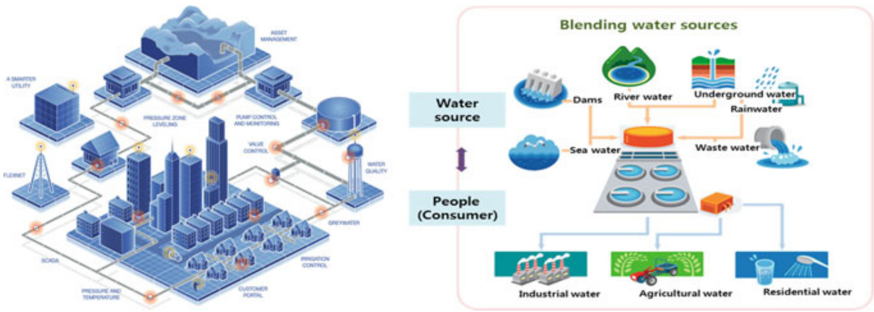


Fig. 3.57 Conceptual model of smart water grid

The Case of Ecosystem-Based-Approach to Smart Water Grid

A Workshop Guide to Smart Water Grid: Ecosystem-Based Approach to Integrated Water Resources Management (IWRM)

The IUTC and UN-Habitat jointly held an international training course on the integrated urban water management and sanitation in Korea on 3–10 November, 2015, for participants from Fiji, Nepal, and the Philippines.

The author developed "A Workshop Guide to Smart Water Grid: Ecosystem-based approach to IWRM" for this particular training course.

Overall, this workshop aimed to provide a better understanding of the role and potential of SWG approaches and practices in IWRA. The following specific objectives were identified:

- To give a guide to the participants to help describe how SWG in their cities looks like, and give them advice for the next 15 years (2015–2030)
- To ensure that the workshop was conducted in a comparative manner and to address all relevant case study questions.

The following topics are covered in this guide in the form of questions, which were addressed by the participants. Case examples for each topic are provided, if available.

1. Project overview,
2. Database of projects: A big data,
3. SWG design for urban planning,
4. Mechanism of Technology Facilitation for ICT application for digitization,
5. Implementation,
6. Funding and costs,
7. Benefits,
8. Awareness and capacity building,
9. Monitoring: performance indicators, and
10. Lessons learned from the workshop and outlook to future action.

The Application for the Water–Energy–Disaster Nexus

This section is the summary of the outcomes of the workshop by participants.

Figure 3.58 is the photograph of IUTC SWG planner members who have participated in the workshop.

The Fiji team selected a water loss issue. Energy consumption was selected for Nepal and water quality for the Philippines.

Fig. 3.58 IUTC smart water grid planner members

Greater Suva Area, Fiji Islands

The Fiji team developed smart grid solutions for water loss in the Fiji Islands.

Water loss is a big challenge in the urban and rural areas of Fiji Islands because of aged and undersized pipes' frequent bursts and leakages, water meters' under registering or zero reading of water meters, and illegal connections.

Development of action plan to reduce the water loss:

The Greater Suva Area (GSA) consists of one city, three towns, and 13 informal settlements. The population in GSA is approximately 420,000. By 2020, it is anticipated to increase to 500,000. The area has set a target to reduce by 5–10% water loss every year. By 2030, it targets to achieve a reduction of 20% water loss in line with the sustainable development goal (SDG) #6 as compared to the current 45% level.

An "Action Plan-Smart Grd-Fiji" was developed by the Fiji team, focusing on the reduction of water loss. In Table 3.7, planned activities are described for the gaps identified by each issue of water loss.

Proposal on smart grid for the reduction of water loss

Figure 3.59 shows a smart grid solution for water loss using new pipes, smart pressure management reading devices, and smart telemetry meters. It is important to analyze how robust the grid; that is, how much the results change if spatial components and attribute components are modified.

The main features of this system can be summarized as follows:

1. In a spatial smart grid model, the study area boundary directly impacts water loss.
2. The issue related to connectivity extension is the way in which distances between facilities and devices are calculated.
3. Smart grid data has both a spatial component and an attribute component. Features have to have the correct location and the collect attributes to ensure the results of the smart grid model are valid.

Kathmandu Valley, Nepal

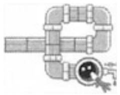
The Nepal team supervised by the author focused on the development of a SWG for energy conservation.

In Kathmandu, energy consumption to convey, treat, and distribute 45 ML of water per month is 25,000 kW-h which costs $5000 USD. This cost saving is very powerful. Table 3.8 shows energy consumption at tube wells for smarter water management.

Development of action plans for implementation

The action plan covers eight areas/sectors: (1) smart pumping, (2) smart valve and pressure meters, (3) smart transformer, (4) biosensor, (5) ICT, (6) centralized control system, (7) sectoral SWG, and (8) TOD energy meter. These areas/sectors are explained by planned activities, expected results, time frame, M&E method, experts responsible for the implementation, and funds needed (Table 3.9).

Table 3.7 Action Plan-Smart Grid-Fiji

	Area/sector	Planned activities	Expected result	Times frame	M&E methods	Responsibility	Funds needed (USD) (m)
1	Leaking pipes/mains (trunk and distribution)	Pipes—AC mains replacement and upgrading	**Reduce**: • Water loss • Leak complaints	2015–2020	• NRW levels on monthly basis • No of burst mains complains per month	PMU + NRW customer service	$39
		Leak detection equipments		2015–2018	No. of leaks detected and fixed	Leak detection unit	$0.50
2	High pressures in some district metered area 	Pressure management program • PRV • Master meter • Air valve replacement	• Reduce intermittent supply areas • Reduce no water complaints 	2015–2018	"No water" complaints No of intermitted supply areas No. of PRV installed per month	NRW team	$2
3	Automatic meter reader—under registering	AMR meter replacement program – Pilot phase in Fuji	– Accurate billing – No estimation in billing	2015–2019	No of water meters replace per month	NRW team	$20

(continued)

Table 3.7 (continued)

	Area/sector	Planned activities	Expected result	Times frame	M&E methods	Responsibility	Funds needed (USD) (m)
							
4	Poor billing systems	Upgrade billing system	– More efficient billing and tracking unpaid users	2015	– Number of billing complains received per month	Customer service unit	$0.1
5	Illegal connections	Enforcing fines on those found to have illegal connections	Reduce illegal connections	Ongoing	No. of illegal connections identified per month	Customer service + legal team	
6	Water conservation 	– Public awareness – Enforce rainwater harvesting for all commercial and industrial customers and all upcoming developments – Tariff(Water fees)rate increase	Water conservation through damand management Reduce wastage	Ongoing 2016	Customer feedback	WAF WAF/line ministry/comm Comm	$0.5 $5

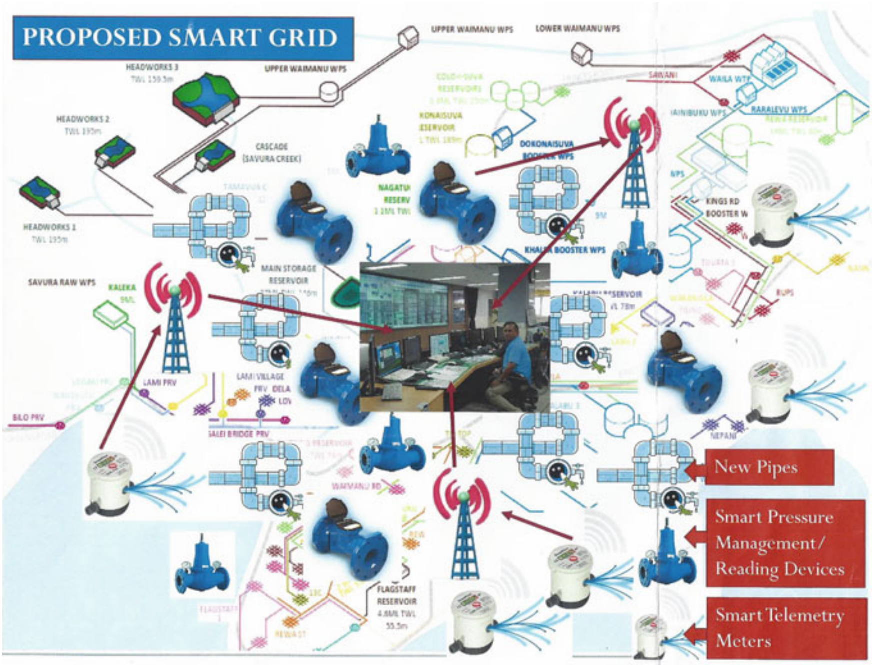


Fig. 3.59 Proposed smart grid solution for water loss in Fiji Island

Table 3.8 Energy consumption at tube wells

Monitoring tube well station	Water production per month, million liter	Energy consumption per month, kilowatt	Energy charge per month, $USD
MK-1	3.0	1800	360
MK-2	3.0	1800	360
MK-3	4.0	2400	480
MK-4	4.5	2500	500
MK-5	4.5	2500	500
MK-6	6.0	2700	540
MK-7	7.0	2800	560
MK-8	7.5	2900	580
MK-9	8.0	3000	600
MK-10	5.0	2600	520
Total	45	25,000	5000

Proposal on SWG for energy savings

The proposal includes smart pumps, smart valves, pressure meter, smart power transformers, biosensors, TOD energy meters as well as an ICT-supported integrated control system for the deep tube well (Fig. 3.60).

It is important to note that smart connect-tech will be employed in this proposal to connect each SWG activity with the integrated control system shown in the middle of the proposal.

Savings in energy consumption at tube wells

Table 3.10 shows the energy cost savings after application of the SWG within 2030. Based on Table 3.10, total energy cost savings by 2030 is expected to be $4500 USD per month for ten tube well stations.

Current and future research efforts are needed to provide information relevant to the operation of the SWG.

Metro Kidapawan Water District, Kidapawan City, Philippines

The study area, Kidapawan city, is located at the south eastern portion of North Cotabato Province, located almost midway between the cities of Davao and Cotabato.

The Metro Kidapawan Water District (MKWD) is basically a surface water harvester for potable water production. As such, it can be affected by all potential problems along the surface of the soil in the watershed. Popularizing eco-tourism and trekking in the watershed, as well as camping, might create some pollution problems later as the number and frequency of visitors increase.

Development of action plans for implementation

The action plan developed aims at a better control of water quality through a SWG. The planned activities cover four areas: (1) construction of wastewater treatment plants; (2) installation of systemized monitoring system with smart meter, multi-contaminant sensor, biosensor, and smart valve; (3) capability building on information technology for indigenous people (IP) communities; and (4) expansion of watershed area.

These planned activities are explained by expected results, time frame, monitoring and evaluation, implementing agency/office, and funds needed for implementation (Table 3.11).

Proposal on SWG for water quality

Figure 3.61 shows existing condition of MKWD, while Fig. 3.62 shows a proposal for a SWG for water quality.

Table 3.9 Action plans for implementation

SN	Area/sector	Planned activities	Expected results	Time frame	M&E method	Responsible for implementation	Funds needed
1	Smart pumping	Replace old pumps with above 70% efficient smart pump at deep tube wells Pumping to households with also smart pumps	Adjust power levels based on environmental condition Variable speed pumps to sense water condition and to ramp up or down with 70% cost saving Sense clog in system and break the clogs or reverse water flow Pressure management in distribution system. Reduce pipe deterioration	1 year	Data recording of each pump	Pump operator	$2 million
2	Smart valve, pressure meters	Replace old valves with smart valves, pressure meters, and construction of valve chambers	Adjust or block the water as per environmental conditions (leakage) Pressure management to reduce pipe deterioration	1 year	Data recording	Valve operator	$ 20,000
3	Smart transformer	Replace old and bigger sized with smart transformer	Electricity charge reduction Help to shift electrical usage to off-peak time Make power generation and delivery more efficient and resilient. Less costly	1 year	Validation with electricity authority	Pump station in charge	$0.1 million

(continued)

Table 3.9 (continued)

SN	Area/sector	Planned activities	Expected results	Time frame	M&E method	Responsible for implementation	Funds needed
4	Biosensor	Install biosensors	Locate problematic biofilms that slow the water flow			Pump operator	$50,000
5	ICT	Integrate sensors, controls, and analytical components	Ensure the energy consumption. Adjustments of valves, pumps, water distribution schedule automatically	1 year	Data recording	Valve operator	$20,000
6	Centralized control system	Collected data will be stored and transferred through mobile broadband, wireless broadband (Wi-Fi), personal area network, and satellite communication	Automatic operation and monitoring energy consumption.	2 years	Physical testing	IT expert	$1 million
7	Sectoral smart water grid	Smart zoning of the distribution area in three with around 10,000 nos. connections in each	Saving energy consumption by reducing long length of conveyance of water	2 years	District metering area procedure	Water management engineer	$10 million
8	TOD energy meter	Replace existing normal energy meters by TOD meters	Energy bill as per pumping water in peak/normal energy demand time Cost saving due to higher charge at peak hrs	6 months	Compare the energy bill	Electrical engineer	$1 million

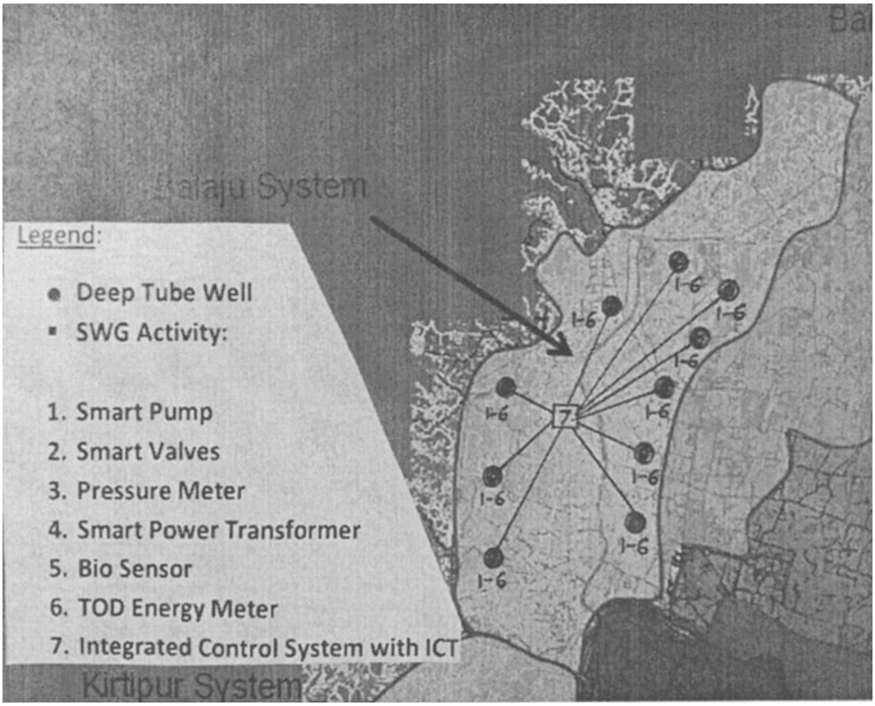


Fig. 3.60 Proposal on smart water grid for energy savings, Kathmandu Valley, Nepal

Table 3.10 Savings in energy consumption at tube wells

Monitoring tube well station	Water production per month, million liter	Energy consumption per month, kilowatt	Energy charge per month, $USD	Energy cost saving after application of SWG within 2030, $USD
MK-1	3.0	1800	360	324
MK-2	3.0	1800	360	324
MK-3	4.0	2400	480	432
MK-4	4.5	2500	500	450
MK-5	4.5	2500	500	450
MK-6	6.0	2700	540	486
MK-7	7.0	2800	560	504
MK-8	7.5	2900	580	522
MK-9	8.0	3000	600	540
MK-10	5.0	2600	520	468
Total	45	25,000	5000	4500

Table 3.11 Action plans for implementation: issue: water quality

Planned activities	Expected results	Time frame	Monitoring and evaluation	Implementing agency/office	Funds
1. Construction of waste treatment plants	Treated water safe for reentry into the rivers	2016–2030	– DOH and DENR Standards	PLGU/LGU/MKWD	P210M – Loan
2. Installation of systemized monitoring system – Smart meter – Multi-contaminant Sensor – Biosensor – Smart valve	Real-time monitoring of water age and detect pressure differentials that can cause contaminant intrusion	2016–2020	– Satellite control center – Centralized control center	MKWD	P100M – Loan
3. Capability building on information technology for IP communities	Be able to report real situation in case of contamination	2016–2030	Weekly inspection	PLGU/LGU/MKWD	P5M – IRA
4. Expansion of watershed area – Reforestation – Legislation	Sustainability of water sources	2016–2030	Installation of CCTV and rainfall monitoring gadgets	PLGU/LGU/MKWD	P15M – IRA

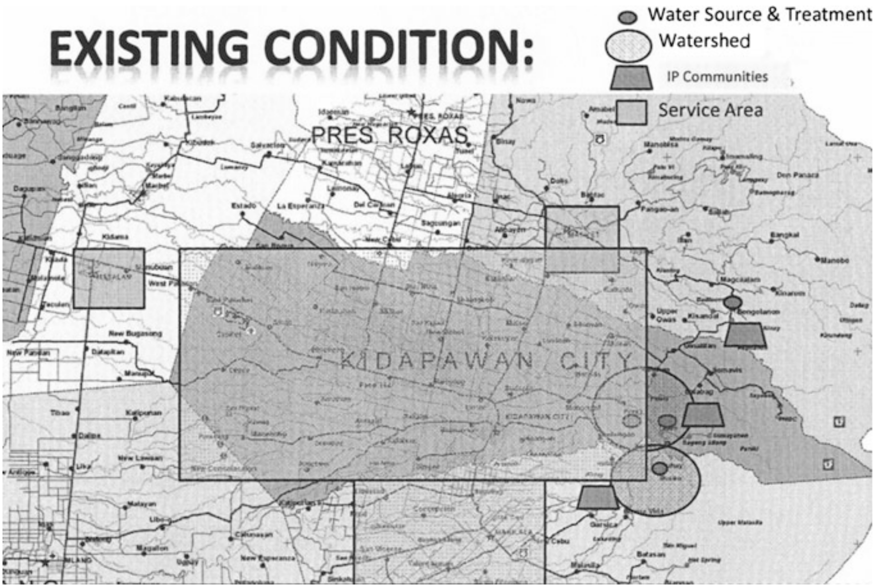


Fig. 3.61 Existing condition of MKWD, Kidapawan city, Philippines

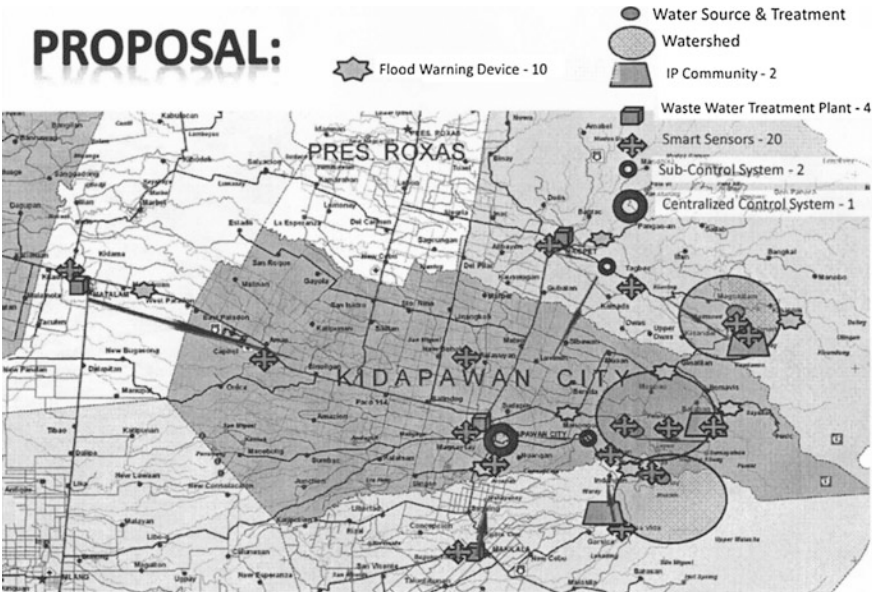


Fig. 3.62 Proposal on smart water grid for water quality, MKWD, Kidapawan city, the Philippines

The main features of the proposal include:

- The grid system is used to connect water source and treatment, wastewater treatment plants (4), smart sensors (20), sub-control systems (2), centralized control system (1), and flood warning devices (10).
- The number of smart-tech and devices employed for the system should be considered according to individual circumstances, and level of knowledge and technologies.

Finally, the smart grids for water loss, energy consumption, and water quality can be superimposed on an integrated SWG for IWRM as shown in Fig. 3.63.

Application of Smart Water Grid in Integrated Water Resources Management: A Science Revolution

Water is life and climate change is threatening this precious resource.

IWRM has been defined by the Global Water Partnership (GWP) as "a process which promotes the coordinated development and management of water, land and related sources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."

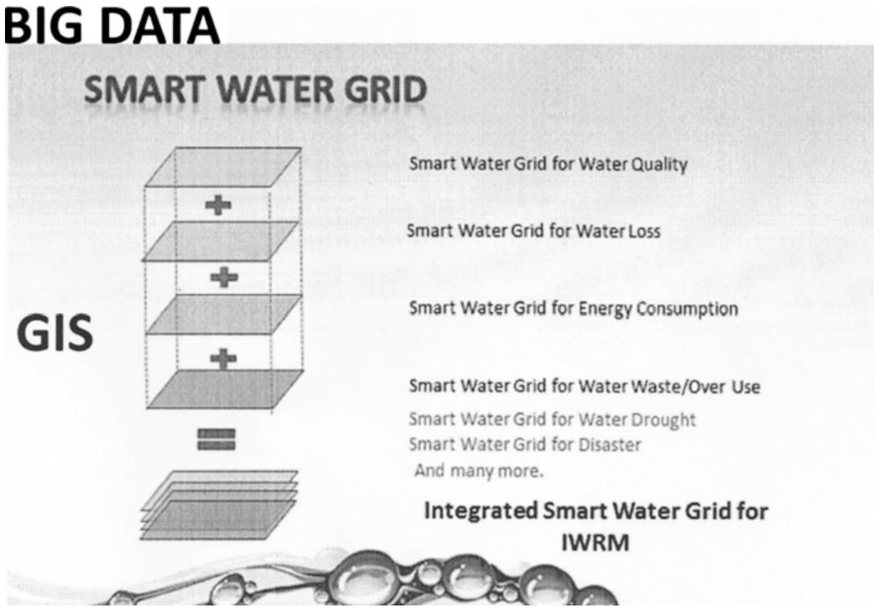


Fig. 3.63 Integrated smart water grid for integrated water resources management: a "big data" for smart water grid using GIS

Figure 3.64 depicts well-connected integrated water-use cycle adopted by California, USA. One of the main features of this cycle is overarching innovation which embraces data, water system management, water/energy nexus, and water quality.

Innovation opportunities for IWRM include:

- SWG,
- Smart flood management with ICT,
- Smart drought management with ICT,
- Efficient fixture retrofits,
- Advanced metering, remote sensing, and real-time information and big data,
- Growth of capture and reuse, and
- Outdoor water-use efficiency.

Figures 3.64 and 3.65 show the concept plans on the IWRM practices with digitalized connections, while an application of smart connect-tech is shown in Fig. 3.65 (Fig. 3.66).

Jeju Smart Grid Center, Korea, is an exhibition center which shows many different kinds of smart grid pilot projects in Korea (Fig. 3.67).

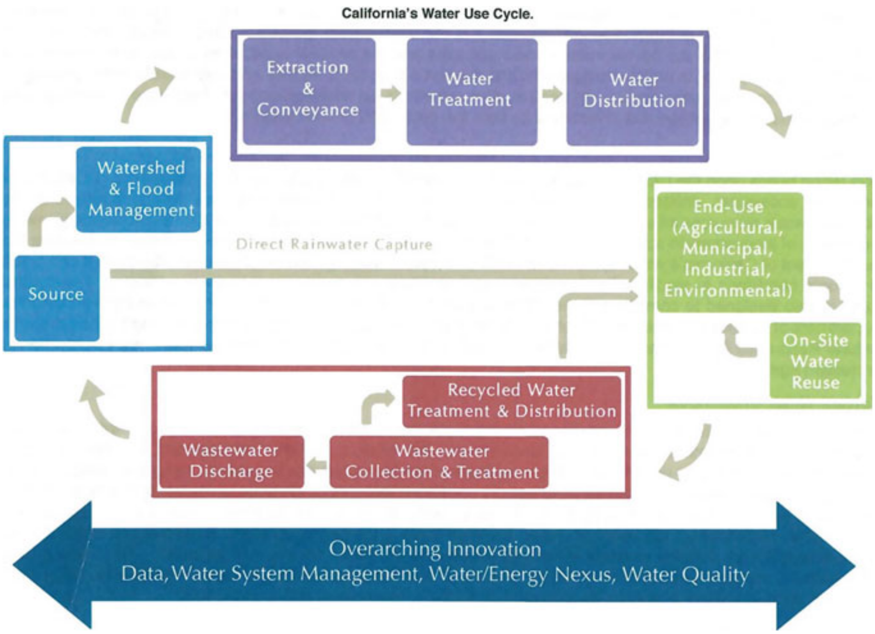


Fig. 3.64 California's integrated water-use cycle. *Source* California Council on Science and Technology, Achieving a Sustainable California Water Future Through Innovations in Science and Technology, April 2014, p. 2

Fig. 3.65 Concept plan on the integrated water resources management (IWRM) practices

Fig. 3.66 Application of smart connect-tech for total water disaster management. *Source* K-water

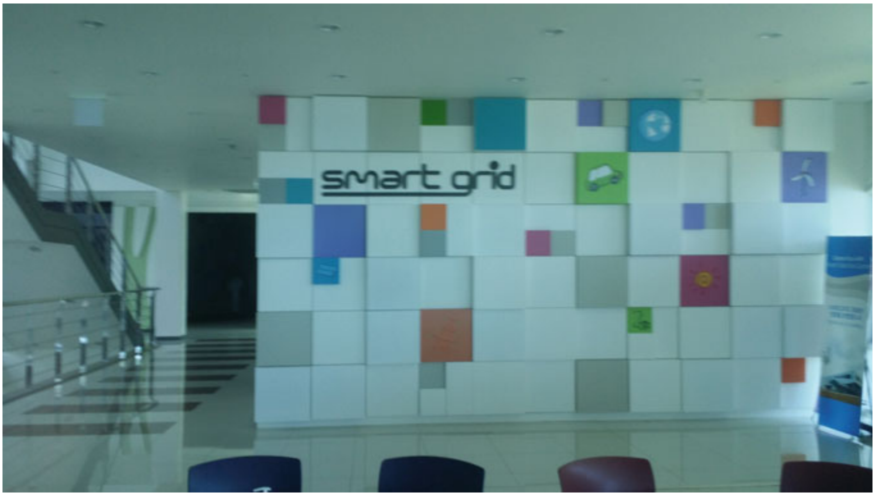


Fig. 3.67 Jeju Haengwon Smart Grid Center, Korea

Integrated Drought Management Practices with ICT: Water, Drought, and Food Nexus

Drought threats water and food security. The increasing risk of severe droughts and water shortage emphasizes the need for (1) an integrated approach to drought mitigation, (2) improved preparedness for drought in water supply systems, and (3) tools useful for better decision-making process in drought management (Figs. 3.68, 3.69, and 3.70).

The Decision Support System (DSS) developed within a European research report consists of three main parts:

1. Deals with the advanced techniques for hydrological drought identification and monitoring;
2. Analyzes the successful use of climate–crop-soil models in defining deficit irrigation strategies (Fig. 3.71); and
3. Provides tools for improving the operation of irrigation supply reservoirs.

All methods are embedded in a user-friendly DSS package that has been applied in several case studies in Mediterranean countries (Portugal, Italy, Tunisia, Jordan, and Syria) and whose results are also compared.

According to the World Meteorological Organization and Global Water Partnership, the central objective of Integrated Drought Management Program (IDMP) is to support stakeholders at all levels by providing policy and management guidance and by sharing scientific information, knowledge, and best practices for integrated drought management. In the wider sense, IDMP aims to build climate

Fig. 3.68 Sewage farms through the tertiary treatment, Munster, Germany

Fig. 3.69 Water and energy nexus

Fig. 3.70 Water, food and solid waste nexus

resilience, reduce economic and social losses, and alleviate poverty in drought affected regions of the world through an integrated approach to drought management.

The overarching approach is proposed for the IDMP centers around four key principles:

1. To shift focus from reactive to proactive measures;
2. To integrate vertical planning and decision making;
3. To promote the evolution of the drought knowledge base; and
4. To build capacity.

The major output from IDMP will be a coherent global framework for drought management, prediction, and monitoring by networking new and existing programs and activities worldwide.

Fig. 3.71 Modernized irrigation systems together with land consolidation. *Source* World Bank, ibid, 2014

The Guide (2013) has developed the 10 steps in the drought policy and preparedness process as follows:

Step 1: Appoint a national drought management policy commission;
Step 2: State or define the goals and objectives of a risk-based national drought management policy;
Step 3: Seek stakeholder participation; define and resolve conflicts between key water-use sectors, considering also transboundary implications;
Step 4: Inventory data and financial resources available and identify groups at risk;
Step 5: Prepare/write the key tenets of the national drought management policy and preparedness plans, including the following elements: monitoring, early warning, and prediction; risk and impact assessment; and mitigation and response;
Step 6: Identify research needs and fill institutional gaps;
Step 7: Integrate science and policy aspects of drought management;
Step 8: Publicize the national drought management policy and preparedness plans and build public awareness and consensus;
Step 9: Develop education programs for all age and stakeholder groups; and
Step 10: Evaluate and revise national drought management policy and supporting preparedness plans.

3.3.4.4 Smart Heat Grid for Climate Change

Large amount of energy is used for heating and cooling, and the benefits of optimizing these systems can be very significant.

Smart heat grids provide platforms for financially and environmentally sustainable district heating and cooling. Smart heat grid technology provides a platform for operational interaction between the energy company and their consumers. In a traditional district heating system, the energy company can only react to the heat demand without doing anything about it. On the other hand, in a smart heat grid, the energy company takes control of the heat demand.

The reason smart heat grid technology works from a business perspective is that the energy company is generally interested in optimizing the operational behavior in relation to the load, while the building owners want to save energy.

A smart heat grid combines these two goals into an operational unity. The energy companies who promote increased interaction and mutual dependency with their customers will have a definite advantage when building sustainable energy infrastructure for the future.

Figure 3.72 depicts a simplified conceptual smart heat grid showing operational interaction between consumers and a heating station.

The Korea District Heating Corporation promotes system-wide optimization of district heating and cooling systems by integrating electricity projects, new and renewable energy projects (Fig. 3.73).

Reservoirs for cooling purposes can be the integrated smart heat grid.

There is a man-made water reservoir, almost a lake, under the city of Helsinki, Finland, for cooling system. It is expected that there will be more such reservoirs as a part of the future smart grid systems for smart fusion industries (Marko 2016).

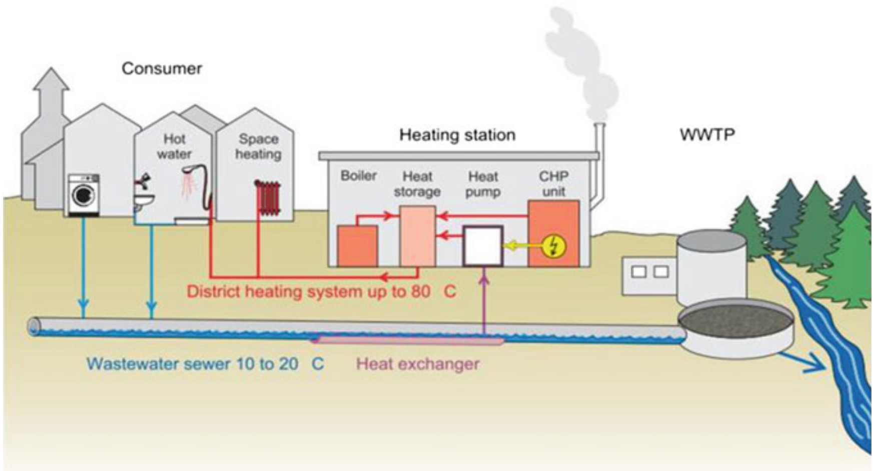


Fig. 3.72 Simplified conceptual smart heat grid. *Source* http://www.google.co.kr/blank.html

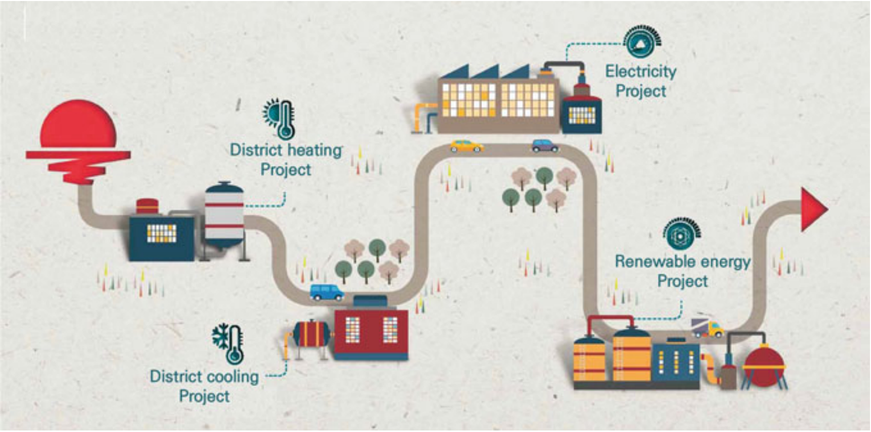


Fig. 3.73 Future vision of the Korea District Heating Corporation toward climate change and volatile energy markets. *Source* Chosun Daily Newspaper, Number 29649, A31, 6 May, 2016

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Chapter 4
Methods and Techniques for Climate Resilient and Low-Carbon Smart City Planning

Abstract This chapter addresses methods and techniques for climate resilient and low-carbon smart city planning in more detail through the analysis of selected practices. There have been a number of urban planning methods and techniques over the past few decades. However, there is a lack of sufficient connectivity in planning options. How to actually link the smart grid with urban planning for the digitalization of cities is a real challenge. Thanks to the recent tech revolution, the digital planning revolution is coming to us. Innovative methods derived from virtual reality and the spatial network revolution and techniques provide useful tools to connect urban planning and climate change with ICT. A framework and its components are provided to incorporate land development tools, adaptation and mitigation measures, and physical infrastructure development as an integrated solution.

Keywords Innovative methods and techniques · Land development · Smart digital zoning · Low emissions development · Low impact development · Adaptation planning · Physical infrastructure development · Intelligent operation · Low-carbon economic development · The 6th industry

Thanks to the recent tech revolution, the digital planning revolution is coming to us for digitalization of cities.

Recently, increased attention has been given to the digitalized connections between urban planning and climate change with ICT. There are innovative methods and techniques which are useful tools for connecting urban planning and climate change with ICT as the virtual reality and spatial network revolution have already begun.

4.1 Components and Connections to Achieving Climate Resilient and Low-Carbon Smart City Development

This chapter, in particular, investigates land development, climate change mitigation and adaptation measures, and physical infrastructure development in a connected way at the urban level. Also, it identifies innovative tools for providing access to climate resilient and low-carbon smart techniques and technology pilots.

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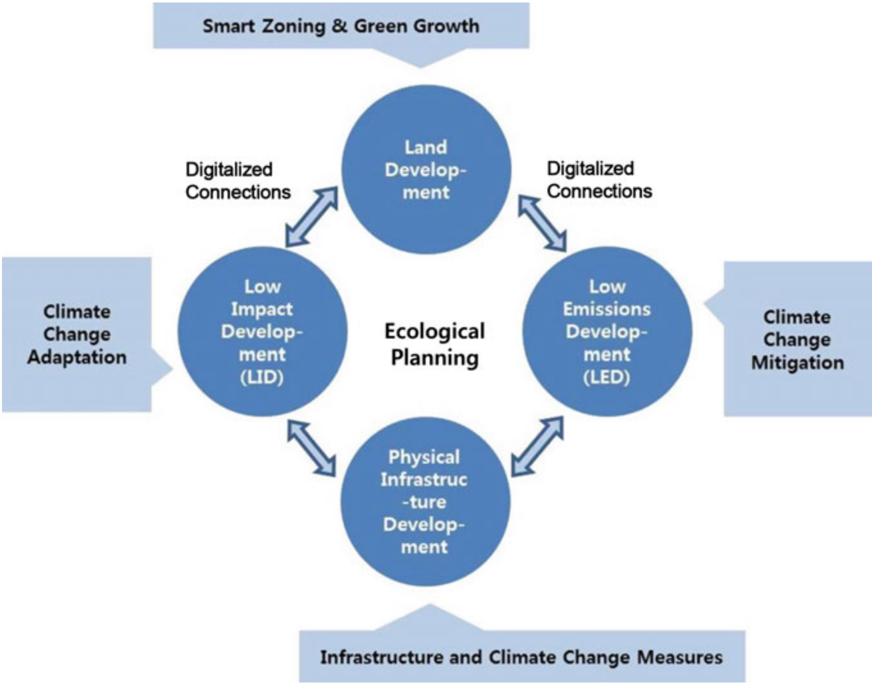


Fig. 4.1 Components and connections to achieving climate resilient and low-carbon smart city development

One of the main features of this chapter is to explore new cross-sectoral approaches to develop climate smart planning tools and to promote the use of climate smart technology at the city level in order to support the implementation of planning strategy at the city level, its supporting system, and financial opportunities.

As an example at the city level, if passenger traffic is controlled to enter the city center areas, this contributes smart land development, and reductions in greenhouse gas (GHG) emissions and improvement of livelihoods of the city.

Elements of planning are shown in Fig. 4.1. The figure provides a framework to incorporate land development, adaptation and mitigation measures, and physical infrastructure which will be described more in detail later on in this book.

4.2 Land Development

Figure 4.2 shows components of climate smart land-use planning which contains areas for land development, low impact development, low emissions development, and physical infrastructure development.

Despite a wealth of the literature on climate smart land-use planning, only a fraction of the current literature successfully integrates the theory and practices from across the full range of relevant disciplines (Fig. 4.3).

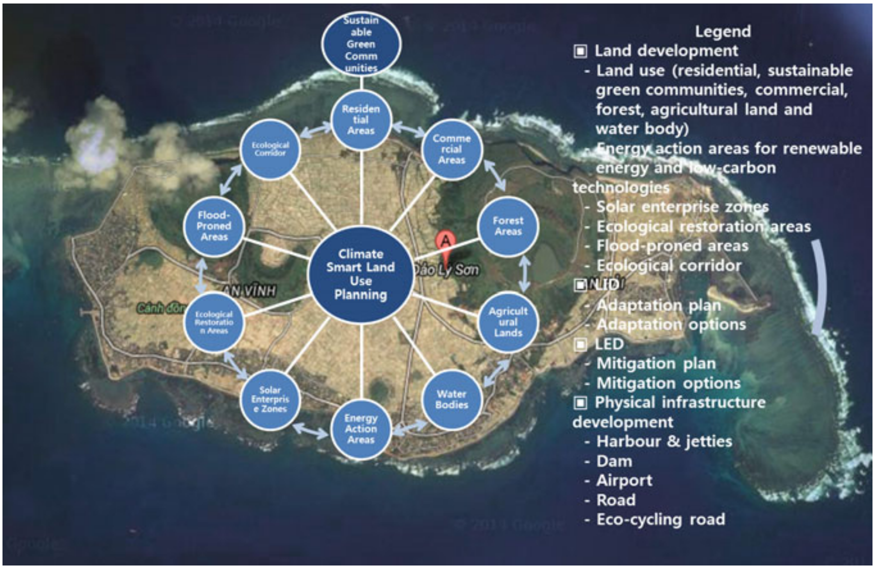


Fig. 4.2 Components of climate smart land-use planning

Fig. 4.3 Salinity affected areas: Vegetables cannot grow in this village because of too much salinity content in the soil caused by the sea-level rise, Central Province, Sri Lanka

4.2.1 Land-Use Suitability and Carrying Capacity Analysis

Two ideas are central for developing climate smart land-use planning.

One is that hydrologic, geologic, and other features, when viewed collectively, yield insights into the type of use "intrinsically suitable" for a particular parcel of land.

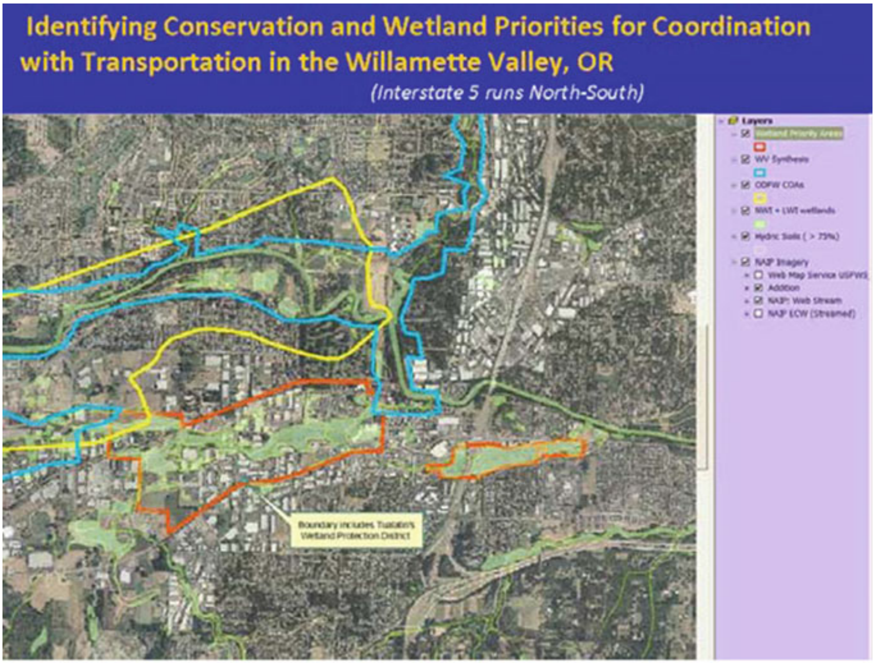


Fig. 4.4 Identifying conservation and wetland priorities for coordination with transportation in the Willamette Valley, OR (Interstate 5 runs North-South)

A second important concept is "carrying capacity," the limits to how much growth an area can accommodate without violating environmental quality goals (Ortolano 1984).

The analysis of carrying capacity and the intrinsic suitability of land for certain uses provides systematic ways of utilizing environmental information to guide strategic planning and smart zoning in a connected way (Figs. 4.4 and 4.5).

Vulnerability and risk assessment, Southold, New York, USA
Source : Naver image

Advancement zones, Southold, New York, USA
Source : Naver image

Fig. 4.5 Vulnerability (*Left*) and advancement (*Right*) zones, Southold, New York, USA

Figure 4.5 shows the GIS/GPS-based smart technology being used for climate change vulnerability and advancement zoning based on land-use suitability analysis.

4.2.2 Digital Landscape Architecture for Land-Shaping

Digital landscape architecture is a virtual reality technique which can be used to develop smart land-use plans.

The landscape architecture profession has seen a good deal of change in both content and representation tools (George Hargreaves 2012).

Digital-mapping techniques, virtual reality programs, arrays of climate projection, and other new media melded with landscape architecture are supporting the new approaches to land-use planning. New technology stimulates innovators, and innovators are sensitive to science and to the practices of artists, to the ways that artists today are themselves using new media and technology in their work, envisioning advanced conceptions of land-shaping via virtual, interactive, and living, spatial artwork (Nadia Amoroso 2012).

Through artistic experiments, the reader can see technologically driven design solutions that emerge when artists use new media and landscape designers pay attention to the outer boundaries of artistic practice.

4.2.3 Climate-Friendly Land-Use Zoning: Smart Digital Zoning

There are a number of different techniques to carry out smart zoning.

Floating zones, cluster zoning, and planned unit developments (PUDs) are possible even as the conventional Euclidean code exists, or the conventional code may be completely replaced by a smart code, as the city of Miami is proposing.

To respond to climate change, green growth, and innovation economy, new zoning policy should be introduced to encourage climate-friendly utilization of land.

There are many zoning types or zone classification systems specific to climate change. The zoning types can be categorized into two types, zoning for climate change mitigation and zoning for climate change adaptation shown in Table 4.1.

The best example of climate smart zoning is the California's Senate Bill 375 (SB 375) which is the first statewide legislation in the USA to link transportation and land-use planning to climate change.

The law is lengthy and complex, but the central concept is simple: locate homes closer to jobs, services, and transit so that Californians drive less frequently, travel shorter distances, and reduce their GHG emissions.

The Sustainable Communities Strategy (SCS) in the USA establishes one requirement related to compact, transit-oriented residential and mixed use development which makes it easier for people to live their lives without depending on the automobile.

Table 4.1 Smart zoning types for climate change mitigation and adaptation

Smart zoning for climate change mitigation	Smart zoning for climate change adaptation
• Floating zones • Cluster zoning • Planned unit developments (PUDs) • Compact, transit-oriented residential and mixed use development • Energy action areas • Smart energy zones • Solar enterprise zones • District-based energy distribution • Modernization of grid infrastructure • Ecosystem-based zoning	• Disaster risk zoning • Salinity affected areas • Flood prone areas • Integrated coastal zone management (ICZM) • Seismic zonation (or microzonation) • Rezoning of low-lying coastal land at risk from tsunamis • Ecosystem-based zoning

London has established Energy Action Areas to act as spatial catalysts for renewable energy and low-carbon technologies. Victoria, Australia, has launched smart energy zones as a similar program. San Francisco has committed to establish a simplified permit process for renewable energy systems, such as solar photovoltaics; to establish solar enterprise zones in two districts within the city; and to develop a solar access ordinance.

Toronto has committed to create permissive regulations for district-based energy distribution between multiple properties.

New York has also committed to facilitate the repowering and construction of power plants and dedicated transmission lines, to expand clean distributed generation, and modernize grid infrastructure.

The concept of integrated coastal zone management (ICZM) for effective climate change adaptation was born in 1992 during the Earth Summit of Rio de Janeiro. The specifics regarding ICZM are set out in the proceedings of the summit within Agenda 21, Chap. 17.

Critical issues for ICZM include the following among others:

- Climate change and sea-level rise; vulnerability and adaptation assessment;
- Capacity building; and
- Institutional analysis, policy and planning for ICZM.

ICZM is a tool to sustainably manage the change of the global coast. ICZM projects range from local-scale projects such as ICZM for local governments to providing global analysis for the United Nations Organizations.

The US EPA Coastal Zone Management Act (CZMA) encourages states/tribes to preserve, protect, develop, and where possible, restore or enhance valuable natural coastal resources such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as, the fish and wildlife using those habitats.

A unique feature of this law is that participation by states/tribes is voluntary. To encourage states/tribes to participate, the act makes federal financial assistance available to any coastal state, tribe, or territory that is willing to develop and implement a comprehensive coastal management program.

On January 19, 1993, the US EPA issued its Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, which addresses five major source categories of nonpoint pollution: (1) urban runoff, (2) agriculture runoff, (3) forestry runoff, (4) marinas and recreational boating, and (5) hydro modification.

ICZM appears to be a key element for the sustainable development of these zones.

However, this recent notion may not be adapted to all cases. The natural disasters such as the Sumatra earthquake and the Indian Ocean tsunami had serious impact on the coastal environment and also on the stakeholder's perception on mitigation and management of coastal hazards.

The successful implementation to the idea of ICZM is still a major challenge.

ICZM must embrace a holistic viewpoint of the functions that make up the complex and dynamic nature of interactions in the coastal environment. Management framework must be applied to a defined geographical limit (often complicated) and should operate with a high level of integration.

A common thinking process and decision-making framework can be fairly uniform as a part of the ICZM around the world. The 2015 Sustainable Development Goals (SDGs) include the following goal and targets related to ICZM.

- Goal 14. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development; and
- Target 14.2
  By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.
- Target 14.5
  By 2020, conserve at least 10% of coastal and marine areas, consistent with national and international law and based on the best available scientific information.

To achieve the goal and targets set out in the SDGs, a step-by-step process can be adhered to the following:

Firstly, issues and problems need to be identified and assessment of these needs should be quantified.

Secondly, once the issues and problems have been identified and weighted, an effective management plan can be drawn up. The plan will be specific to the area in question.

Thirdly, the adoption of the plan can be carried out. They can be legally binding statutory plans, strategies, or objectives which are generally quite powerful, or they can be non-statutory processes and can act as a guide for future development.

Fourthly, the active phase of implementation of the plan includes law enforcement, education and training, and development associated with smart connect-tech.

The implementation activities will be, of course, as unique as their environments and can take many forms.

Lastly, the final phase is evaluation of the whole process.

The principles of sustainability mean that there is no “end state.” ICZM is an ongoing process which should constantly readjust the equilibrium between economic development and the protection of the environment. Feedback is a crucial part of the process and allows for continued effectiveness even when a situation may change.

Public participation and stakeholder involvement is essential in ICZM processes, not only in terms of a democratic approach, but also from a technical-instrumental point of view, in order to reduce decisional conflicts (Ioppolo et al. 2013).

One way to reduce the physical impacts of disasters such as earthquakes is to adopt hazard mitigation practices such as land-use planning and seismic zonation.

With regards to land-use planning, according to Lindell and Prater (2002), land-use practices can reduce hazard vulnerability by avoiding construction in areas that are susceptible to hazard impact. They go on to argue that government agencies can encourage the adoption of appropriate land-use practices by establishing regulations that prevent development in hazardous locations, providing incentives that encourage development in safe locations, or informing landowners about the risks and benefits of development in locations throughout the community (Figs. 4.6, 4.7, 4.8, 4.9, and 4.10).

Fig. 4.6 Flood damage, Davao City, Mindanao, the Philippines

Fig. 4.7 Sand beach erosion, Hoi An City, Vietnam (1)

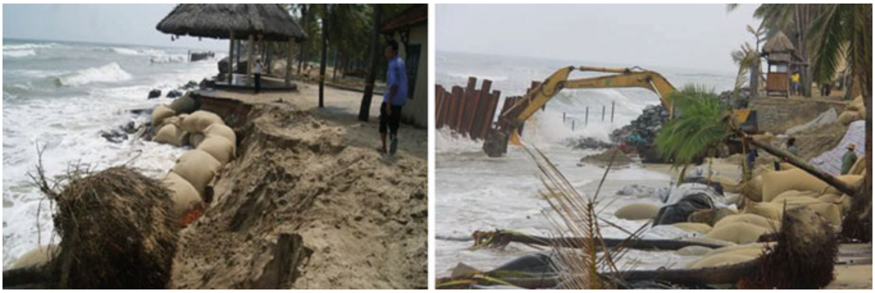


Fig. 4.8 Sand beach erosion, Hoi An City, Vietnam (2)

Fig. 4.9 Sand beach erosion, Negombo City, Sri Lanka

Fig. 4.10 Destruction of sea wall, Hoi An City, Vietnam

Seismic zonation (or microzonation), on the other hand, refers to the subdivision of a region into smaller zones that have relatively exposures to various earthquake effects (Nath et al. 2008) and, therefore, it is an essential prerequisite to develop good planning in a connected way.

Smith (2001) states that the microzonation of land is expensive but necessary in urban areas where the aim is to convert already developed areas into parkland or other open spaces and to prevent the further development of hazardous places. He further states that the highest priority is to map areas susceptible to enhance ground-shaking, as a result of the presence of soft soils or landfill, because it is often the major factor in property damage.

According to Olshansky and Wu (2001), although microzonation maps can improve the intelligence of planning, the hazard differential is not sufficient to justify regulating land-use type or intensity. He also argues that such maps can be used as the basis for requiring further study, and they can help authorities set priorities in managing land-use, enforcing building codes, conducting seismic-strengthening programs for existing buildings, and planning for emergency response and long-term recovery.

Finally, earthquakes are one of the main causes of tsunami. In this context, Smith (2001) suggests that the rezoning of low-lying coastal land at risk from tsunamis, in association with the structural strengthening of buildings, can be an effective defense (Fig. 4.11).

Further research is needed in order to create reliable microzonation maps in places where earthquakes occur. The resulting zoning should be the foundations to develop a sustainable land-use planning.

Land-use zoning for ecosystem-based climate change adaptation and mitigation is another type of climate-friendly land-use zoning.

Ecosystem-based zoning for conservation and development of the environment utilizes the geographic information system (GIS), which establishes ecologically and climatologically related zones, derived from known ecological and climatic criteria. The zoning can be done by land suitability and carrying capacity analysis as described earlier on in this chapter.

A series of goals, objectives, and strategies should underpin the desired outcomes of each of the ecologically and climatologically related zones.

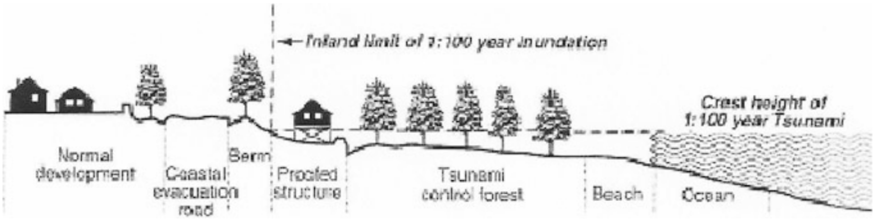


Fig. 4.11 Coastal land-use planning designed to mitigate tsunami. The beach and the forest are used to dissipate the energy of the onshore wave, while development and the coastal evacuation route are located above the predicted height of the 1:100 year event (based on Preus 1983)

4.2.4 An Example of Land Development for Ecosystem-Based Climate Change Adaptation and Mitigation

Land development for ecosystem-based climate change adaptation and mitigation forms a part of climate smart resilient city planning. Ecosystem-based approaches to climate change adaptation and mitigation maintain existing carbon stocks, regulate water flow and storage, maintain and increase resilience, reduce vulnerability of ecosystems and people, help to adapt to climate change impacts, improve biodiversity conservation and livelihood opportunities, and provide health and recreational benefits (Ecologic Institute and Environmental Change Institute, Oxford University Center for the Environment 2011).

Applying this definition, this case study aims to demonstrate how to maintain, enhance, and restore ecosystem in land development process which can be a very important part of climate change adaptation.

Introduction

This project has jointly conducted with IUTC, UN-Habitat, and Tam Ky City, Quang Nam province, Vietnam, as a part of the City Development Strategy Project.

In the project, a series of ecosystem-based plans show how to connect land development planning, climate change adaptation and mitigation planning, and physical infrastructure planning in a simple, easy, and practical way to achieving climate resilient and low-carbon smart city development shown in Fig. 4.1. Potentially, it is envisaged that knowledge and information of the relationships between land use, climate change adaptation and mitigation, and physical infrastructure development could help to adapt climate change impacts, improve livelihood opportunities, and provide health and recreational benefits.

The Study Area

Tam Ky is the third-grade city of Quang Nam province which is a central coastal province of Vietnam (Fig. 4.12). Tam Ky has 13 administrative units including nine words and four communes. The study area is a commune which is a part of Tam Ky located beside the Song Dam Lake, as a demonstration site.

According to the Tam Ky City Master Plan: 2030–2050 Eco-city vision, the Song Dam Lake plays an important role in the management of Tam Ky's urban ecology which motivates the sustainable development of the proposed resilient eco-city.

Base Map

Currently, data on natural and socioeconomic conditions, biodiversity, and environmental impacts needed for planning for the commune are limited. However, Fig. 4.13 shows the basic data necessary for climate change adaptation and mitigation planning, and eco-development planning of physical infrastructure.

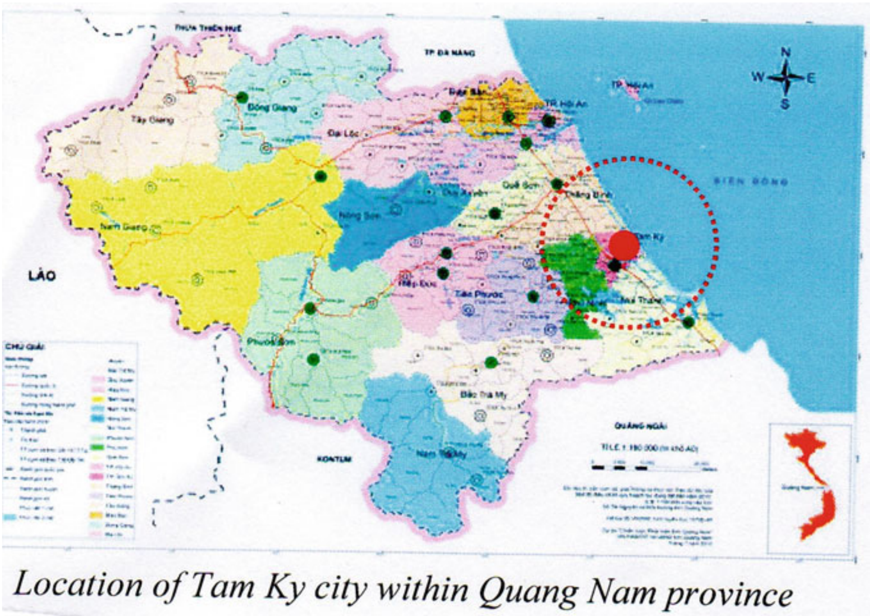


Fig. 4.12 Location of Tam Ky City within Quang Nam province

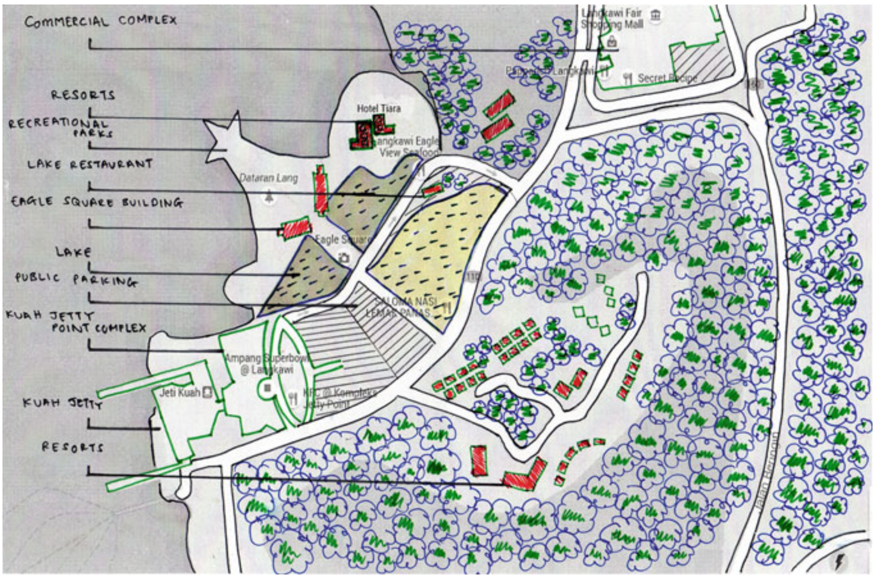


Fig. 4.13 Base map of the selected site

The figure provides the information on existing land use, communal facilities, and water features. The aim of the typological study is to propose a communal fabric that allows inhabitants to be both responsible for and beneficiaries of the planning products and their spatial conditions. The spatial quality of the archetype becomes both the end and the means of spatial control by adaptation and mitigation measures and adequate infrastructure.

Ecosystem-Based Adaptation Planning

In order to understand the connection between land-use and climate change impacts, we have to look at ecosystem-based adaptation measures.

In this area, flood hazard is principally a product of maldevelopment. There are certain physical phenomena and characteristics of settlement location and agricultural practices that shape the geography of flooding, but flood hazard could be mitigated with available technology and management systems.

Figure 4.14 shows use of mangrove forests, bioswales, and wetlands for flooding control.

Climate change is the new challenge for lake and river restoration in this study area. The proposed projects can be opportunities to demonstrate best practices for ecological restoration principles that integrate climate proofing with other key aspirations outlined in this book.

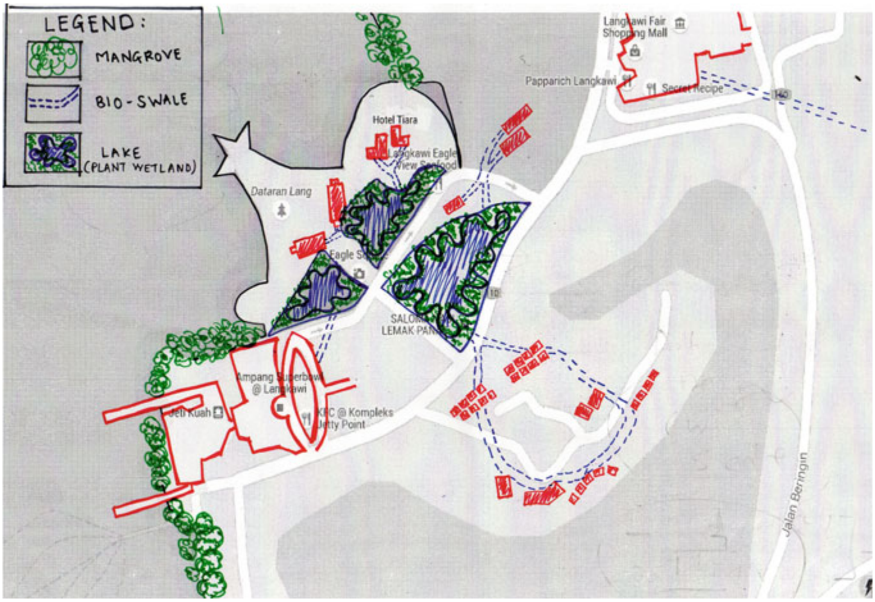


Fig. 4.14 Adaptation planning

Mitigation Planning

Mitigation-integrated land-use planning represents the land-use system as interwoven overlaid processes rather than one singular layer in which land uses compete with each other for space. Stated as a planning solution to climate change impacts, the mitigation plan aims to provide a zero-carbon master plan which maps out energy, water, waste, and ecosystem nexus (Fig. 4.15). The mitigation plan has a floating solar power plant, five rainwater harvesting systems, LED street lightings, a sewage treatment plant, a community vegetable garden, and biodiesel-engine ferries.

Physical Infrastructure Planning

Smart-connected infrastructure is a key element of climate smart city, as envisioned in Fig. 4.1. Just as it is critical to maintain and enhance the built environment and its supporting infrastructure, it is vital to maintain and enhance a communal green and blue infrastructure.

In the study area, lake and river restoration are a prerequisite to land development as improved, more sustainable flood management, or a better livelihood and are seen as integral to transforming social and economic conditions.

Some green infrastructure projects are shown in Fig. 4.16.

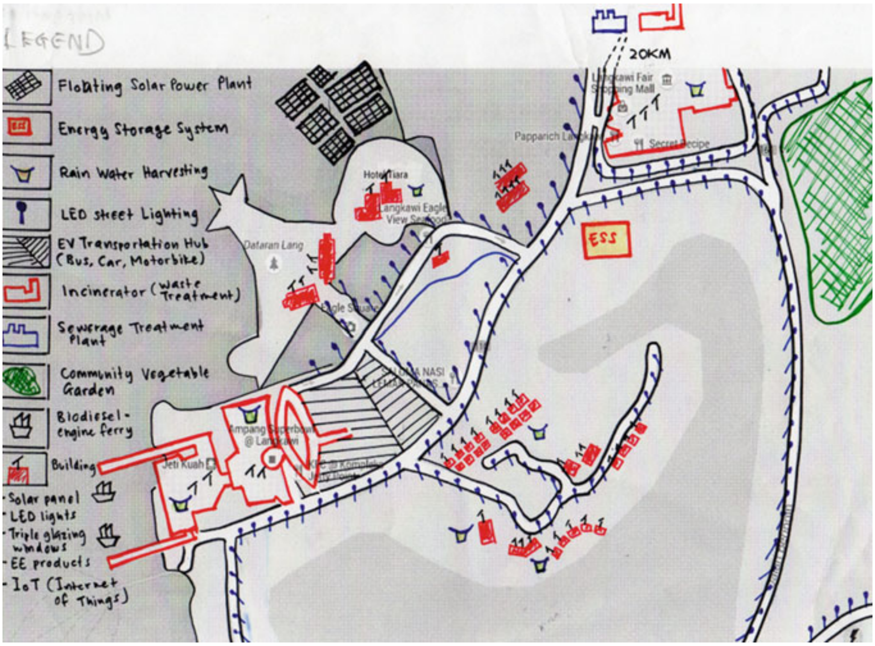


Fig. 4.15 Mitigation planning

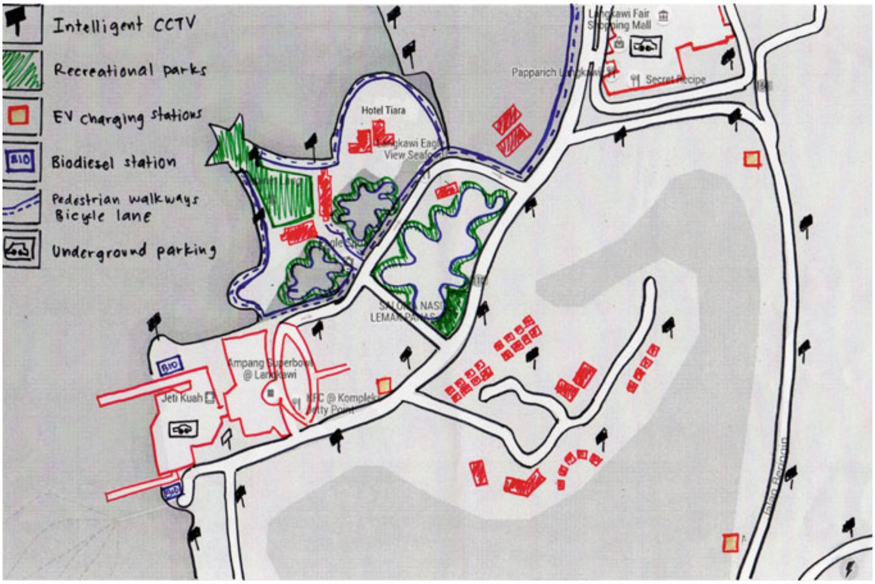


Fig. 4.16 Physical infrastructure planning

Synthesized Super Imposed Planning: Land Development Plan

Ecosystem-based urban and regional planning includes the following:

- Land-use zoning
- Increase of green infrastructure and spaces (e.g., green roads, urban tree planting, parks/recreation areas, green belts);
- Increase blue infrastructure and spaces (lakes and ponds); and
- Increase soil infiltration in parks, parking lots, and green curbs (Ecological Institute and Environmental Change Institute, Oxford University Center for the Environment 2011).

Therefore, ecosystem-based land development plan should be inclusive in order to include measures linked to ecosystem-based adaptation (EbA) and ecosystem-based mitigation (EbM), as shown in Table 3.1. Figure 4.17 superimposes EbA (Fig. 4.14) and EbM (Fig. 4.15) on the green and blue infrastructure (Fig. 4.16).

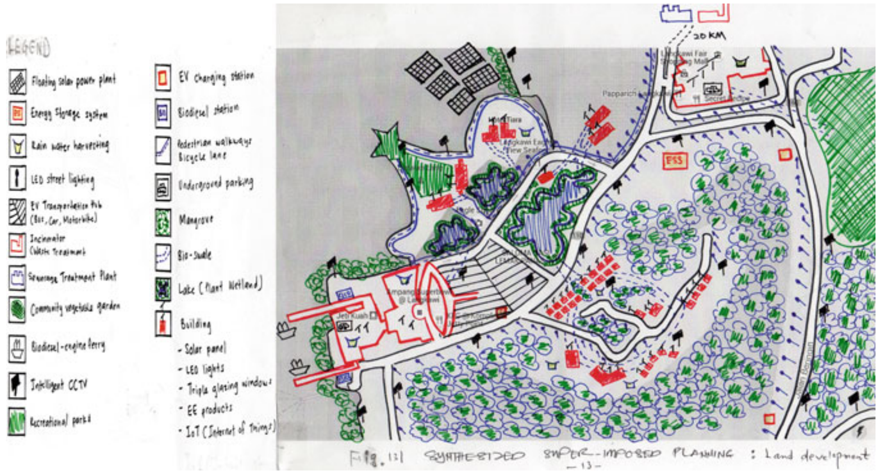


Fig. 4.17 Synthesized super imposed planning: land development plan

4.3 Low Emissions Development (LED) for Climate Change Mitigation: Low Emission Development Strategies (LEDS) and Nationally Determined Contribution (NDC) Adopted by the Paris Climate Change Agreement

How can decision makers scale up climate actions through city-wide approaches to low emissions development (LED)? (World Bank).

A recent study commissioned by the World Bank, Turn Down the Heat, reports that the planet would warm by 4 °C at the end of the century, if the global community fails to act on climate change (Potsdam Institute for Climate Impact Research and Climate Analytics 2013).

According to the World Bank, the methods for LED may include the following:

- Develop an open knowledge system;
- Find innovative solutions; and
- Formulate collaborative solutions.

The low-carbon smart city innovation for the low-carbon smart society is shown in Fig. 4.18.

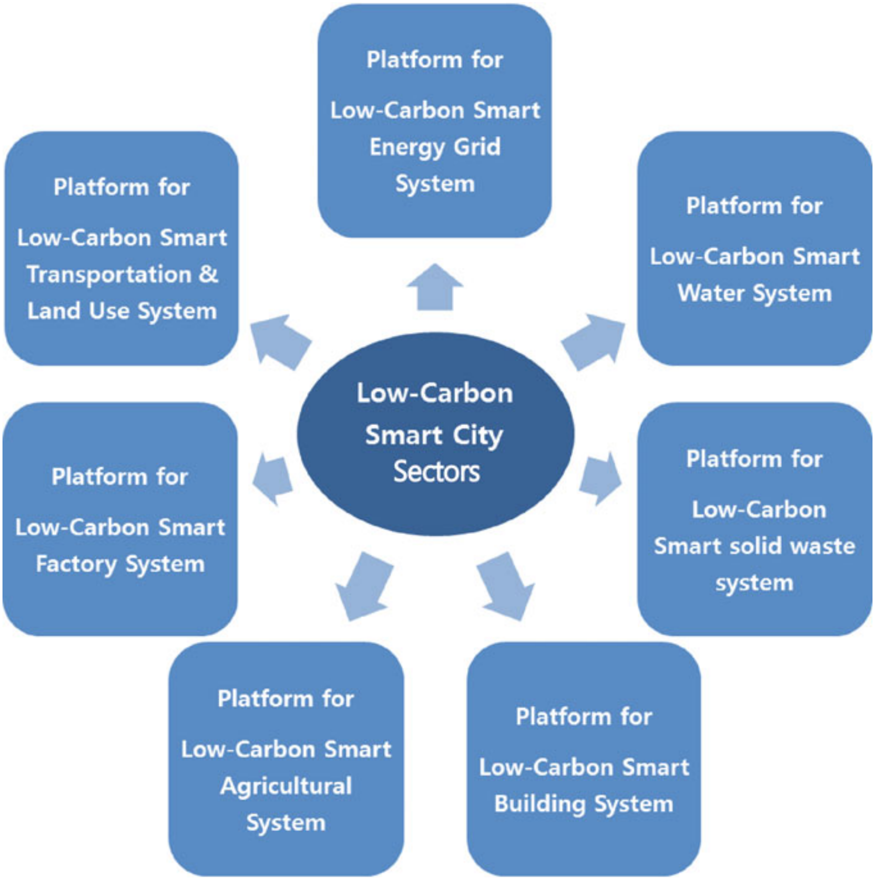


Fig. 4.18 Low-carbon smart city sector for low-carbon smart society

4.3.1 Guide Flowchart of Climate Change Mitigation Planning

A guide flowchart of climate change mitigation was developed to deal with climate change mitigation issues at the city level as shown in Figs. 4.19 and 4.20. This flowchart can help local governments or communities develop a climate change mitigation plan.

Based on Figs. 4.19 and 4.20, the process for climate change mitigation plan is divided into planning and implementation process. The planning process considers three analytical functions associated with climate change: data, projections, and issues and challenges. Methods for global data collection can model projections. Projections can be made at the national, regional, and local level. This phase will

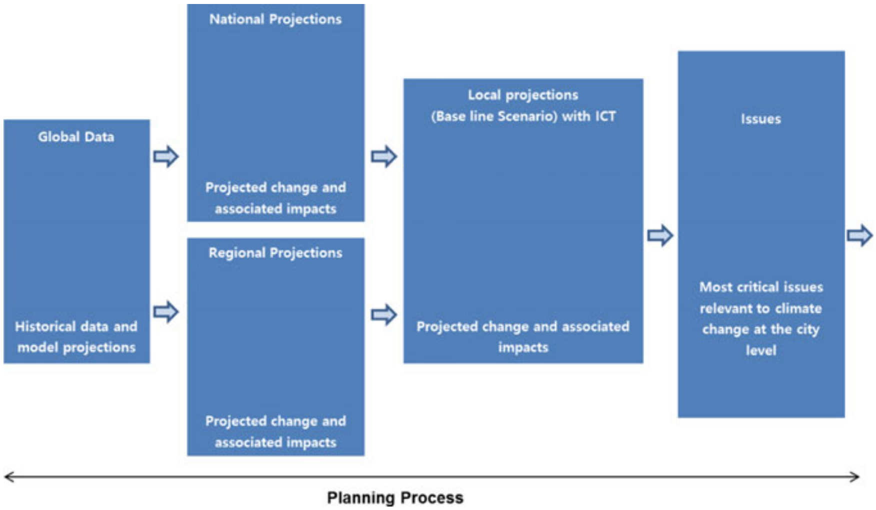


Fig. 4.19 Guide flowchart of climate change mitigation

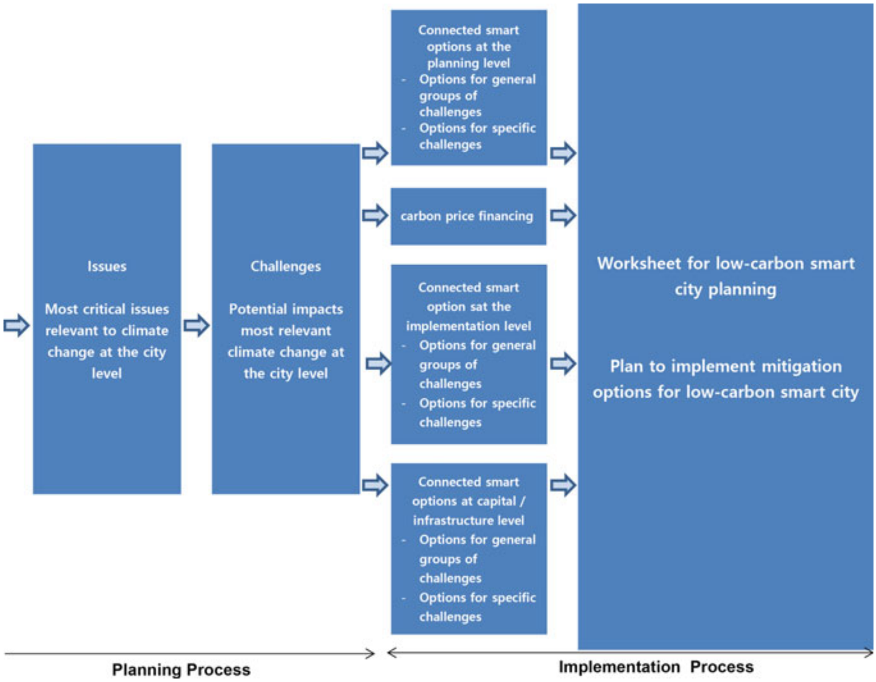


Fig. 4.20 Continues

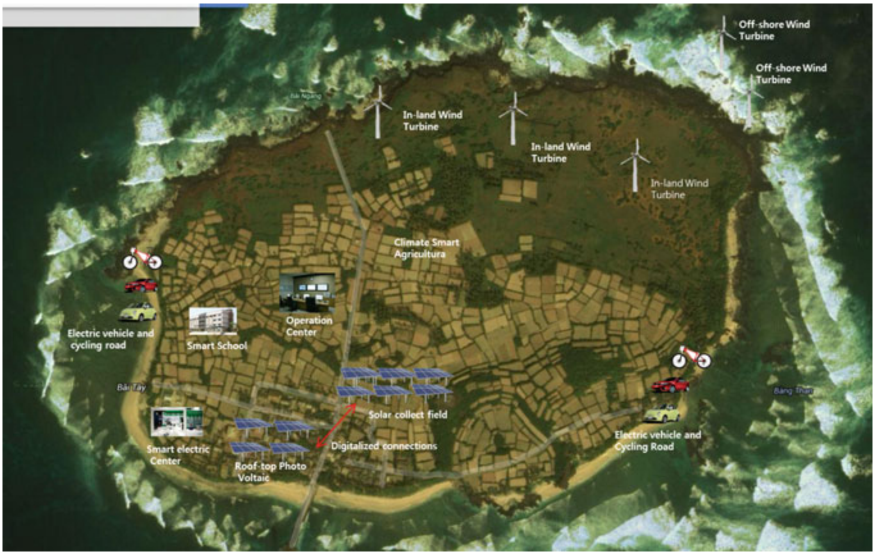


Fig. 4.21 Concept plan on "carbon free island" development in Ly Son Island, Quangnai City, Vietnam

help quantify GHG emissions from local government operations or the community as a whole, including a baseline inventory.

The implementation process outlined in the flowchart includes connected smart options for general group of challenges and specific challenges on the planning and implementation level, and at capital and infrastructure level.

The worksheet for low-carbon smart city planning provides plan to implement mitigation options for low-carbon smart city. It can be used for small- and mid-size communities with beginner- and intermediate-level experience.

It is believed that the flowchart will bring a new meaning and value to the so-called integrated approach effect.

Figure 4.21 shows a concept plan for the "carbon free island" development of Ly Son Island, Quangnai city, Vietnam, prepared by the author. The guide flowchart of climate change mitigation in Fig. 4.20 can be used to explore subsequent phases for the development of actual projects and programs for this island.

4.3.2 An Example of Techniques to Reduce GHG with Optimal Parking Space

There are a number of digitalized techniques for parking information brokerage service including "SPARKING", "iParking", "Park here" and "Parking of us." "SPARKING" for real-time sharing of best parking space provides suppliers with

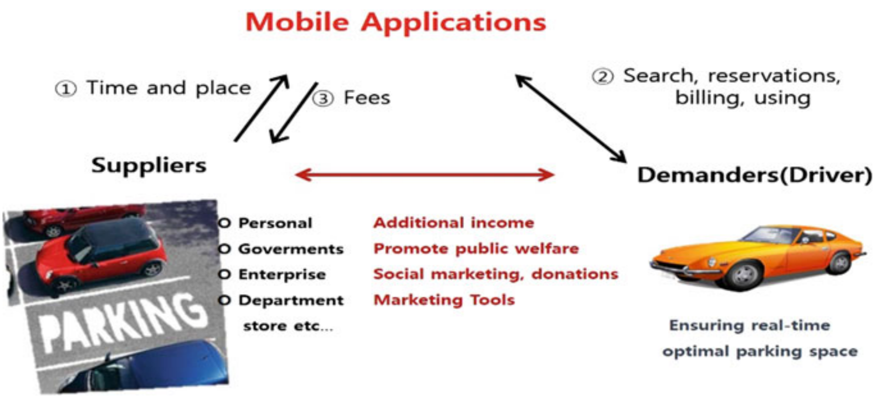


Fig. 4.22 Mobile applications for parking information brokerage services. *Sources* SMARTTKING, SPARKING, 2016

an opportunity to monitor parking space and demanders (drivers) cheap use of real-time optimal parking space. It is a big data-based future parking projection algorism. Smart parking includes dynamic pricing that the USA implemented for Miami and Boston as piloting projects.

The information provided by mobile applications includes availability, fees, distance (or time), size, safety, and networking of parking spaces (Figs. 4.22 and 4.23).

Governments promote public welfare and social marketing, and encourage climate-friendly utilization of parking lots and spaces.

4.4 Low Impact Development (LID)

Low impact development (LID) is a method for climate change adaptation. Climate change adaptation is defined by the IPCC as "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects" (IPCC 2007).

LID is an approach to land development (or redevelopment) that works with nature to manage storm water as close to its source as possible. The hard, impermeable areas associated with development can result in undesirable consequences in terms of the rapid runoff of surface water. This can result in poor quality water entering watercourses and a risk of local flooding.

The LID approach includes the following:

- To preserve and recreate natural landscape features;
- To minimize effective imperviousness to create functional and appealing site drainage that treats storm water as a resource rather than a waste product;

Fig. 4.23 ICT exhibition *Sources* Ministry of Science, ICT and Future Planning, National IT Industry Promotion Agency (nipa) and Korea IT Business Promotion Association (iPA), SW R&D: Creative Idea Challenge, COEX, 2016

- To minimize the negative impacts of climate change on people, property, and ecosystem; prepare the integrated disaster management plan which includes the following:
  - Cyclone disasters;
  - Flooding;
  - Drought;
  - Extreme weather due to the global warming; and
  - Landfall and landslides.
- To manage hazard prone areas with GIS map technique.

It is important to note that rainwater parks which improve water quality by filtering runoff and provide localized flood control are aesthetically pleasing and provide interesting planting opportunities. Other LID techniques include bio-retention, green roofs, permeable pavers, rain barrels and cisterns, soil amendments, and tree box filters (Low Impact Development Center 199-2007).

4.4.1 Adaptation Planning

Climate change adaptation plan helps to find the way to structure a program that could benefit populations vulnerable to the effects of climate change.

An integral part of increasing climate change resilience is to conduct a risk assessment and adopt an associated decision-support framework (Fig. 4.24). This framework should be an iterative process of identifying projected impacts and challenges associated with climate change, assessing risks from these impacts based on current thresholds for failure or damage, selecting and implementing adaptation options, and then revisiting assessments when new information is available or when additional capacity to implement options is in place. The framework should also include other stressors besides climate change (e.g., land use, population, and regulatory changes) (Fig. 4.25).

Note: While the overall analysis and operational plan design and steps are relatively standard, the level of engagement of the local stakeholders at the various steps will vary according to the planned action location. The closer to the "local" level (cities versus districts, all the way down to community levels), the more important it will be to engage the local stakeholders in the initial steps, starting with the identification of climate change challenges and hazards and to involve them in

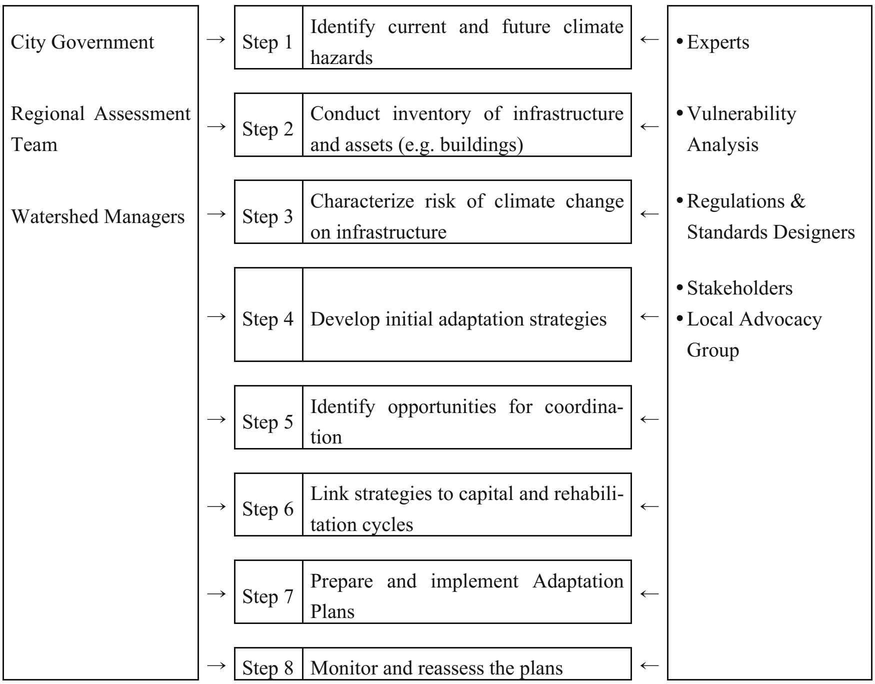


Fig. 4.24 Operating system of adaptation assessment steps and major actors for each step. *Source* New York City Panel on Climate Change (2010, p. 245). Modified by the author

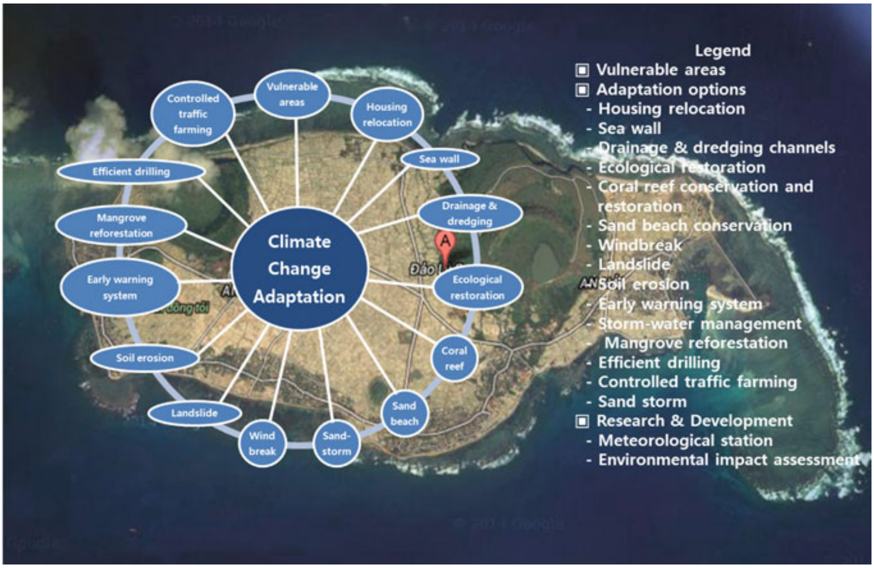


Fig. 4.25 Conceptual layout of climate change adaptation practices

all the subsequent steps to ensure both viability and implementation of the proposed strategies.

Figures 4.26, 4.27, and 4.28 show some adaptation options practiced in the disaster risk management.

Critical infrastructure that could impact populations vulnerable to the effects of climate change which should be taken into account in the adaptation planning is as follows (New York City Panel on Climate Change 2010):

Communications

Communications infrastructure includes, but is not limited to, lines, control installations, and other facilities.

Energy

Energy infrastructure includes, but is not limited to, generating facilities, lines, towers, administrative and control structures, and other facilities.

Transportation Infrastructure

Transportation infrastructure includes, but is not limited to, subways, trains, airports, roads, bridges, tracks, administrative and support structures, and other facilities.

Fig. 4.26 Techniques for climate change adaptation

Water and Waste

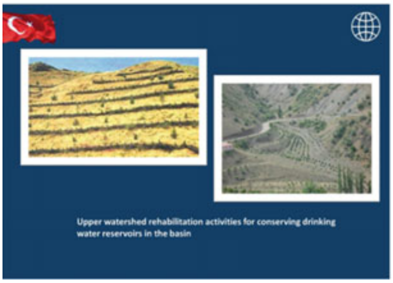
Water and waste infrastructure includes, but is not limited to, drains, sewers, water pollution control plants, marine transfer stations, parks, wetlands, trees, and administrative and control structures and other facilities.

Social, economic, and environmental benefits of an adaptation planning can be summarized as follows:

- Increase collection capacity;
- Increase resilience of service;
- Enable incremental expansion of service;
- Decrease carbon footprint;
- Leverage opportunities for co-benefits;
- Improve public image;

Efficient crop irrigation system (drip irrigation)
(Source : World Bank)

A resort area with sand erosion problem, Hoian, Vietnam
ICZM is a solution
(Source : Chu Manh Trinh)



Upper watershed rehabilitation activities for conserving drinking water reservoirs in the basin (Source : World Bank)

A restored sand beach ecosystem, Gangneung, Korea
(Source : Gangneung City)

Fig. 4.27 Ecological restoration

- Create new green jobs;
  - Create value chain which contributes to the skills and expertise of city staffs and community members with the appropriate ICT.
- Ensure the well-beings of the populations vulnerable to the effects of climate change; and
- To tangibly improve the lives of the citizens.

4.4.2 Green Infrastructure (GI)

Green infrastructure is important to the delivery of high-quality sustainable development, alongside other forms of infrastructure such as transport, energy, waste, and water. Green infrastructure can help urban, rural, and coastal communities mitigate the risks associated with climate change (http://planningguidance.planningportal.gov.uk/blog/guidance/climate-change/) and adapt to its impacts by storing carbon; improving drainage (including the use of sustainable drainage systems) and managing flooding and water resources; improving water quality;

A hillside landside caused by typhoon and storm, Mt. Apo, Kidapawan, Mindanao island, Philippines

An engineered creek, Seoul, Korea

A roadside engineered structure, Mt. Apo, Kidapawan, Mindanao island, Philippines

A restored area with the engineered structure and revegetation technique, Korea

Mass landslides caused by a severe typhoon, Seoul, Korea.
Engineered structure with revegetation technique is a solution

Fig. 4.28 Landslide risk management

reducing the urban heat island effect; and, where appropriate, supporting adaptive management in coastal areas.

Green infrastructure networks also help species adapt to climate change by providing opportunities for movement. Green infrastructure solutions (Fig. 4.29), applied in synergy with biodiversity, are less energy-intensive and require less upkeep than conventional solutions and are therefore more efficient, connected, and sustainable.

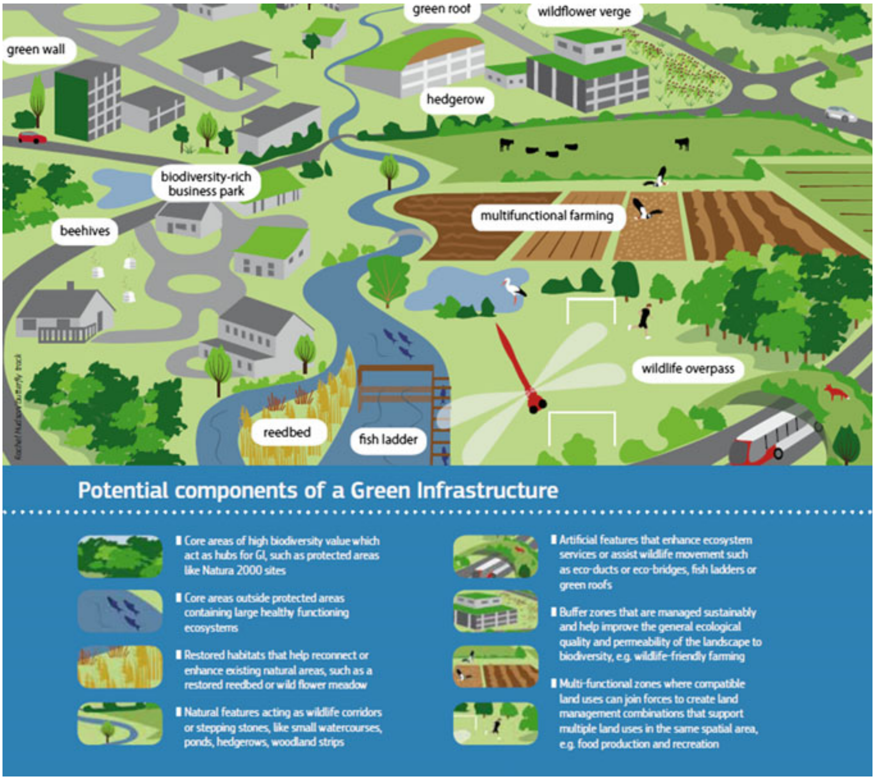


Fig. 4.29 Potential components of a green infrastructure. *Source* European Union (2013, p. 8)

4.4.3 An Example of Adaptation Planning

New York City's Department of Environmental Protection (NYCDEP) provides drinking water, wastement treatment, and storm water management services to approximately 9.2 million people in its metropolitan region. The NYDEP is involved in both local and national efforts to study and plan for climate change, and it collaborates with other utilities as part of the Water Utility Climate Alliance, as well as with members of the research community (such as the Water Research Foundation and NOAA's Regional Integrated Science and Assessment), to establish sound decision-making tools in light of climate uncertainty. Responding to current operational challenges and the threat of climate change, the NYCDEP collaborated with Columbia University and the City University of New York to better understand how climate change may affect its operations and infrastructure. Using downscaled projections from three General Circulation Models, the NYCDEP performed a vulnerability assessment which demonstrated that future challenges were likely to reflect the increased probability of the occurrence of some current challenges, such as high-turbidity events caused by intense precipitation and highly erodible soils. Warming winters are projected to lead to less snow accumulation and increased winter stream flow. This may result in more nutrients and sediment entering the reservoirs during the winter as opposed to the spring.

While not implemented specifically in response to climate change, existing NYCDEP programs enhance resilience to challenges that may arise in the future. For instance, the acquisition of land in the Catskill Mountains and Delaware River watersheds and conservation efforts with landowners help protect the areas surrounding reservoirs and controlled lakes. Other strategies to enhance the resilience of NYCDEP's systems include more frequent sewer maintenance, enhancing green infrastructure to decrease storm water runoff, promoting water conservation, and an Operations Support Tool that allows greater flexibility in response to conditions like high turbidity. The NYCDEP plans to adjust its adaptation strategies as it develops tools and programs to manage existing demands and continues an interactive planning process to anticipate challenges (US EPA 2013).

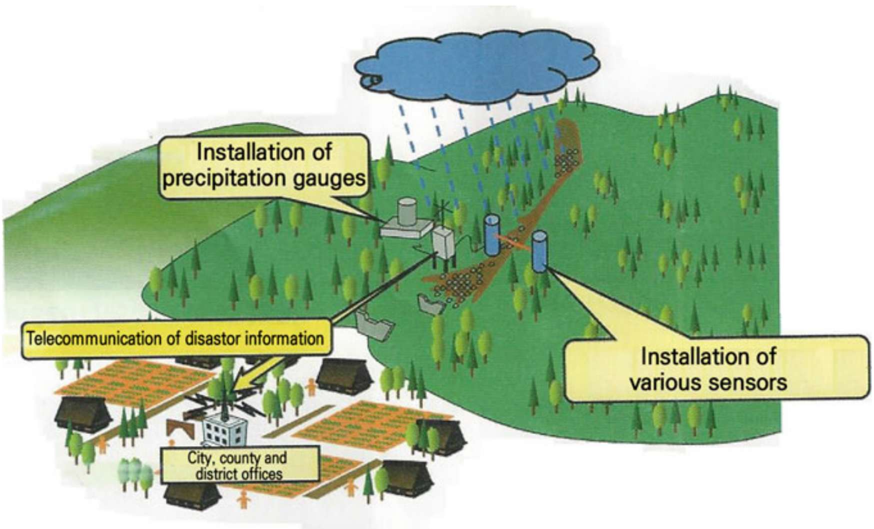


Fig. 4.30 Conceptual model of mountain disaster information system. *Source* Korea National Institute of Forest Science, Landslide Disaster Prevention Measures for Mountain Areas in Japan, Seoul, 205, p. 43

4.4.4 An Example of Techniques to Assess the Susceptibility and Probability of Landslidings

Conceptual model of mountain disaster information system is considered as a tool aimed at aiding the natural disaster risk management (Fig. 4.31).

There are a number of technologies which have been developed in the recent years to assess the susceptibility and probability of landslidings.

One technique practiced in the natural disaster risk management in Korea is the use of crack gauges. Crack gauges are used to monitor horizontal or vertical movement across cracks on flat rock surfaces. Different types of potential landslidings were identified and numbered for the installation of crack gauges (Fig. 4.30).

A measuring system of precipitation and snowfall is used in Seoraksan National Park, Korea, to examine the frequency of high-intensity rainfall and snowfall periods and correlate that with landslide occurrences as the exact dates of landslide occurrences were not feasible to know (Fig. 4.32).

In this park, some gabion walls are used to retain earth slopes on roadsides. It takes up the pressure exerted by the soil and rock (Fig. 4.33).

Seoraksan National Park is a representative of the natural ecosystem or natural and cultural sceneries of the country which are protected and managed for the sustainable use by national parks designated by the government. Seoraksan, located in the middle of Baekdudaegan Mountain Range, was designated as the fifth national park in Korea in 1970 because of its unique and spectacular natural environment. Even before the designation as a National Park, its value was recognized as a natural reserve in 1965, and also was chosen as a UNESCO Biosphere Reserve in 1982.

Although the crack gauge technique is used for protected area management, the areas of application for the monitoring, structural condition analysis, and evaluation, earth work controls to minimize effects of landslides and preventive maintenance are almost unlimited both in urban and rural areas.

4.5 Physical Infrastructure Development and Climate Change Measures

A new urban development approach in the era of global warming is needed to decarbonize development. Any physical infrastructure development should achieve as far as practical the four main aims of appropriate, climate-friendly, affordable, and equitable infrastructure which serve the community and promote growth.

The term "infrastructure" includes the large-scale physical facilities associated with the development of cities and regions. Examples are smart water supply reservoirs, smart water recycling infrastructure, smart transportation networks including highways, smart electric power plants, smart wastewater facilities, smart

Fig. 4.31 Crack gauge to monitor horizontal and vertical movement across cracks on different rock surfaces, Seoraksan National Park, Korea

Fig. 4.32 Measuring system of precipitation and snowfall with its protector, and a solar panel for power supply, Seoraksan National Park, Korea

airports, smart dams, smart flood control structures, and smart landfill sites which are characterized by many fold activities and are important components for digitalization of cities (Fig. 4.34).

The physical infrastructure development approach includes the following:

- Clarifying the nature of the climate change problem and the criteria to be used in formulating and evaluating alternative approaches to dealing with the problem;
- Producing a more detailed conception of alternative plans to reduce land degradation, flood, and drought damages and a preliminary analysis of the impacts of the different schemes; and
- Emphasizing the evaluation of alternative plans.

A climate solution for physical infrastructure development can be seen in the construction and operation system of the Hyangdeung landfill gas (LFG) generation clean development mechanism (CDM) project (Fig. 4.35). It is a kind of energy recovery system.

Fig. 4.33 Gabion walls to retain earth slopes on roadsides, Seoraksan National Park, Korea

In Fig. 4.35, the roles of the actors of the system are as follows:

- Gwangju Metropolitan City
  - General operation and management of Hyangdeung landfill site (Waste Facility Team, Climate Change Response Department, Environment and Ecology Bureau, Gwangju Metropolitan City);
  - Investment on facility building; and
  - Preparation and submission of documents for obtaining carbon emissions rights (CERs).

Fig. 4.34 Climate bike ride in the USA supports sustainable projects: Bike tour covered 292-miles in California in support of clean energy projects, clean transport development, and sustainable infrastructure. *Source* Climate Action News, 17 June, 2016

- The Ministry of Environment
  - General management of all landfill sites in the nation; and
  - Investment in facility building.
- Gwangju Metropolitan City Corporation
  - Construct the landfill site.
- Gwangju Environment Corporation
  - Entrusted by Gwangju city for the management of the landfill site;
  - Monitor electricity generation from collected methane for CERs; and
  - Select services company for environmental impact assessment.
- Resident (Citizens)
  - Form a consultative group (of 10 residents from three counties);
    - Support project for citizens residing in nearby affected areas;
    - Join selection process for a professional research institute for environmental impact assessment;
    - Recommend citizen monitoring agents (monitoring for entry of inappropriate waste, and for proper treatment process, etc.); and
    - Discuss identification of nearby affected areas.

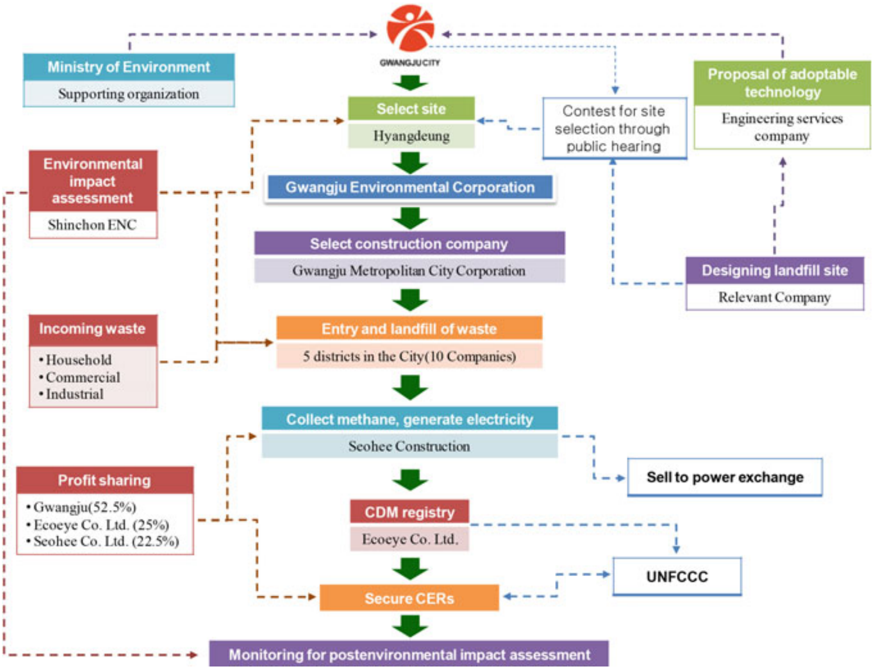


Fig. 4.35 Construction and intelligent operation system of Hyangdeung landfill site, Gwangju, Korea

Note: Raised $1,660USD in 2013 for the support to citizens in the affected areas

- Technology services company (Seohee Construction)
  - LFG management
    Note: Management transferred to Panax Energy Co. Ltd. since January 2014.
- Environmental impact assessment (Shinchon ENC)
  - Assessment entrusted by Gwangju Environment Corporation
    Note: Services company is selected every year through public bidding
- CDM agency company (ECOEYE, Co. Ltd.)
  - Documentation and application for the verification as a CDM project
    Note: Gwangju Metropolitan city's sanitary landfill LFG power plant CDM project was registered to UNFCCC in May 2011
- Sales of electricity (Seohee Construction)
  - Sell electricity to Korea Electric Power Corporation
    Note: Management transferred to Panax Energy Co. Ltd. since January 2014

- UNFCCC
  - CDM certification; and
  - CERs insurance.

4.6 Low-Carbon Economic Development: Economic Aspect of Climate Smart City

Local economic development is a bottom-up approach to creating wealth and jobs (UCLG 2015).

The involvement and leadership of local and regional governments (LRGs) in planning, implementing, and coordinating strategies for low-carbon economic development are crucial to promoting local economic development.

The strategies for green urban development and low-carbon economy which are the aim of climate smart city can add much economic value to cities. This value can stimulate investments without generating environmental and social impacts, job creation, and income generation. Low-carbon industries grow fast and jobs pay more, so supporting low-carbon green economy which attracts young people.

Low-carbon economic activities are taking place in a primary urban context. Cities provide opportunities for actors of formal and informal economy to integrate climate change issues with local economic development planning processes.

Low-carbon production and consumption is enabled through climate resilient and low-carbon urban development and management, which are critical to Low-Carbon Development Strategies (LCDS).

True low-carbon economic development can be achieved only when we can guarantee a carbon-free society and connectivity of urban systems. Science and technology must be linked to local knowledge and strategies for the connected smart cities with IoT should be implemented.

Agencies or offices for low-carbon economic development, launched at the initiative of the city government actors, play a key role in mapping the assets of all stakeholders, and in the partnership scheme.

Low-carbon economic development is a policy, planning, and governance process that includes public–private partnership, aimed at generating wealth from local, regional, and national territories to create quality jobs and improve the quality of life of the inhabitants, as well as the competitiveness of the urban economy.

A low emission development strategy is the key for low-carbon economic development. Low emission development tools in cities can be summarized as follows:

- Participation of NGOs;
- Public-private partnership (P3s);
- Climate change integration initiatives, programs, and projects;
- Global partnerships;

- Clusters for low-carbon technology;
- UNEP Technology Facilitation Mechanism and technology transfer;
- R&D action plan.

Low emission development is not weakening local economic development. It provides the opportunity to strengthen the capacities of citizens and local governments to respond to climate change for economic benefits.

Very recently, the Ministry of Agriculture, Food and Rural Affairs of Korea announced the expansion of “ICT-based Smart Farm” for the 6th industry.

The 6th industry is the IoT and big data-based industry which creates added value by linking production of goods and services in the primary industry (1), processing of the products for the secondary industry (2), and marketing and tourism for the tertiary industry (3) (Fig. 4.36).

The recently proposed “The EU-Korean Platform on Green Urban Development and Low-Carbon Economy” shall be not only an information sharing platform but ultimately also play a role as a facilitator for the development and implementation of the potential low-carbon economic cooperation projects identified by EU and Korean stakeholders (EU Delegation in Seoul 2016).

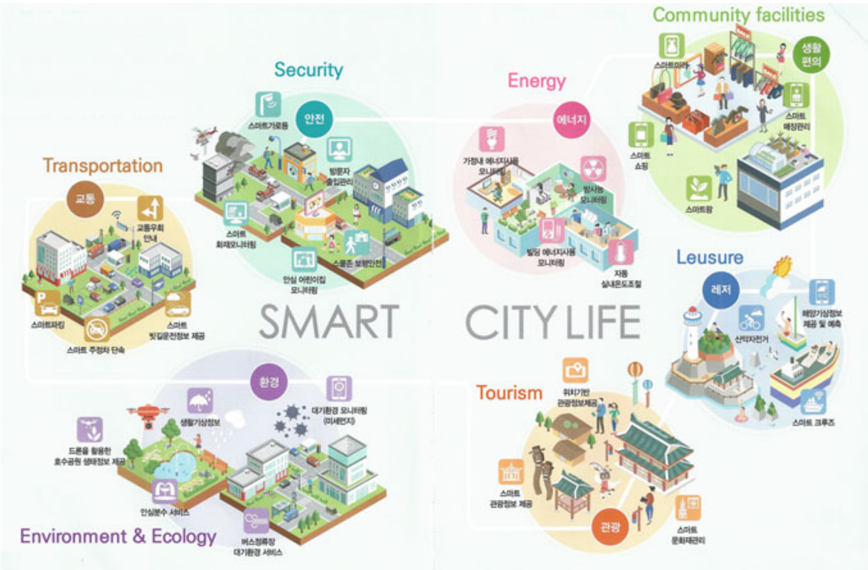


Fig. 4.36 Smart city life which reshapes the future of people, cities, and business: a virtual platform. *Source* NIPA, SMART CITY 2016, pp. 4–5

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Chapter 5
Urban CDM-Based Approach: Urban Carbon Financing

Abstract This chapter takes a look at Urban CDM-based financing and carbon financing banking system as a carbon governance approach. It compares the theoretical underpinnings, methods, tools, and market opportunities between the conventional CDM and an innovative urban-based CDM methodology. The testing of selected Urban CDM principles has shown the possibility of very significant and commercially viable opportunities for GHG reduction at the city-scale. However, numerous barriers are currently hindering the adoption of the Urban CDM, many of which have to be scientifically evidenced according to the new CDM rules and regulations. To facilitate the introduction and implementation of an Urban CDM frameworks, Urban CDM methodologies, and tools, climate smart city activities could include not only technical additionality but also non-technical additionalities such as policies and planning related to large climate change mitigation and adaptation potential. New market mechanisms including voluntary carbon markets discussed in the Paris Climate Change Agreement and emission trading system (ETS) shall be further explored for Urban CDM and to sell or trade carbon emission rights (CERs) derived from climate smart city activities. Carbon banking system is one option for Urban CDM which enables GHG emissions reduction to be compensated in the form of green cards. This system has been recognized by the World Bank and NYU Wagner and Center for an Urban Future as an urban innovation initiative.

Keywords Urban CDM model · Urban carbon financing · Expanded program of activities (PoA) · CERs · Executive board · Validation project document · Baseline scenario · Cross-sectored program of activities UNFCCC · Carbon financing banking system · Carbon points · Urban innovation initiative

World leaders, as well as heads of cities and corporations, have issued a joint statement urging governments and business to set up carbon markets and carbon emissions tax ahead of climate talks in Paris in December 2015.

The call to price carbon came from the Carbon Pricing Panel, a group convened by World Bank Group President Jim Yong Kim and IMF Managing Director Christine Lagarde.

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DOI 10.1007/978-3-319-59618-1_5

French President François Hollande said: "If we really want to send market signals to enable enterprises to make their decisions under optimal economic conditions, which may be optimal ecological conditions, then the issue of carbon prices inevitably arises as it is the most tangible signal that can be sent to all economic actors … I am aware of the fears created by this notion of carbon pricing, particularly among the most carbon-intensive industries, which have concerns, and rightly so, over their competitiveness. We must therefore act with resolve. Countries, big countries such as China, are already setting carbon prices. Europe already has a carbon market."

Existing examples of carbon financing method include Clean Development Mechanism (CDM), Nationally Appropriate Mitigation Action (NAMA), Expanded program of activities (PoA), Emission Trading Scheme (ETS), Carbon Bond, and Carbon Banking System.

Urban CDM (U-CDM) coined by the author is one of new market mechanisms. The CDM adopted by the United Nations enables cities in developing countries to carry out sustainable development through receiving foreign investment in eco-friendly technologies. It is a mechanism to promote the adoption of low-carbon green technology through cooperation between cities in both developed and developing countries, based on a carbon financing scheme.

It is now recognized that city is the main cause of global warming. However, at present less than 1% of carbon is credited with carbon emission rights by greenhouse gas reduction activities in cities. This is the principal reason why reform of existing CDM is needed in this stage.

The author has developed an Urban CDM model as a comprehensive carbon-centered (3Cs) approach specifically targeted for cities in particular to climate smart city planning.

5.1 Concept of Urban CDM

ICT and green development are expensive. Urban CDM can pay for this.

Urban CDM could be a form of responsible financial investment. An Urban CDM platform can be built for policy, planning, governance, and technical additionality with ICT and smart technologies. It can be a package CDM or an expanded PoA CDM.

Urban CDM is the name given to the belief that the mitigation of the GHG emissions must be seen in the context of urban green development in a holistic manner and that economic incentives should play a key role, especially in cities of developing countries. Urban CDM is a mechanism which gives financing incentives and may provide certified emission reductions (CERs) as much as certified amount of emission reduction compared with baseline emissions at the city-scale.

Urban CDM approach to respond to climate change incorporates GHG reduction activities into low-carbon green city development goals and planning framework described in the previous chapters. It is not mandatory yet.

Table 5.1 Comparison of conventional CDM and innovative CDM methodologies

	Conventional methodology	Innovation methodology
Theoretical underpinnings	Isolated stand-alone view	Holistic, integrated, smart view
Context	Singular project development framework	Urban planning and development framework
Scope	Technology and product-oriented system	Extension of CDM to include policy, planning, and governance
Methods	Use of existing methods approved by UNFCCC	Combination of existing and new methods
Baseline scenario	Constant level of emission	Considerations for population and economic growth, etc.
Measurement	Quantification	Quantification and estimation
Certification	Tradable certified emission reduction (CERs) at single CDM project level	Aggregated tradable certified emission reduction (CERs) at the city-scale and between cities
Market	Carbon markets implemented at the national or regional level	Carbon markets to be implemented at the city level
Tool for urban planning	Tool for disconnected infrastructure	Tool for 3Cs (carbon-centered comprehensive) planning, Land-use-based mechanism
Effectiveness analysis	Project cost-benefit analysis	Carbon balance sheet analysis

The approval of CDM Executive Board in the form of expanded program of activities (PoA) with appropriate aggregation levels is subject to further discussion with United Nations Framework Convention on Climate Change (UNFCCC) in order to address global warming.

The objective of the Urban CDM is to support cities in increasing their access to carbon finance, through the CDM. In so doing, it will contribute to the broader objective of global climate change mitigation, by reducing GHG emissions from cities.

The Urban CDM activities in the form of new market mechanism are compared with the conventional CDM in Table 5.1.

Establishing the Urban CDM should be one element of a much broader climate change policy framework. Main features of the Urban CDM can be summarized as follows:

- Urban CDM can be a mechanism which gives financial incentives and provides CERs as much as certified amount of emission reduction at the city-scale compared with baseline emissions at the city-scale;
- These CERs can be traded and sold and used by industrialized countries to meet a part of their emission reductions targets under the Kyoto Protocol (Table 5.2);
- For the developing countries, Urban CDM can include intercity CERs trading and purchase of CERs using the UN Green Climate Fund (Table 5.3);

Table 5.2 Difference between conventional CDM and Urban CDM methodologies

	Joint implementation (JI)	Clean development mechanism (CDM)
Carbon financing under the Kyoto Protocol (conventional CDM)	**Annex 1 parties** **Projects** that reduce GHG emissions or enhance GHG removal earn tradable emission reduction units (ERU)	**Non-Annex 1 parties** **Projects** that assist the host country in achieving sustainable development while reducing GHG emissions or enhance GHG removal earn tradable certified emission reductions (CERs)
Carbon financing under the Urban CDM	**Annex 1 parties** **Multiple programs** that reduce GHG emissions or enhance GHG removal earn tradable emission reduction units (ERU) **at the city-scale**	**Non-Annex 1 parties** **Multiple programs** that assist the host country in achieving sustainable development while reducing GHG emissions or enhance GHG removal earn tradable certified emission reductions (CERs) **at the city-scale**

Table 5.3 Comparison between the Urban CDM approach, a city-wide approach to carbon finance and an economic approach to low-carbon cities

Framework	A city-wide approach to carbon finance	An economic approach to low-carbon cities	An Urban CDM approach to climate change
Author(s)	The World Bank	Center for Low-Carbon Futures, Center for Climate Change, Economics and Policy	Gwangju Metropolitan city, UNEP, KEI, UEA
Theoretical underpinnings	A city-wide carbon finance view: a generic program design	A city-scale Mini-Stern view: an investment program design	A city-wide CDM holistic view: a carbon-centered planning policy and development program design
Approach	To expand the scope of CDM PoA by including multiple sectors and methodologies: simple aggregation of existing CDM methodologies	To develop a robust model for assessing the costs and benefits of different levels of decarbonization at the city-scale: realistic projections of the energy, cost, and carbon savings emerging from different measures	To expand the scope of CDM PoA by including urban planning and policy tools and methodologies: comprehensive aggregation of existing and newly proposed CDM methodologies including cross-sectoral aggregation

(continued)

Table 5.3 (continued)

Framework	A city-wide approach to carbon finance	An economic approach to low-carbon cities	An Urban CDM approach to climate change
Tools and models	Use of tools for cities to take comprehensive and effective action to improve quality of life which are provided by existing sustainable development initiatives such as the global city indication program	Use of methods which evaluate the cost and carbon effectiveness of a wide range of existing low-carbon options that could be applied in households, industry, commerce, and transport	Extensive systematic use of carbon-smart urban environmental planning policy tools and development mechanisms developed by existing initiatives for prediction, estimation or calculation, and measurement of GHG emission reductions for the whole city
The case	Amman City, Jorolan	Leeds City Region, UK	Gwangju Metropolitan City, Korea
Implications for the economy and employment	The city-wide carbon financing would be available for the mandatory and voluntary carbon markets. This approach can be used to access funds from various sources	Investments in decarbonization at the city-scale would also protect competitiveness, improve energy security, reduce fuel poverty, and improve public health	Carbon-smart urban planning and development plans would provide a significant opportunity to reduce carbon footprints from which cities can be financially benefitted under the mandatory and voluntary carbon markets

- Rationale behind Urban CDM
  - A tool for carbon financing: market-based mechanism;
  - A tool for low-carbon green city: urban metabolism-based mechanism;
  - A tool for a 3Cs planning: land-use-based mechanism.
- Therefore, it can be used as a political carbon decision support system both for green growth and green economy and for urban planning and management
- This tool has the public and private nature to incorporate the CDM into the planning.

5.2 The Need for the Urban CDM

A specifically targeted Urban CDM is needed because, currently, less than 1 per cent of projects registered under the CDM are credited to cities. Sixty percentage of emissions is natural fit establishing urban carbon markets, and emission trading schemes will therefore open up a big new field for carbon emission reduction. This field can deliver multiple benefits for cities, enabling them to (1) meeting GHG reduction goal and targets, while at the same time (2) growing the economy, (3) creating jobs, (4) reducing exposure to increasing energy costs, and (5) securing competitive edge in the global marketplace.

In short, local governments can use the Urban CDM to finance carbon reduction projects, and to support political carbon decision making and climate smart city planning and management.

5.3 The Challenges of Using the Urban CDM

A carbon reduction project can only become a registered and implemented CDM project when it is proved that the carbon reduction would not have happened anyway (establishing additionality). This is done by using an Executive Board (EB) approved CDM methodology through which a baseline is set, and emissions reductions for the future are estimated. The case must then be validated by a third-party agency, called a designated operational entity (DOE). This party checks whether the project results in long-term emissions reductions which are real and measurable. Finally, the Executive Board approves (resisters) or disapproves the project. If the project is registered, credits or certified emission reductions (CERs) are issued. One of main challenges or risks of Urban CDM is how to establish additionality in a aggregated way.

5.4 The Urban CDM Methodology

In accordance with the principles and requirements of the Kyoto Protocol Mechanisms, Urban CDM methodologies should provide an organized approach for encouraging cities in developing countries to contribute to emission reduction efforts, and helping cities in developed countries meet their emission targets at the city-scale. In other words, the Urban CDM is a CDM methodology focused on urban areas.

The Urban CDM approach is different from a "city-wide approach to carbon finance" and an "economic approach to low-carbon cities." Table 5.3 shows a comparison between these three approaches.

As shown in Table 5.3, the proposed Urban CDM approach is compared with selected approaches to GHG reduction measures and carbon finance at the city-scale. Here, the economic approach to low-carbon cities is for a pure cost-benefit analysis to prioritize various green growth investment options.

The main distinction between Urban CDM and city-wide approach to carbon finance is whether it includes development of new urban-specific CDM methodologies. Depending on the characteristics of targeted markets (mandatory or voluntary markets) and projected benefits/costs, we may prefer an approach to another contained in Table 5.3.

Main challenges of the Urban CDM methodology can be summarized as follows:

- Implementation gaps should be taken into account.
- Investment analysis together with cost/benefit analysis for reduction options should be conducted.
- Many activities require the development of new methodologies for Urban CDM and have to be registered in the UNFCCC Executive Board of CDM.
- Voluntary carbon markets also shall be explored for the Urban CDM.
- Cities participating in the Urban CDM activities will need capacity and the data revolution.

5.5 Steps for Urban CDM

There are basically two stages of verifying emission reductions under the Kyoto Protocol Mechanisms. These stages are project development and project operation, as illustrated in the table underneath (Table 5.4):

Based on the two stages mentioned above, the procedure for using an Urban CDM approach can be suggested as follows:

Step 1	Establish urban boundary (on-site and off-site)
Step 2	Identify sources of GHG emission and prepare GHG emission inventory report: Detailed steps and tools should be developed to complete a greenhouse gas inventory. The most important and time-consuming step in inventory development is the identification and quantification of emissions sources, as a lot of data are needed
Step 3	Formulate baseline scenario
Step 4	Identify the best available cross-sectoral program of activities for GHG reduction for the whole city: The program of activities for built form and urban infrastructure should be selected
Step 5	Deploy selected program of activities in the master plan at the city-scale
Step 6	Formulate planning policy and development mechanisms for implementation of the selected program of activities
Step 7	Quantify emission reductions of each program of activities: Measure or estimate
Step 8	Aggregate emission reductions of each program of activities for the whole city
Step 9	Develop a “program of activities design document (PDD)”
Step 10	Estimate the aggregated GHG emission reduction scenario of planned program of activities
Step 11	Implement and monitor the activities
Step 12	Evaluate carbon effectiveness of existing CDM methodologies and newly proposed CDM methodologies: Economic feasibility analysis
Step 13	Validate or verify ER benefit from Urban CDM

Tools for each step will be described more in detail in the following section. The procedures for project design document (PDD) are shown in Table 5.5.

Table 5.4 Stages of verifying emission reductions under the Kyoto protocol mechanisms

	Project developer	Hosting country	Accredited independent entity	JISC
Project development	• Provides project idea and design	• Approves project design	• Appraises project design and reports to JISC	• Approves project design
Project operation	• Operates projects • Monitors emission reductions	• Issue • ERUs (after approval of verified emission reductions)	• Verifies emission reductions and reports to JISC	• Approves emission reductions, enabling hosting country to issue ERUs

Table 5.5 Procedures for project design document (PDD)

Steps and activities of conventional CDM		Steps and activities of Urban CDM	
Step	Activities	Step	Activities
Step 1: Using existing single project methodology or development of single project methodology	1. Project overview 2. Baseline methodology 3. Set duration of project implementation and of CERs issuance 4. Monitoring methodology 5. Calculation of GHG emissions 6. Environmental effect evaluation 7. Comments from stakeholders	Step 1: Development and registration of new methodology for Urban CDM	Standardization of Urban CDM methodology and registration to UNFCCC as a CDM project (This requires development or aggregation of methodologies available to use at a city-scale.)
		Step 2: Planning	1. Formation of project team
			2. Capacity building/training for cities
		Step 3: Project design (being planned)	3. Identification of participating cities
			4. Establishment of baseline scenario
			5. Calculation of the emissions expected without PoAs
			6. Development of multiple PoAs
			7. Formulation of policy actions and development plans at the city-scale
			8. Preparation of PoAs management plans
			9. Establishment of monitoring methodology to measure the actual level of emissions with PoAs
			10. Establishment of aggregation methodology
			11. Establishment of quantification and estimation methodology for cumulative volume of the emissions reduced with appropriate levels of aggregation
			12. Preparation of project design document (PDD)

(continued)

Table 5.5 (continued)

Steps and activities of conventional CDM		Steps and activities of Urban CDM	
Step	Activities	Step	Activities
	Note: Procedure for CDM project using existing methodology		Note: Procedure for registration of new methodology
Step 2: CDM national approval and validation	1. Approval and validation by DNA and DOE	Step 4: National approval	13. Approval of PDD by designated national authority (DNA)
		Step 5: Validation	14. Validation of designated operation entity (DOE)
			15. Request for registration
Step 3: CDM registration	2. Apply for registration of CDM project to CDM Executive Board (CDM EB) 3. Registration fee for CDM project varies according to projected average annual emission reductions	Step 6: Registration	16. Registration of PDD by CDM Executive Board (CDM EB)
Step 4: Financial resources		Step 7: Construction and operation	
Step 5: Monitoring	4. MRV (monitoring, report, verification) by CDM project implementing body or the third party (for certification) • Submit monitoring report to CDM Designated Operation Entity (DOE)	Step 8: Monitoring	17. Monitoring of GHG reduction activities
			18. Aggregation of monitoring results of PoAs
			19. Quantification or estimation of the cumulative volume of the emissions reduced, compared with the BAU baseline level of emissions
			20. Preparation of monitoring report (MR)

(continued)

Table 5.5 (continued)

Steps and activities of conventional CDM		Steps and activities of Urban CDM	
Step	Activities	Step	Activities
Step 6: Verification and certification	5. The purpose of verification of CDM project is to identify achievements of actual GHG emissions reduction 6. CDM designated operation entity (DOE) carries out evaluation of performance outcomes such as consistence between project design document and monitoring report, method used for monitoring, identification of GHG reduction amounts, project results, etc. 7. CDM DOE requests for issuance of certified emission reductions (CERs) in accordance with certified amount of GHG reductions 8. CDM DOE documents a certification report based on the submitted verification report	Step 9: Verification and certification	21. Verification/certification of monitoring report by DOE and request for issuance
Step 7: Issuance of CERs	9. CDM EB receives MRV report and issues CERs unless objections are made in 15 days	Step 10: Issuance of CERs	22. Issuance of CERs by CDM EB
		Step 11: Publication	23. Publication of the report on Urban CDM joint program
		Step 12: Post-PoA management and evaluation	24. Selling and trading of CERs
			25. Post-PoA management
			26. Periodic evaluation
			27. Final project reporting

Table 5.6 Expanded carbon financing under the Kyoto protocol mechanism

Joint implementation (JI)	Clean development mechanism	Emissions trading
Annex I Parties Projects that reduce GHG emissions or enhance GHG removal to earn tradable emission reduction units (ERU)	**Non-Annex I Parties** Projects that assist the host country in achieving sustainable development while reducing GHG emissions or enhancing GHG removal to earn tradable certified emission reductions (CERs)	**Between Annex I Parties**

Table 5.7 Expanded carbon financing under the Urban CDM mechanism

Joint implementation (JI)	Clean development mechanism	Emissions trading
Annex I Parties Multiple programs that reduce GHG emissions or enhance GHG removal earn tradable emission reduction units (ERU) at the city-scale	**Non-Annex I Parties** Multiple programs that assist the host country in achieving sustainable development while reducing GHG emissions or enhancing GHG removal to earn tradable certified emission reductions (CERs) at the city-scale	**Between cities in Annex I Parties**

5.6 Tools for Urban CDM

To achieve the goals of the Urban CDM, tools for the new market mechanism may be developed for the expanded carbon financing under the Urban CDM mechanism (Tables 5.6 and 5.7) and are expected to be empirically tested in a practical manner for a climate solution.

5.6.1 Establish Urban Boundary (On-Site and Off-Site)

Setting the boundaries of urban system is based on administrative areas or based on the whole big city area.

The boundary defined for Urban CDM determines what is included and excluded from the identification of emission sources.

An organizational boundary refers to the emissions directly under local government control [e.g., public transport, owned and tenanted buildings, car fleet, owned land, and other facilities (e.g., visitor centers)]. A geopolitical boundary refers to the emissions within the territory where the local government has full jurisdictional authority.

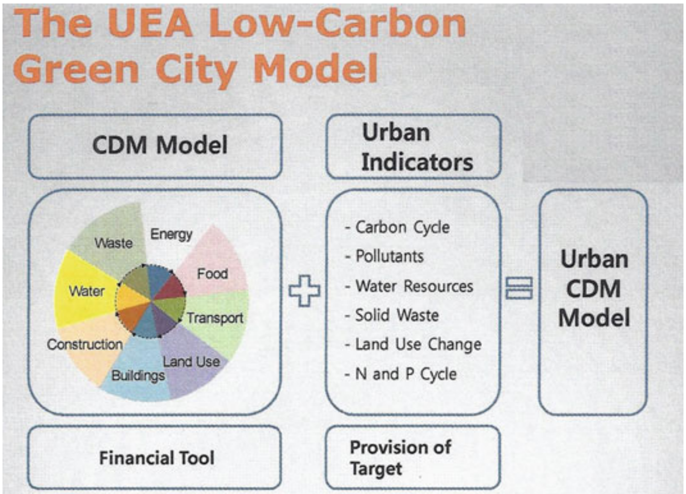


Fig. 5.1 Combination of CDM model with urban indicators for climate-resilient and low-carbon smart urban planning

When an integrated, system-based approach to CDM is used, the integrated boundary for the entire city can be developed synergistically as follows:

- Consider on-site and off-site sources of GHG emission.
- Replace the politically oriented hierarchy of planning units with nested units that are established at least in part to respect climate functions and follow natural boundaries.
- Attempt to overcome the fragmentation by encouraging new planning units, agencies, and methods that promote integrated decision making.
- Integrate residential, commercial, industrial, and public areas and connect them with alternative transportation means that people will drive cars to reach their destinations, generating GHG and traffic.
- Include some activities which may fall under the city's responsibility or regulation/support role but be physically located outside the city's geographical boundaries due to resource availability (e.g., for a wind farm) or site availability (e.g., waste treatment facility or landfill).
- Adopt a much longer and broader perspective that includes attention to off-site, cross-boundary, intergenerational, and cumulative effects.

5.6.2 Tools for Analysis of the Urban Carbon Cycle

The Urban CDM model is beyond the traditional CDM model. It is a low-carbon smart city model which combines urban indicators with the CDM model shown in Fig. 5.1.

The urban carbon cycle provides the important knowledge and information for the carbon overlay and carbon footprint.

Issues such as deforestation, reforestation, increasing or decreasing human or animal populations affect the carbon cycle that happens upon land.

Since it has taken decades for the carbon cycle to become out of balance, as a result of the release of greenhouse gases, it will also take decades for man to reverse the effects of global warming. This is assuming an earnest effort is made to reverse the effects.

The carbon overlay and carbon footprint can be used to assess the impacts of GHG reduction activities (PoA) on the carbon cycle for the entire city.

5.6.3 Tools for GHG Emissions Inventory and Reporting at the City-Scale

There are many standards, protocols, programs, catalogs, guidelines and initiatives which help GHG emissions inventory and reporting at the city-scale. They include:

- Global Protocol for Community-Scale GHG Emissions (GPC);
- 1996/2006 IPCC Guidelines for National GHG Inventories (IPCC Guidelines);
- International Local Government GHG Emissions Analysis Protocol (IEAP);
- International Standard for Determining GHG Emissions for Cities (ISDGC);
- Baseline Emissions Inventory/Monitoring Emissions Inventory Methodology (BEI/MEI);
- U.S. Community Protocol for Accounting and Reporting of GHG Emissions (USA Community Protocol);
- PAS 2070: Specification for the assessment of greenhouse gas emissions of a city GHG Protocol Corporate Standard.

Source: World Resources Institute, et al., Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC), Draft version 2.0-07/22/14, p. 120

5.6.3.1 Comparative Analysis of the GHG Inventory Tools

A low-carbon smart city development needs systematic planning and quantitative support.

The GHG inventory tools help cities identify the key drivers of emissions source to enable effective low-carbon actions. An inventory should strive to reach the following objectives:

a. To provide a baseline from which to assess the program's success;
b. To manage GHG risks;
c. To identify reduction opportunities, public reporting, and participation in voluntary/mandatory programs;
d. To participate in GHG markets; and
e. To provide information for recognition of early voluntary action.

While a large number of cities are measuring city-wide emissions, the methodologies that they follow vary. The most common methodologies are based on the IPCC's Guidelines for National Greenhouse Gas Inventories. The lack of standardization in city measurement makes comparability between cities difficult.

However, city governments now have access to a strong, clear methodology for measuring city-wide GHG emissions. On May 14, 2012, C_{40} and ICLEI (Local Governments for Sustainability) in collaboration with the World Resources Institute (WRI) and the Joint Work Program of the Cities Alliance between the World Bank Group, UN-Habitat, and UNEP announced the publication of the Global Protocol for Community-scale Greenhouse Gas Emissions (GPC). The GPC provides a consistent and transparent system for cities to plan for and finance climate change action. It will allow cities who have followed the GPC guidance to compare their emissions to other cities.

It is important to note that the GPC provides enough flexibility for cities to develop their own methodologies for measuring city-wide GHG emissions.

For more information about the GPC, please contact GPC@C40.com.

The author conducted a comparative analysis of nine GHG cases (Table 5.8).

The findings of the comparative analysis inventory tools are as follows:

- The low-carbon livable city development needs systematic planning and quantitative data support.
- The GHG inventory tools help cities identify the key drivers of emissions sources to enable effective low-carbon actions.
- In case the data for the base year are not available, emissions are estimated using data from other years, applying appropriate methods such as averaging, interpolation, and extrapolation.
- By monitoring against the initial inventory, the tools demonstrate performance in a transparent and engaging manner for external stakeholders and the general public.
- The following methods are being used to calculate emissions:
  - Reductions compared to base year (e.g., 2005);
  - Reductions compared to baseline scenario (BAU).

Table 5.8 Comparative analysis of inventory tools

Category		Cases					International Standard				
		New York City	Melbourne City, Australia	Negombo city, Sri Lanka	Gwangju (Environmental Corporation)	Gwangju (GPD)	International Standard for Determining GHG Emissions for Cities (2010)	International Local Government GHG Emissions Analysis Protocol	Carbon Cities Climate Registry	GPC (2012)	Remarks
CURRENT STATUS REPORT	Sector	• Residential • Commercial • Industrial • Public • Public Transport • Other Transport	Standard Categories specified by the IPCC • Residential • Commercial • Waste • Freight Transport (road + rail) • Passenger Transport (road + rail) • Manufacturing • Water • Other	• To test the 2006 IPCC guidelines and the 2010 International Standard for Determining Greenhouse Gas Emissions for Cities	• Energy • Industrial Operation • AFOLU • Waste *Sorted by Direct/Indirect Emission Sources	<Developed> • Electricity • City Gas • Drinking Water <To be Developed> • Energy (Oil/Coal) • Waste • Industrial Operation • Agriculture/Forestry					
	Utilization	• Carbon Reduction Plan • Identification of Key Emission Factors • Identification of Trends • Environmental Impact Evaluation • Climate Change Policy	• An understanding of the contribution of each sector to the emission from community activities which is crucial to maximize the effectiveness of Zero Net strategies and supporting actions	• To assist the local government to formulate strategies to mitigate GHG emissions	• GHG Inventory that considers characteristics of local governments • GHG reduction policies for local governments • Basis for climate change response policies for local governments	• Development and spread of Climate Actions for GHG reduction in local governments					

(continued)

Table 5.8 (continued)

Category		Cases					International Standard				
Category		New York City	Melbourne City, Australia	Negombo city, Sri Lanka	Gwangju (Environmental Corporation)	Gwangju (GPD)	International Standard for Determining GHG Emissions for Cities (2010)	International Local Government GHG Emissions Analysis Protocol	Carbon Cities Climate Registry	GPC (2012)	Remarks
CURRENT STATUS REPORT	Purpose	• Quantification of GHG emissions from entire city	• To estimate community emissions for understanding the emissions associated with specific activities and to facilitate a greenhouse gas emission reduction policy.	• To use the GHG emissions inventory to identify voluntary actions that could contribute toward mitigation, which may result in some microclimatic effects as well.	• Accurate, Complete, and consistent GHG Inventory that considers characteristics of local governments, that will be a basis of climate change policies (e.g. GHG reduction policies)	• Understanding of GHG emissions in a city • Promoting GHG reduction policies • Universal utilization through distribution to international society					
	Emission by Category	• Direct Emissions – Vehicles – Buildings, Boilers, etc. • Indirect Emissions		• Use of the IPCC methods to identify four key sectors: Energy; Industrial Processes and Product Use; Agriculture, Forestry and other Land use; and Waste	• Direct Emissions – GHG caused by electricity use, industrial operation, AFOLU, and waste • Indirect Emissions – GHG caused by electricity, heat, and water, and by waste						

(continued)

Table 5.8 (continued)

Category		Cases					International Standard				
		New York City	Melbourne City, Australia	Negombo city, Sri Lanka	Gwangju (Environmental Corporation)	Gwangju (GPD)	International Standard for Determining GHG Emissions for Cities (2010)	International Local Government GHG Emissions Analysis Protocol	Carbon Cities Climate Registry	GPC (2012)	Remarks
CURRENT STATUS REPORT	Base Year			• The base year for the first inventory runs from 1 January, 2010 to 31 December, 2010	• The base year is 2005	• The base year is 2001–2012					
CURRENT STATUS REPORT	Emission by Sector	• Residential: use of electricity, natural gas, oil, and steam • Commercial: use of electricity, natural gas, oil, and steam • Institutes: use of electricity, natural gas, oil, and steam • Industrial: use of electricity, natural gas, oil, and steam • Transportation: use of gasoline and diesel • Waste: residence, business, construction and demolition • Aviation: gasoline loaded onto planes at LaGuardia, JFK Airport • Overwater transport: fuel loaded onto entering/departing ships	Top-Down Approach <Step 1> • "Standard categories specified by the International Panel on Climate Change (IPCC)", based on the categories of sectors adopted by the status report at National/State level. <Step 2> • Disaggregation of the end-use sector to understand the emissions associated with specific activities and to facilitate a greenhouse gas emission reduction policy by assigning a percentage to City of Melbourne based on the most appropriate indicator. <Step 3> • Normalizations and projections		<Direct Emissions> • Energy: Cogeneration/Heat Production Facility – Estimation of GHG emission at other sectors – Manufacturing and construction (major consumer of city gas, and GHG emissions) – Transport: road (98.8%), private flight, rail, overwater • Industrial Operation – Guideline from National Env. Mgt. Corp. (Article 26) • AFOLU – Livestock, land, comprehensive emission sources (Non-Co2 emissions) • Waste – Landfill, biological treatment, incineration, wastewater treatment <Indirect Emissions> • Electricity • Heat • Drinking Water • Waste	Top-Down Approach • Step1: GHG emissions caused by electricity, city gas, and drinking water use via analysis at household, commercial, industrial, public sectors. • Step2: GHG emissions analysis at energy (oil, coal), industrial operation, waste, agriculture & forestry sectors					

(continued)

Table 5.8 (continued)

Category		Cases					International Standard				
Category		New York City	Melbourne City, Australia	Negombo city, Sri Lanka	Gwangju (Environmental Corporation)	Gwangju (GPD)	International Standard for Determining GHG Emissions for Cities (2010)	International Local Government GHG Emissions Analysis Protocol	Carbon Cities Climate Registry	GPC (2012)	Remarks
CURRENT STATUS	Residential	• Step 1: Hire Consultants • Step 2: Review by ICLEI, NYC civil officials • Collect raw data and categorize into Residential/Commercial/Public/Industrial Sectors		(1)Energy (2)Agriculture, Forestry and Other Land Use (3)Waste (Refer to p.10 for details of data collection and calculation of GHG emissions)	• "Guideline of GHG Emissions Estimation for Local Government (Sep. 2010)", drafted based on 2006 IPCC Guidelines • Data from 2000 to 2008 is available considering national statistics' condition	<Developed> • Data collected by Energy Supply Corporation - KEPCO (2002–2012) - City Gas Corporation (2004–2012) - Waterworks Corporation (2001–2012) <To be developed> • Energy(Oil, Coal) • Waste • Industrial Operation • Agriculture/Forestry					
	Commercial										
	Public										
	Industrial										
REPORT	Strong Points					• Data availability, collected by each corporation. Available to check and project GHG emissions of the whole city					
	Weak Points					• By now, GHG reductions by Climate Actions are not available to check (to be improved)					

- It is important to note that most inventories include emissions caused by human; i.e., it does not contain the records of natural source of emissions which are beyond human interventions. This has been done because the inventory is supposed to assist the local government to formulate strategies to mitigate GHG emissions; mitigating natural sources of GHG is not in their hands.
- Inventory tools are subject to changing depending on how they are used such as;
  - For the planning of low-carbon smart city
  - For being credited with Urban CDM.

5.6.3.2 Data Collection and Calculation of GHG Emissions

GHG emissions data collection and calculation method have to adopt an interdisciplinary approach to information, databases, and database management software. There is a need for big data which refers to collection of data that are so enormous in size, so varied in content, and so fast to accumulate that they are difficult to store and analyze using traditional approaches.

They have to entail a greater scale of information gathering and more integration of information providers, both amateur and expert.

If local data are not available for a city, international, regional, and/or national factors are available through resources provided by UNFCCC.

5.6.3.3 Formulate Baseline Scenario

Baseline scenario is defined as a scenario that describes future greenhouse gas emissions level in the absence of future additional efforts and policies. In general, GHG gas emissions baseline scenario models are available as follows:

(1) Bottom-up models which provide a fairly detailed representation of the energy system: breakdown of energy system (e.g., New York, USA);
(2) Simple extrapolation top-down models (e.g., Melbourne, Australia);
(3) More complete representation of macro-economic trends and feedbacks;
(4) Hybrid models which can combine elements of top-down and bottom-up models.

The author has done the comparative analysis of baseline scenario tools for six cases (Table 5.9). Main findings of the simplified comparative analysis on GHG emissions baseline scenarios can be summarized as follows:

(1) For cities in all developed and developing countries (irrespective of the type of pledge), baseline scenarios are valuable for urban planning purpose, including to support the design of energy and climate change policy and investment decisions.

Table 5.9 Comparative analysis of baseline scenario tools

		Cases					International standard	
Category		New York City, USA	Melbourne City, Australia	Negombo City, Sri Lanka	Gwangju (Environmental Corporation)	Gwangju (GPD)	National GHG emissions baseline scenarios	Remarks
Projection	Assumption and sensitivity analysis	• Bottom-up model which provides a fairly detailed representation of the energy system	• Simple extrapolation top-down models at the different sectors	Projections were not conducted	• "Guideline of GHG Emissions Estimation for Local Government (Sep. 2010)," drafted based on 2006 IPCC Guidelines – GHG-CAPSS • Data from 2000 to 2008 is available considering national statistics' condition	• Originally developed estimation equation-Monitoring data collected by each corporation – Equation are developed after data collection		
Projection	Assumption and sensitivity analysis				<Assumption> • In case of BAU, Gwangju aims 2020 for target year <Items to be considered> • Population growth • Increase in households • Economy size • Economically active population • Gross regional domestic product • Number of vehicle registration	<Developed> • Consumption of electricity, city gas, drinking water in 2001–2012, and – Average energy price – Energy distribution rate – Population – Industrial product index – Temperature – Rainfall – Cooling degree days – Heating degree days – Seasonal factors – Social phenomena are taken into		

(continued)

Table 5.9 (continued)

		Cases					International standard	
						consideration for estimation <To be developed> In addition to already developed factors, additional factors are under development		
Projection	Data management				Data managed by • Nation • Local Govt. • Supply Org.	Data managed by • Nation • Local Govt. • Supply Org.		
	Transparency (International peer review) Diversity (Stakeholders)							
	Resource need							
	Form of sophistication							
	Anticipated accuracy							
	Inherent uncertainty							

Note Empty boxes indicate either “Not Available” or “Not Applicable”
Sources 1. City of New York, Inventory of New York city: Greenhouse gas emissions, April 2007
2. City of Melbourn, Zero Net Emissions By 2020: Update 2008, April 2009

(2) There is currently no international guidance on how to develop baseline emission scenarios for cities, and there is no explicit requirement for cities in all developed and developing countries to report emission baselines.
(3) The selected baseline setting methods in this analysis differ widely in their sources of GHG emissions.

5.6.3.4 Identify the Best Available Cross-Sectoral Program of Activities (PoA) for GHG Reduction for the Whole City

This step identifies what sectors (and related programs) are responsible for emitting most GHGs, as illustrated underneath (Fig. 5.2):

Table 5.10 shows an interaction matrix between GHG reduction activities and land-use types. The matrix is used to incorporate a list of GHG reduction activities in addition to land-use types. A GHG reduction activity is identified at the interactions of the identification matrix between an activity and a land-use type.

5.6.3.5 Select the Program of Activities for the Urban CDM

Existing CDM project of activities can be used to select the program of activities for the Urban CDM in terms of built form and urban infrastructure.

Table 5.11 shows how to evaluate existing methods for CDM project of activities. The selection is made using nine criteria in Table 5.11.

Examples of carbon reduction projects of activities without methodologies approved by UNFCCC in urban areas are shown in Table 5.12.

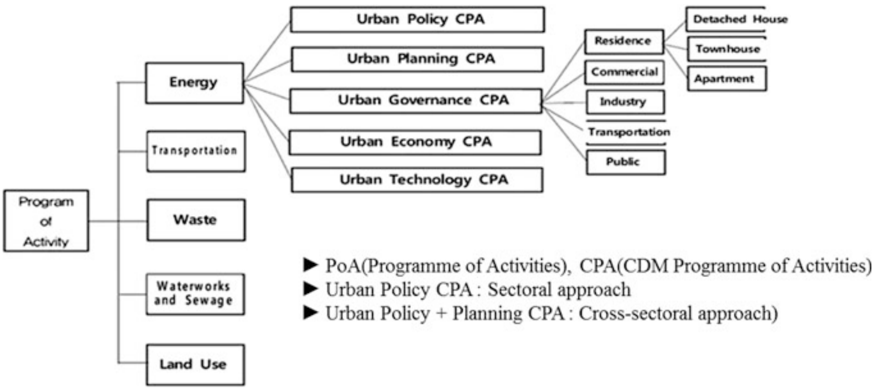


Fig. 5.2 Identification diagram for cross-sectoral program of activities

Table 5.10 Interaction matrix between GHG reduction activities and land-use types

Area		Residential	Commercial	Private buildings	Public buildings	Urban infra			Industry	Agriculture	Forest	…
Sector						Water works	Sewage	Landfill				
Energy	Renewable (biomass)											
	Distribution											
	Energy saving (at home and at work)	Optimize energy and resource use	Use of an area energy network for the efficient use of energy									
Solid waste management	Collection											
	Management (Heat recovery)											
Sewage	Treatment											
	Reuse											
	Heat recovery											
Waterworks	Improvement of water supply											
	Water saving											
Rainwater	Collection	Rainwater penetration and storage rate (↑) Rainwater evaporation rate (↓) Rate of direct runoff of rainwater (↓)										
	Use											
	Rainwater											
Lighting	Replacement (including LED)											
	Newly set											
New public transport												

(continued)

Table 5.10 (continued)

Area		Residential	Commercial	Private buildings	Public buildings	Urban infra			Industry	Agriculture	Forest	…
Sector						Water works	Sewage	Landfill				
Land use		Compact city: land form										
Space planning		High-density development (population density)										
Designing complex	Ventilation											
	Orientation											
	Landscaping											
	Passive design											
Wetland restoration	Marsh											
	Swamp											
Urban form	Horizontal city											
	Vertical city											
Open space (ratio of open space)												
Building												
Low-carbon lifestyles												
Carbon-oriented urban regeneration												
Low-carbon business practices												
Use of natural climate control systems												
Smart grid system (use of an area energy network for the efficient use of energy)												
Composting												

Table 5.11 Evaluation of methods for CDM project of activities

Criteria	Components of criteria	Methods for CDM project of activities				
		1	2	···	19	20
Set boundaries						
Possibility of providing additionality						
Existence of approved methodology						
Calculation of emissions						
Monitoring						
Resource requirements						
Applicability						
Flexibility						
GHG treatment technology	GHG emission reduction					
	CCS					
	CCU					
	Carbon offset					

Note L Substantial compliance, low resource needs, or high applicability, low flexibility limitations, *S* Partial compliance, moderate resource needs or moderate limitations; *N* No or minimal compliance, high resource needs

Although the development of the methodologies is still underway, the following conclusions can be drawn:

- Firstly, enough pre-evaluation needs to be conducted that consider characteristics of each sector of CDM in order to program "Cross-sectoral CDM," including emission reduction and carbon offset sectors (e.g., restoration of wetland).
- Secondly, the influence of carbon sequestration rates and GHG effects in the urban land use is not directly relevant to individual emission reduction products. Therefore, on/off-site carbon balance analysis or urban carbon-budget analysis will be necessary to assess the impact of Urban CDM on global warming potential (GWP). It is due to the difference in calculated amount of emission and carbon balance sheet analysis conducted at a city level.

5.6.3.6 Deploy Selected Program of Activities in the Master Plan at the City-Scale

A total urban system model is very useful to understand inter-relationships between energy suppliers and consumers, and between built form, urban infrastructure, and CDM mechanism for them, in a total holistic manner (Fig. 5.3a–c).

Table 5.12 Carbon reduction projects of activities without methodologies approved by UNFCCC in urban areas

Field		Content	Feature	Dwelling	Commerce/Public	Industry	Traffic
Building		Passive house	Urban planning Urban technology	**X**	**X**		
Water		Rain water recycle (Plan the decentralized rainwater management system in the aspect of whole town)	Urban planning	**X**	**X**		**X**
Land use	Density	Compact city policy		**X**			
		Considering the accessibility by compressive development of complex and intensive spatial structure	Urban planning	**X**	**X**		
	Create the urban green and swamp	Create the urban park and street trees	Urban planning	**X**	**X**		
		Create the urban swamp, greening the rooftop, urban agriculture, etc.	Urban planning	**X**	**X**		
	Nature adaptation arrangement	Building arrangement considering sunshine and geographical features	Urban planning	**X**	**X**		
		Building arrangement considering wind pass and atmospheric circulation					
	Traffic	Install the cycle lane and exclusive pedestrian road	Urban planning	**X**	**X**		**X**
		Introduce the low-carbon transit					
Energy	Demand side	Watch less TV, Use less computer, Maintenance of the appropriate capacity of refrigerator use, Use less washing machine, etc.	Urban Governance	**X**			
	Supply side	New district heating network	Urban Policy	**X**			

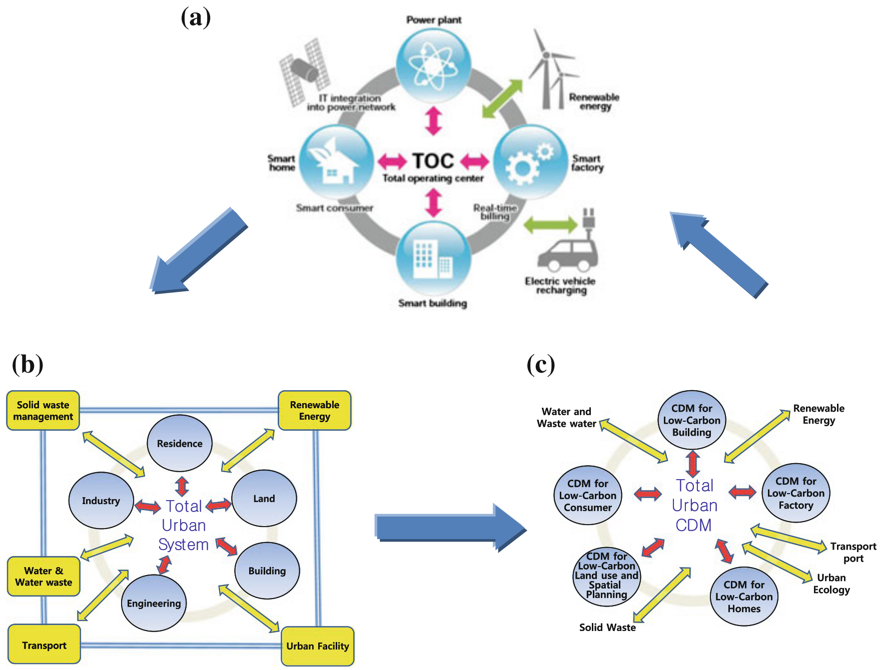


Fig. 5.3 **a** Urban smart grid system. **b** Integrated urban planning and management. **c** Total Urban CDM model

With this model, the spatial deployment of GHG reduction activities can be shown in the master plan at the city-scale.

The design of the agglomeration of various options becomes key for the master plan. Here, two steps can be taken: the first step would be for the immediate trial testing of deployment of options, and the second step for the costing of putting the idea into practice.

This development plan shows how to achieve the ultimate goal of the Urban CDM for "climate resilient and low-carbon smart city."

5.6.3.7 Formulate Planning Policy and Development Mechanisms for the Implementation of the Selected Program of Activities for the Whole City

Implementing GHG reduction activities requires political decisions and mechanisms, and efforts of everyone.

A summary of urban policy and mechanisms is outlined in Table 5.13. On the other hand, as Table 5.14 presents, land-use zoning, i.e., the decisions regarding the location and density of residential, commercial, industrial land uses, among others, has the widest influence on other sectors (Fig. 5.4).

Table 5.13 Examples of urban policy and mechanisms

Urban policy		Mechanism
I	Construction of low-carbon and highly efficient city	Spread low-carbon implementation campaign
		Improve the energy application
		New renewable energy application
II	Developing green governance	GHG reduction implementation
		GHG reduction education to the citizens
III	Urban ecological restoration	Systemic management of the urban ecology
		Green space expansion
IV	Establishment of water-friendly city	Promote rainwater use
		Water cycle expansion
V	Energy efficient city design	Sustainable city design
		Expansion of low-carbon green buildings
VI	Waste-free recycling city construction	Control the waste occurrence
		Increase the waste recycle
		Mobilization of waste resource
		Model town construction
VII	Green industry hub city	Fostering green industries
		Fostering lighting industries
VIII	Expansion of green traffic	Establishment of green traffic infrastructure
		Promotion of bicycle use
		Promotion of public transit
		Streamlining public transit
		Supply of eco-friendly automobile

5.6.3.8 Estimate the Aggregated Emission Reduction of Planned Program of Activities

Underneath, the GHG emission reductions based on the target of GHG emission reduction for Gwangju city, Korea, are estimated for 2020 as an example (Fig. 5.5).

Business-as-usual GHG emission scenario also is shown in this figure. The aggregation process will be elaborated more in detail in the next section.

Table 5.14 Urban sectoral interactions: potential for climate policy complementarity and tradeoffs

Impact → (reads horizontally)	Land-use zoning	Transportation
Land-use zoning Land-use zoning determines the density, height of buildings, and proportion of undeveloped land on each property		Segregation of land uses impacts travel distances and frequency; transit-oriented development zones encourage use of mass transportation
Transportation Transportation policies determine the development and extension of road and mass transportation network	Transportation infrastructure policies shape demand for land and acceptance of density increases	
Natural resources Natural resources policies determine which areas are preserved from development and what uses are acceptable on them	Natural resources policies determine the limits of developed land-use zones and can improve quality of high-density zones	Natural resource policies affect the placement of road and mass transportation infrastructure
Building Building policies, including building codes, affect building materials, construction types, and other physical conditions	Building codes can increase acceptability of high-density zones by requiring design features to improve quality of high-density structures	
Renewable energy Renewable energy policies can increase on-site renewable energy production and share of energy produced by renewable sources		
Waste and water Waste policies determine the means and extent of waste disposal. Water policies determine service extent, pricing, and water sources		

(continued)

Table 5.14 (continued)

Impact → (reads horizontally)	Land-use zoning		Transportation
Natural resources	Building	Renewable energy	Waste and water
Zoning designates natural resource areas that may be set aside to reduce vulnerability to flooding or urban heat island effects	Zoning impacts placement and density of buildings, which in turn impacts building energy efficiency and vulnerability to flooding and urban heat effects	Zoning density can constrain on-site renewable energy production but can also increase efficiency of service delivery	Zoning density can determine the efficacy of delivery of waste, recycling and composting services; and the energy required for and efficacy of delivery of water services
Transportation systems impact natural resource and preserved zones		Transportation policies can require renewable energy sources for mass transportation systems	
		Natural resources endowment makes certain renewable energies possible	
		Building codes can require the on-site generation of renewable energy	Building codes can require design and building materials that produce less construction waste and reduce water consumption in buildings.
			Renewable energy production can involve high water consumption

Source OECD (2010), Cities and Climate Change, p. 109

5.7 Testing of Urban CDM: The Gwangju Case Study, Korea

To test the method and tools mentioned in the previous sections, an Urban CDM case study was conducted for Gwangju Metropolitan City in general and Gwangju Multiple PoA as a planned program in specific.

Fig. 5.4 Use of smart mobile phone in subway train, digital city of Seoul, Korea

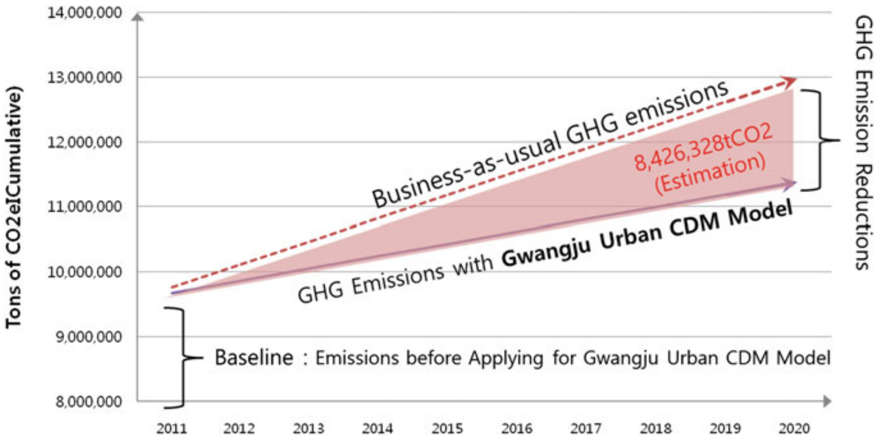


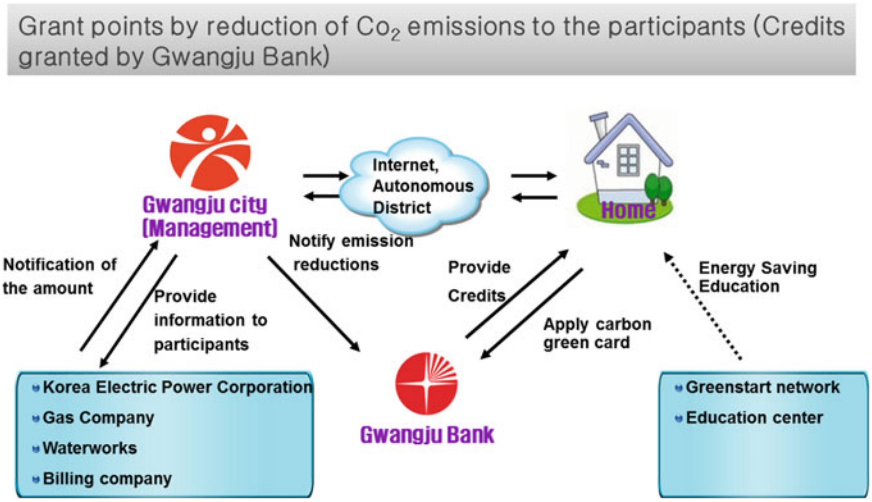
Fig. 5.5 Estimation of cumulative GHG emission reduction in Gwangju for 2020

5.7.1 Types of CDM Program of Activities Practiced in Gwangju, Korea

Although Korea is not a mandatory greenhouse gas reduction country, there are many national and regional measures being enforced. Gwangju has been operating Carbon Banking System, Gwangju Green Action, and Creation of Low-Carbon Apartments as self-measures of greenhouse gas reduction efforts.

Example measures include:

- Urban Policy CPA: Gwangju City's GHG reduction policy;
- Urban Governance CPA: Carbon Banking System;



- Urban Technology CPA;
  - Case 1: LED CDM business (already accredited in Gwangju)

  - Case 2: LFG CDM business of waste landfill (already accredited in Gwangju)

- Program of Activity: Multiple Program of Activity
  - Gwangju Multiple PoA as a planned program.

5.7.2 A Case Study: PoA of New Type of "Gwangju's Multiple Urban CDM" as a Planned Program

5.7.2.1 The Approach: A Simplified Framework

The approach uses "Gwangju Data on Climate Change Measures" as a planned program from fifty low GHG measures chosen based on practicality and the best available techniques (Fig. 5.6).

It focuses primarily on the potential for the wider deployment at measures including planning policy, governance and technology.

5.7.2.2 The Results

Based on an anticipated population and economic growth in Gwangju, a forecast was made that projects future emissions if mitigation strategies and measures are not implemented. This forecast serves as business-as-usual (BAU) GHG emissions to evaluate the reductions to be expected from mitigation strategies and measures.

Estimated cumulative GHG emissions trajectory and reduction in 2020 is shown in Fig. 5.7. The results highlight the presence of very significant and commercially viable opportunities for GHG reduction at the city-scale.

Figure 5.8 shows examples of GHG reduction activities in Gwangju.

Implementing these measures would generate wider social and economic benefits (Fig. 5.9).

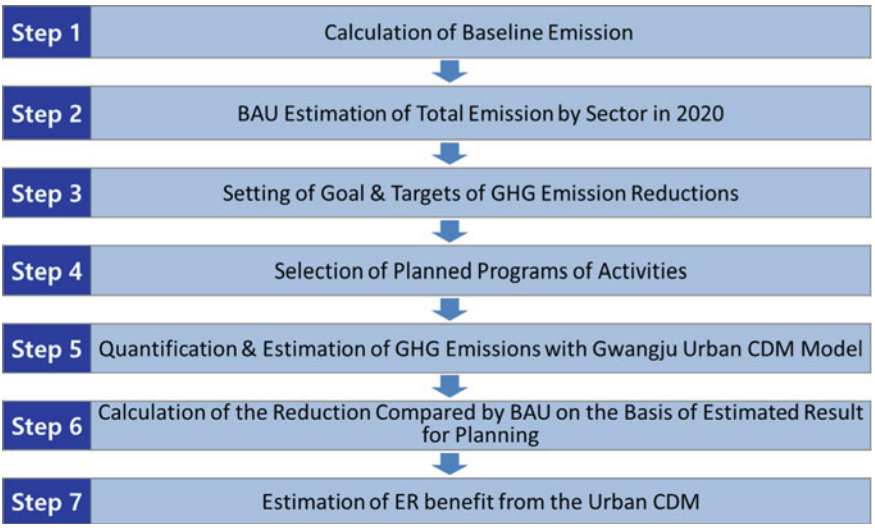


Fig. 5.6 Steps of Gwangju Urban CDM model

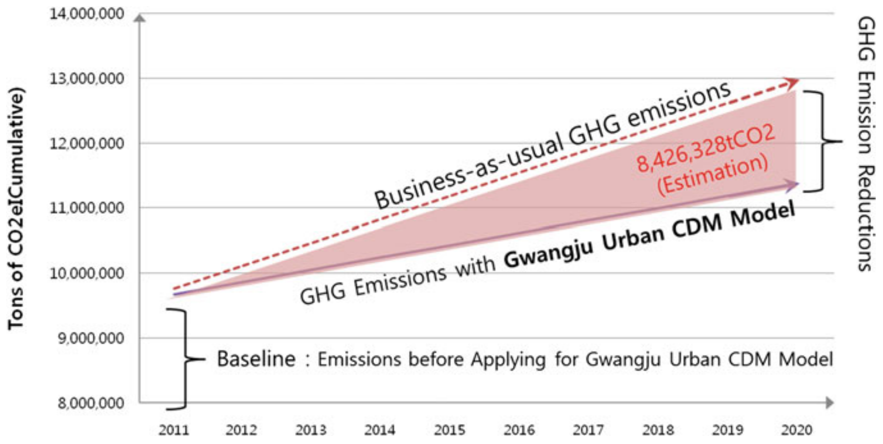


Fig. 5.7 Illustrative GHG emissions trajectory for Gwangju city

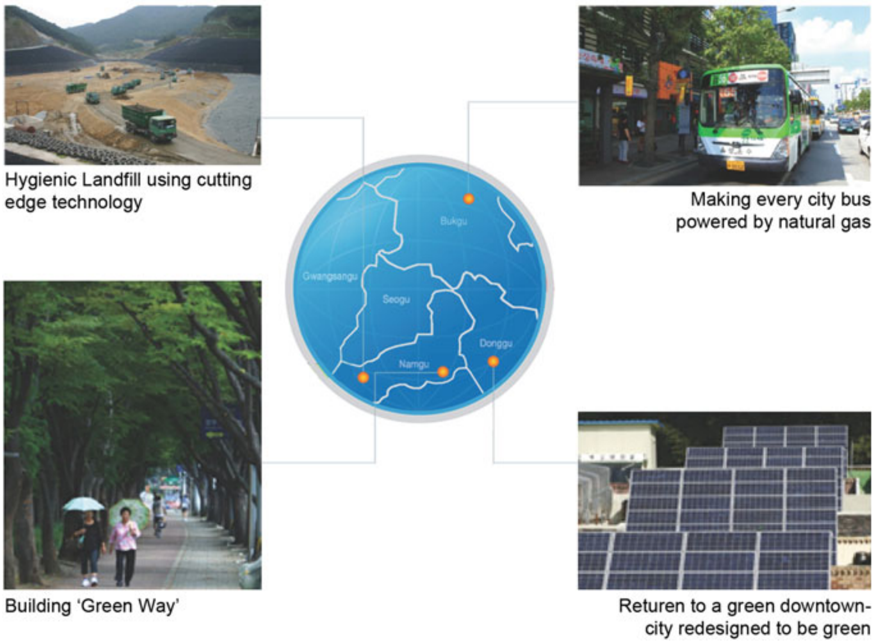


Fig. 5.8 Examples of GHG reduction activities in Gwangju

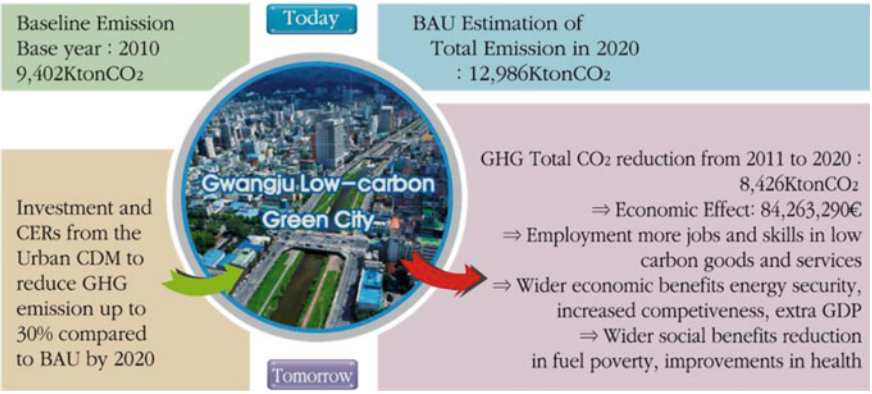


Fig. 5.9 Economics of low-carbon green city: the case of Gwangju

Under the assumption that 1 ton CO_2 costs 10 € (Euro), the Urban CDM in Gwangju would generate 84,263,290 € by 2020.

5.7.2.3 Recommendations for Going Forward

Based on the case study, several recommendations can be made as follows:

- Firstly, implementation gaps should be taken into account.
  - The case study used realistic reduction targets. However, implementation of planned emission reduction program will remain uncertain because the mount of reduction mentioned in case studies is based on the assumption on the plan rather than actual monitoring data.
- Secondly, investment analysis together with benefit/cost analysis for reduction options should be conducted.
  - The scope for the deployment of reduction options at the city-scale has to be adjusted to take into account the associated investment needs, returns, carbon footprints at the city-scale, and implications for the economy and employment.
- Thirdly, out of 50 activities chosen as a planned program, many activities require development of new methodologies for CDM and have to be registered in the UNFCCC Executive Board of CDM.
- Lastly, voluntary carbon markets also shall be explored for the Urban CDM with international agreement.

Multiple CDM program of activities (PoA) can deliver multiple benefits for cities, ① enabling them to meet GHG reduction goal and targets while at the same time, ② growing the economy, ③ creating jobs, ④ reducing exposure to increasing energy costs, and ⑤ securing a competitive edge in the global marketplace.

It is important to note that cities also should follow holistic and policy-related approach to reduce emission with the Urban CDM, "non-technical" projects with large mitigation potential (e.g., urban planning policy and carbon governance).

Urban technologies that every climate smart city should have can secure additionality for the Urban CDM. However, it has to be scientifically evidenced according to the new CDM rules and regulations.

To do that, the scope for the deployment of urban smart technologies for smart climate control system in homes, businesses, and public sectors have to be adjusted to take into account the associated additional investment needs, returns, carbon footprints at the city-scale, and implications for the climate change, economy, and employment.

Climate smart city activities require development of new framework and methodologies for CDM and have to be registered in the UNFCCC Executive Board of CDM.

The activities could include "technical" and "non-technical" programs and projects with large climate change mitigation and adaptation potential.

New market mechanisms including voluntary carbon markets discussed in the Paris Climate Change Agreement and emission trading scheme (ETS) shall be further explored for the Urban CDM to sell or trade the CERs derived from climate smart city activities.

5.8 The Carbon Financing Banking System: A Carbon Governance Approach

The carbon banking system is a carbon finance system to reduce GHG emissions per capita. It is a voluntary GHG reduction campaign in the manner of carbon governance approach to climate change at the household level.

5.8.1 Objectives and Background of the Carbon Banking System

The objectives of the system are threefold:

(1) To calculate energy reductions through energy savings on the demand side in each household in the field of electricity, city gas, and drinking water;

(2) To offer "carbon point" with green cards; and thus
(3) To contribute to GHG emissions reduction for the realization of climate-resilient and low-carbon smart cities.

The overall objective of the Carbon Banking System (CBS) policy is to reduce GHG emissions by 10% from households in 2020 in Gwangju, Korea.

Gwangju City signed an agreement with the Ministry of Environment of Korea to become as a pilot city for climate change response on April 10, 2008, and the planned activities around a carbon banking system to draw citizens' attention on the plan to reduce GHG emissions by 10%.

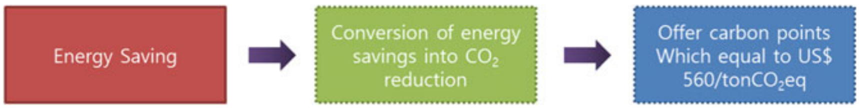
Because Gwangju's household and commercial levels accounted for 39% of GHG emissions in the city, reductions at the household level were urgently needed (as of 2005, unit: tonCO_2):

- Household, commercial: 2581 (39%);
- Transport: 2130 (33%);
- Industry: 1464 (22%);
- Public, other: 440 (6%).

The average household has an important role to play, as was demonstrated in Gwangju, a city of 1.5 million people located 270 km south of Seoul. With an ambitious goal to become carbon-neutral by 2050, the city implemented a carbon banking system which encourages households to act green resulting in 54% of participating households reducing consumption of electricity, city gas, and water in four years (Fig. 5.10).

5.8.2 *Operation of the CBS*

Three steps of carbon points calculation procedure are shown below:



The CBS is a program of integrated smart connect-tech and carbon governance in the digital era. Based on these steps, the operation diagram (Fig. 5.11) maps out main steps of carbon banking system together with the roles of main actors who are engaged in the carbon banking process. The process starts with signing ceremony for agreement on the carbon-smart model city between central and local governments and ended up with issuance of carbon points by private banks.

Fig. 5.10 Gwangju's carbon banking system is a practical effort which many cities can implement, says Dr. Kim (*Photograph credit* World Bank)

It is a public–private partnership (PPP or P3s) project. This project has been seen as a collaborative and collective effort among many stakeholders including city government, private consulting company. It is a very practical effort.

Roles of main actors of Fig. 5.11 are described underneath:

a. **Households**

- Participate in carbon banking system;
- Save energy (in electricity, city gas, drinking water);
- Use and accumulate carbon points.

b. **Gwangju Metropolitan City**

- Data analysis on the consumption of electricity, city gas, and drinking water;
- Promotion of carbon banking system, and processing new applications;
- Report on energy-use reductions to the bank;
- Provision of related information to energy/city gas/drinking waterworks companies;
- Expansion of affiliate businesses for more use of carbon points.

c. **Korea Environment Corporation**

- Process data on Gwangju's electricity, city gas, and drinking water.

d. **Korea Electric Power Corporation (electricity company)**

- Report data on energy use to Gwangju and Korea Environment Corporation.

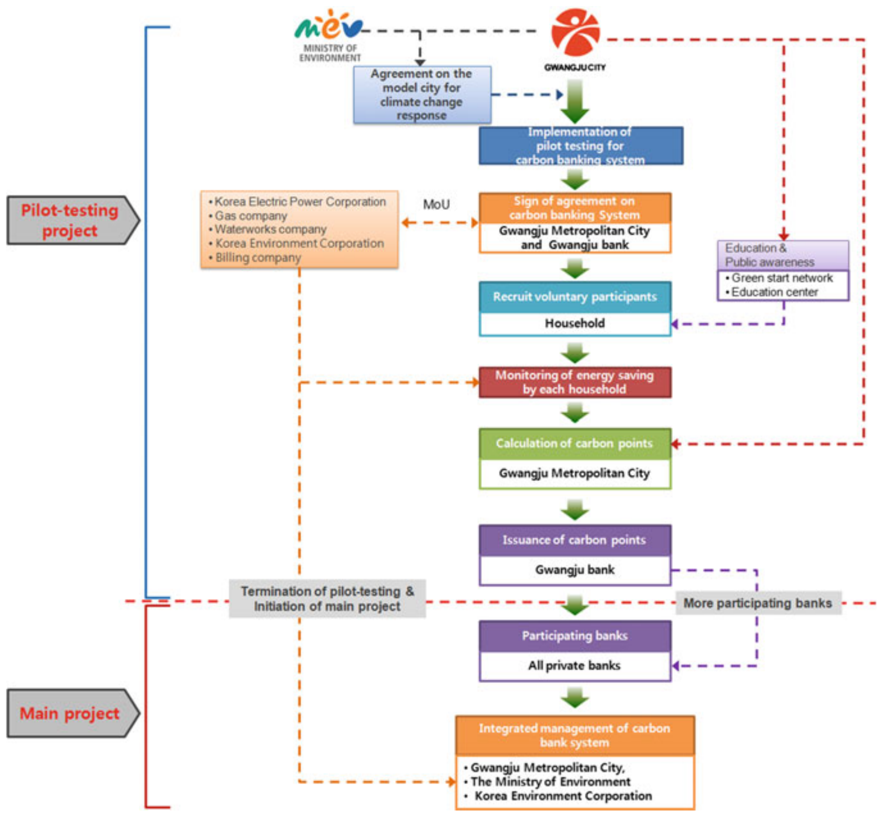


Fig. 5.11 Operating system of the carbon banking system

e. **Gas company**

- Report data on energy use to Gwangju and Korea Environment Corporation.

f. **Waterworks company**

- Report data on energy use to Gwangju and Korea Environment Corporation.

g. **Billing company**

- Issue bills for electricity, city gas, and drinking water.

h. **Green Start Network**

- Promote carbon banking system and encourage participation;
- Educate and promote green life, and organize green leader consultative group.

i. **Education center**

- Promote carbon banking system in broad context of green growth;
- Operate green leader fostering course.

j. **Carbon bank (Gwangju Bank in 2008–2012, all local banks since 2014)**

- Issue carbon points with green card.

k. **The Ministry of Environment (joined since 2013)**

- Organize and manage the carbon banking system;
- Offer carbon points, cash-back, and other incentives.

Carbon banks issued carbon points with green card (Fig. 5.12).

A "green card" is issued to participating households, who earn carbon points when there is more than a 5% reduction in the average consumption of electricity, city gas, and drinking water in the past six months compared to the average of the previous two years. They also get points when they buy registered eco-friendly products or take public transportation—so it incentivizes green behavior. Accumulated points can be used to purchase green goods or to get discounts at national parks and other benefits.

For the pilot phase, agreements were made between Gwangju Metropolitan Government and Gwangju Bank, Korea Environment Corporation, utilities and billing companies. Gwangju Metropolitan Government managed data analysis on consumption and energy-use reductions. Utility companies reported data on energy use to the city and Korea Environment Corporation, which processed data. Gwangju Bank issued carbon points, benefiting from increased usage of green cards, which can be used as ordinary debit cards linked to bank accounts. All local banks are involved starting in 2014. Promotion and public education were managed by the Green Start Network, an NGO supported by the Ministry of Environment.

a. Card used in 2008-2013

b. New card used from 2014

Fig. 5.12 Green card

Households were informed of how to reduce energy consumption—by lowering room temperature while sleeping, using appliances with energy-saving certificates, purchasing green goods, or installing solar panels.

Cooperation between the city, banks, utilities, billing company, civil society, and households is very important. The availability and quality of data, particularly in less-developed countries, are also critical. Sources of GHG emissions cannot always be measured easily.

In Gwangju, practicality was emphasized. This is why electricity, city gas, and drinking water were selected at the pilot stage because they can be measured easily by digital meters at the household level (photographs 1–3). Many cities do have a billing system, so data can be provided for these three sectors. Gwangju Metropolitan Government is exploring opportunities to share accumulated technologies and experiences with developing country cities and to work closely with the Low Carbon, Livable Cities Initiative (LC2) of the World Bank.

Participation increased from 20,327 to 281,730 households in the four-year pilot period beginning in 2008, and 54.3% of participating households successfully reduced consumption of electricity, city gas, and drinking water. Cumulative emission reductions totaled 84.2 kilotons of CO_2. Gwangju hopes to have all 500,000 households participating by 2020, with cumulative emission reductions projected to reach 973.2 kilotons of CO_2 (Fig. 5.13).

While it is a kind of rebate system offered by the Gwangju bank (2008–2013) and all local banks (2014 and onward), the banks can also expect profit due to increase of card use.

The compensation for GHG emissions reduction was made by the Ministry of Environment (appr. $180 thousand USD) and Gwangju city (appr. $180 thousand USD) from 2014 and onward, meaning that the source of finance is the central and local governments.

This system has been recognized by the World Bank (2014) and NYU Wagner and Center for an Urban Future (2016) as an urban innovation initiative (Fig. 5.10).

Photo 1 Electricity meter	Photo 2 City gas meter	Photo 3 Drinking water meter

Fig. 5.13 Smart metering devices. *Source* Photograph 1, Taken at Sinhyochon solar village, Gwangju, by the author, on January 10, 2014. Photograph 2, http://blog.naver.com/mosechu?Redirect=Log&logNo=20191100381. Photograph 3, http://blog.naver.com/jimmy44?Redirect=Log&logNo=140165673316

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Chapter 6
Research Needs

Abstract This chapter examines research needs related to technology and tech-smart urban investments. Smart city planning will need to continually and proactively adapt to constantly emerging new challenges, such as climate challenge and technologies. The emerging challenges of climate city planning are highlighting the need for further and ongoing research on uses, benefits and possibilities of smart technologies for the digitalization of cities. How to fully build an ideal climate smart city is a big question. To answer this question, a lot more research is needed to explore and connect: Smart cities in general; and citizens' participation, new energy industry, big data, land use, water, solid waste, transportation, climate change mitigation, climate change adaptation, green infrastructure, connected smart factory, carbon financing and IoT-based smart city testbed projects in specific.

Keywords R&D ecosystem · Living network of knowledge · Technology facilitation mechanism · Smart city innovation · Narrowband · Social security system · Nanotechnology

Smart city is not just about technology. It is also about policy, planning, and governance. Smart city can help transform cities into a low-carbon knowledge-based economy by nurturing innovation and creativity in all citizens without boundaries of technologies and expertise. The future of smart city planning can be defined by the continuing emergence of new challenges such as climate challenge.

Today, planners, artists, and entrepreneurs have begun to find their own uses, and their own designs for smart city technology.

The process of climate smart city planning has led to the delineation of research needs associated with the connected smart technologies for digitalized cities (Figs. 6.1 and 6.2).

There is a need for reform of the R&D ecosystem for technical partnering between countries and institutions to promote the development and management of climate resilient and low-carbon smart cities and increased networking.

K.-G. Kim, *Low-Carbon Smart Cities*, The Urban Book Series,
DOI 10.1007/978-3-319-59618-1_6

Fig. 6.1 Combined electricity generation of solar energy and wind energy: hybrid system generated by natural energy, Pasar, Japan

The new R&D ecosystem has to be based on a “living network of knowledge” for e-Transformation.

The smart city may be a “more connected city.” It connects us to central nodes in the network. It can incentivize new businesses that create new jobs and new urban tech talent pipelines. Building connectivity or relationships in cities is the key. More investment is needed in research and development of new core technologies for the land-water-energy-waste-food nexus.

Fig. 6.2 Combined electricity generation of solar energy and wind power: hybrid system generated by natural energy, Seoraksan National Park, Korea

6.1 Trends in R&D Ecosystem for Climate Resilient and Low-Carbon Smart City to Attract Tech-Smart Urban Investments

UNEP launched a Technology Facilitation Mechanism for achieving sustainable development goals at the New York Summit in September, 2015. It is a new initiative aimed at increasing the creation and use of innovative technologies that will help achieve the 2030 Agenda on Sustainable Development. It is a wide-ranging collaboration between UN member states, civil society, private sector, scientific community, United Nations bodies, and other stakeholders.

UNEP already hosts such initiatives as the Climate Technology Centre and Network (CTCN) (with UN Industrial Development Organization), the Climate and Clean Air Coalition to reduce Short-Lived Climate Pollutions, and the enlighten initiative on energy efficiency. The CTCN promotes the accelerated transfer of environmentally sound technologies for low-carbon and climate resilient development at the request of developing countries. They provide technology solutions, capacity-building, and advice on policy, legal, and regulatory frameworks tailored to the needs of individual countries (http://www.ctc.org/).

Technology needs and gaps for smart city have been identified and examined, including scientific cooperation, innovation, and capacity-building. However, connected tech has to be further explored to enhance efficiency of smart city and to reduce GHG emissions, and then to lead the new fourth wave of smart tech revolution and realization of smart society paradigm.

Townsend (2014) states that:

> This is a dilemma that poses some tough choices. Do we try to pick winners and rally our efforts behind a handful of big transformative projects? Some parts of the smart city, such as a reengineering the electric power grid, seem to call for Apollo program-scale breakthroughs. Most of the rest is pretty unclear. Should we instead focus on laying the

foundations for a diversity of experimentations to unfold, as we did with the web? Or, if we do both, how do we balance the two and tie them together in productive ways? None of the answers are obvious yet.

We do not yet know how to build a complete climate smart city. But, it is clear what we now know about best ways to build cities and create ICT technologies (IoT, cloud, big-data, etc.) is we need to do more search. It is expected that the R&D topics suggested below will become part of climate smart city projects to connect the disconnected.

6.2 Research Needs for Smart City Innovation

(1) Combination of Internet of Things (IoT) and Internet of Everything (IoE) for connecting things to the Internet and artificial intelligence (AI) with buildings and cities;
(2) Virtualization of digitalized connect-city;
(3) Use of GIS and 3D maps for virtual world (Vi-world);
(4) Applications of data in smart cities: Leveraging smart city data for other applications;
(5) Development of algorism for sunlight and car navigation computer simulation;
(6) Use of eco-mileage for LED lightings, solar photovoltaics, energy action plans, decentralized energy supply system, energy-saving transportation, green buildings, and city guides for a mobile device;
(7) Development of intelligent CCTV automatic disaster water-level perceiving system;
(8) GIS-based CCTV monitoring for crime prevention system;
(9) Development of the fourth wave of system modelings of smart cities as a combinational innovation;
(10) The meanings and value of smart cities to our descendants;
(11) Design and building of the Internet for climate resilient and low-carbon smart cities which could create totally new innovations in terms of software, hardware, and network designs (cable technology);
(12) Use of smart cities as an economic growth engine in terms of labor, capital, and machinery;
(13) Reengineering of the electric power, water, and heat grid to call for large-scale breakthroughs;
(14) Use of public-access cable to encourage cities to adopt the bottom-up approach to smart city planning;
(15) Development of an open-source alternative to the smart city that comes nearly wrapped in a package from Cisco or IBM;
(16) Development of the mobile Web of smart cities;
(17) Development of smart cities in which cities thrive because they create opportunities for people to interact for commerce, learning, and entertainment;

(18) Installation of public Wi-Fi for business improvement districts as new ways of managing cities;
(19) Development and implementation of a city-scale wireless project with public Wi-Fi networks;
(20) Deployment of hot spots around the city for free public Wi-Fi;
(21) Development of social networks and the IoT to solve the challenge of gardening, leveraging a modicum of technology to organize a shift in group behavior with networked sensors;
(22) Training of Web programmers to move up higher-value-added industries with the value chain and brain circulation;
(23) Development of social networks back into the local economy;
(24) Development of mobile phone apps for blood inventory and others instead of text message;
(25) Development of the public–private partnership with Internet service on municipal Wi-Fi as a way to deliver broadband directly to homes and businesses;
(26) Development of transit apps for public policy, announcing the arrival time of the next bus (Fig. 6.3);
(27) Development of snow maps, a Web app that allows neighborhood volunteers to claim local fireplugs as their own winter wards;
(28) Development of the center for art and technology (CAT);
(29) Connecting a fragmented urban ecosystem;
(30) Development of connectedness between citizens and their government;
(31) Preparation of sustainability plan of smart city;
(32) Integrating and interpreting research and clinical practice to build a knowledge base that can better guide individualized patient care;
(33) Development of carbon-zero islands;
(34) E-governance for smart cities: The use by government agencies of information technologies such as wide area networks, the Internet, and mobile computing;
(35) Provision of high-speed telecommunications infrastructure;
(36) Advanced digital infrastructure including broadband and NB (narrowband)-IoT;
(37) Urban planning approach for the realization of low-heat islands;

Fig. 6.3 Bus stop and digital bus information terminal (*BIT*), Seoul, Korea: information on weather and temperature, air pollution, and arrival bus number

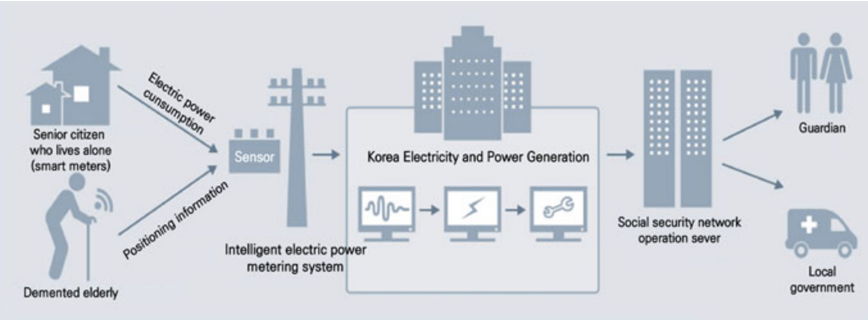


Fig. 6.4 Social security system, Korea Electric Power Corporation. *Source* Chosun Daily Newspaper, No. 29686, A12, 2016

(38) Refinement of smart grid for strategic areas and cities;
(39) Development of testbed for a large-scale implementation of smart grid at the city level;
(40) Development of community energy supply (CES) system for decentralization resources with smart grid techniques as a basic for new energy market;
(41) CES for optimized combined district energy system including heating, gas, electricity, and water for decentralizing energy supply with smart grid techniques as micro-grids;
(42) Policy, regulations and deregulations, and deployment and technology for smart grid;
(43) Social security network with intelligent electric measurement infra (Fig. 6.4);
(44) Mainstreaming the low-carbon economy in smart city planning;
(45) Development of standard practices and techniques of interactive management of smart grids in terms of sectors of smart grids;
(46) Development and maintenance of smart heat grid;
(47) Development of climate smart city software;
(48) Standardization of ICT devices for climate smart cities;
(49) Application of virtual reality and augmented visualization technique; and
(50) Development of land-food-water-waste-energy nexus.

6.3 Research Needs for Implementation of Smart City Planning: Carbon Projects for Opening of the New Climate System in UNFCCC COP22

The global energy needs are set to increase 40% by 2030. Cities are one of the biggest polluters. A fortunate thing is that political will emerge to contribute to the implementation of the Paris Climate Change Agreement through nationally determined contribution (NDC) and low emission development strategy (LEDS).

To effectively realize the Paris Agreement agendas, there is a further need for research and development for climate change action.

6.3.1 Research Needs for Citizens' Participation Include the Following

1. Encouragement of citizens' participation for improving their lives in cities, wherein policy decision makers and citizens cooperate for solving climate and environmental problems and establishing public policies;
2. Citizens' participation and international cooperation of GHG reduction;
3. Citizens' participation and awareness raising for bottom-up approach to climate resilient and low-carbon smart city;
4. Joint public–private partnerships for city-to-city cooperation;
5. Government's perception and attitude toward civil society organizations and their activities from the eco-evolution point of view between government and civil society sector;
6. Technology policy through the involvement of citizens;
7. Development of sensor-based citizens' observatory community for improving quality of life in cities;
8. Public awareness of energy rankings and labeling for increase of energy efficiency through purchasing energy efficient (EE) products;
9. Development of e-learning open campus; and
10. Adoption of consultative process in climate smart city planning.

6.3.2 Research Needs for New Energy Industry

1. EE cities
   (a) Development of virtuous energy cycle;
   (b) Development of nexus of energy, water, and technology;
   (c) Eco-friendly energy town program;
   (d) Major regional governments' plan for transition to sustainable cities;
   (e) Green city certification system;
   (f) Good practices of value chain model for climate smart cities;
   (g) Green techniques in vertical cities for zero emission development (ZED), including vertical building forests;
   (h) Development, technology transfer, and operation of low-carbon smart city incubations and testbed through private investment;
   (i) Demonstration of soft stimulation treatments of geothermal reservoirs; and
   (j) Climate change integrated city and building design contributing to national energy reduction goals.

2. EE buildings

   (a) Development of energy simulation system for low energy consumption by low-energy building and neighborhoods.
   (b) Zero energy building demonstration program.

      - Refinement of value chain model for smart green buildings;
      - Facility improvements and lifestyle change in EE buildings; and
      - Testbed projects to save energy for existing buildings.

   (c) Green remodeling program.

      - Techniques for retrofitting in existing buildings without interference of tenants and existing working/living environments.

   (d) Decision-making system for renovation of rental housing for low-carbon society.
   (e) Knowledge and experiences on nearly zero energy buildings.
   (f) Building materials and components development of insulation materials of high performance and other EE building materials for passive design.
   (g) Smart green building and EE certification system.

      - Green building certification standard should be set, in particular, for passive standardization.

   (h) Technology, policy, and human resources for new renewable energy sector including solar energy.

3. Energy materials

   (a) Development of energy materials such as battery for energy storage system (ESS);
   (b) CO_2 utilization such as catalytic and photocatalytic conversion process for the production of basic chemicals and fuels;
   (c) CO_2 mineralization for building/construction materials;
   (d) CO_2 utilization by biological CO_2 conversion;
   (e) Membrane technology for CO_2 separation from other mixed gases;
   (f) Bio-nano-information technology (BINT) for the development of innovative climate change technology (Fig. 6.5); and
   (g) Development of technology for the production of high value added products from lignocellulosic biomass.

4. Integrated systems

   (a) ICT-based energy management system;
   (b) Development of new energy business model through application of ICT techniques in the life cycle process of energy production, consumption, and conversion;

Fig. 6.5 Center for Nanotechnology (CeNTech), Munster, Germany

(c) Development of the integrated platform on energy data; and
(d) Development of platform on new energy industry export.

6.3.3 Research Needs for Big Data

1. Development of the Carbon Monitoring and Information System that integrates existing sensor networks for monitoring air pollution and CO_2 in urban areas and factories;
2. Development and deployment of mobile carbon monitoring sensors that would be mounted on public bus and taxies;
3. Development of the big data analysis technology including SNS (Social Network Service), broadband, and power blogs so that decision makers and citizens can share social opinions regarding planning issues in the metro cities;
4. Compilation of a complete and accurate energy and environmental basic data bank—physiographically, unique areas should be completely characterized and data stored so that they are readily available. This applies particularly to the following types of information that are often deficient: climate, current census data for low-density and rapidly growing areas, property records, and realistic land-use classifications;
5. Big data for knowledge-based smart eco-city planning;
6. Big data that integrates research and climate practice to build a knowledge base;

7. Development of new sources of real-time data to create an early warning system for social, economic, and disaster crises in order to enhance crisis-sensing abilities;
8. Study on smart city index by using big data;
9. A more systematic method called predictive analytics, which is starting to be widely in business to foresee events before they happen;
10. Development of geolocation systems to complement GPS for capturing location;
11. Development of the green and energy big-data value chain;
12. Building up of online portal on GHG mitigation actions (facility improvements and behavioral change) and measurement of their achievements in nonindustrial sectors including households, public, and transportation sectors;
13. Strategy for information collection and technical solutions for climate change adaptation;
14. Energy information system including smart grid which can be provided to residents who live in surrounding residential areas, e.g., smart meters;
15. Collection of electronic capacity-building resources that will become a valuable tool for building capacities in the future smart cities;
16. Exchange of special services, information, and data between sectors of smart grid systems;
17. Development of big data algorithm with metering data which provides good baseline; and
18. Development of big data for optimization of maintenance of urban infrastructure.

6.3.4 Research Needs for Land Use

1. Development of digital real estate;
2. Use of drone techniques for land-use mapping and improvement of land-use zoning and titling (Fig. 6.6);
3. Building of new digital services in order to enable to use consumer-grade GPS receivers including digital base map of the thriving community and digital version of master street maps;
4. Development of slum mapping;
5. Low-carbon zoning, including clustering of smart green technology firms;
6. Criteria for the location of land uses to minimize GHG emissions;
7. Alternative rates of energy consumption resulting from various settlement patterns;
8. Integration of climate change issues with urban and regional developments—a more streamlined procedure closely tied to carbon-centered comprehensive integrated land-use planning should be researched in order to achieve the goals of sustainability, circularity, resiliency, efficiency, and connectivity of the city;

Fig. 6.6 T-Smart mini drone

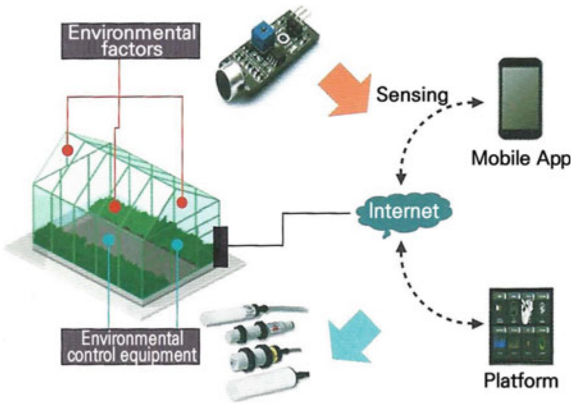


Fig. 6.7 Urban energy self-sufficient smart farming service. *Source* nipa, SMART CITY, 2016, p. 27

9. Public participation in climate smart land-use planning;
10. Data requirements for climate smart land-use research;
11. Emerging digital neighborhoods—reinventing neighborhoods for the digital electronic era;
12. Good practices of low-carbon emission development;
13. Modeling of smart housing and city regeneration; and
14. Urban energy self-sufficient smart farming (Fig. 6.7).

6.3.5 Research Needs for Water

1. Development of the smart water grid system;
2. Development of nexus of water, energy, food, and technology in which water is put at the center of system design and operation;
3. Techniques for advanced hydrological modeling and monitoring for ecosystem and environmental water quality;

4. Smart water management initiative with particular emphasis on smart meters;
5. Techniques for solar energy and other types of renewable energy above water;
6. Good practices to reduce risk including development of alternative water resources;
7. Supply side water management to save energy by using smart system; and
8. Development of ESS including storage of renewable energy/heat in water production process.

6.3.6 Research Needs for Solid Waste

1. CO_2 emission reduction certification system for zero waste activities including the use of food waste for agriculture;
2. Policy formulation and implementation process for less use of waste plastic/vinyl bags;
3. Intellectual property right of hazardous materials, environmental-friendly energy subsidy system, waste classification system, and heating values;
4. Economically feasible waste energy techniques;
5. Methodology and high techniques for stabilization and naturalization after closure of landfill sites;
6. Renewable energy portfolio standard for the implementation of mandatory assignment system of new and renewable energy, fusion techniques, and smart grid;
7. Efficient utilization of CH_4 which is generated from organic waste anaerobic process such as sludge, landfill gas, and food waste;
8. Good practices and technology for zero waste community for self-sufficient and resource circulation sectors;
9. Measurement and accounting of household wastes and wastewater with particular emphasis on their emission intensity per capita considering wastes and wastewater plant design; and
10. Good practices for use of waste energy.

6.3.7 Research Needs for Transportation

1. Development of city guides for a mobile device;
2. Techniques for connected smart car and environment-friendly green vehicle (EV, PHEV, HEV, FCEV);
3. Policy and techniques for smart highway projects;
4. Development of carbon-free transportation;

Fig. 6.8 Bike ride, Munster, Germany

Fig. 6.9 Solar impulse flight. *Source* Chosun Daily Newspaper, March, 10, 2015

5. Creation of climate bike ride (Fig. 6.8);
6. Development of smart mobility (Fig. 6.9);
7. Development of online electric car (Fig. 6.10);
8. Smart parking (Fig. 6.11);
9. Impact of driverless cars; and
10. Issuance of car carbon points.

Fig. 6.10 Cityscoot: public electric scooter, Paris, France. *Source* Chosun Daily Newspaper, No. 29694 June, 28 2016

6.3.8 Research Needs for Climate Change Mitigation

1. Development of new market mechanisms (NMMs) for carbon financing in smart city planning;
2. Development of Urban CDM (U-CDM) as a new carbon market mechanism for climate change mitigation;
3. Tools for LEDS;
4. Energy and material flow in urban ecosystem;
5. Mathematical modeling for mitigation measures;
6. Climate change caused as a result of urban sprawl;
7. Mathematical modeling for carbon footprint;
8. Identifying and building baselines of GHG emissions in smart cities;
9. Good practices to facilitate the reduction of GHG emission in nonindustrial sectors for low-carbon economy;
10. Refinement of energy and material flow techniques to be more applicable to the smart city planning;
11. Mainstreaming of climate change mitigation in the smart city development plans;
12. Strategy and techniques to save energy in the energy-intensive environmental infrastructure;
13. Policy for non-CO_2 management, recycling, and destruction which should be included in the Air Quality Conservation Law and Low-Carbon Green Growth Law;

Fig. 6.11 Smart parking facility, Seoul, Korea

14. Non-CO_2 GHG emission inspection and maintenance standard setting;
15. Good practices for climate, environment, and GHG emission mapping in cities; and
16. Tools of carbon mapping, monitoring, and evaluation.

6.3.9 Research Needs for Climate Change Adaptation

1. Methods and techniques for ecosystem-based adaptation—further work is needed to accurately establish early warning system with ICT;
2. Tools and techniques of eco-engineering for climate change adaptation;
3. Techniques of ecosystem-based adaptation for flooding control;
4. Information and good practices of urban habitat management;
5. Urban wetland designation and management techniques for the realization of low-carbon eco-city;

6. Techniques for climate change adaptation including erosion control in coastal areas;
7. Good practices for urban biodiversity conservation and management techniques;
8. Mainstreaming of climate change adaptation in the smart city development plans;
9. Ecosystem-based ecological restoration;
10. Good practices of transboundary flood management for climate change adaptation;
11. Improvement and restoration of contaminated soils for cities including technology and soil bank program;
12. Improvement of adaptive capacity for smart grid technology, including more thunderstorm and sea-level rise;
13. Spatial planning in disaster risk reduction; and
14. Urban forest management for enhancing resilience to climate change.

6.3.10 Research Needs for Green Infrastructure

1. Creation of water-smart parks, playground, and green alleys which absorb rainfall, reduce flooding, and recharge drinking water supplies while saving energy for water management;
2. Shoreline parks and natural lands which buffer cities from rising seas, coastal storms, and flooding;
3. Shady green spaces which reduce the urban "heat island" effect, protect people from heat waves, and reduce summer energy use;
4. Trails and transit lines which provide carbon-free transportation and link residents to popular destinations and each other;
5. Solar LED garden lightings (Fig. 6.12);
6. To link Aich biodiversity with urban/city biodiversity framework; and
7. Knowledge on the application of the economics of ecosystem and biodiversity (TEEB).
8. Development of future predictive model for optimization of maintenance of urban infrastructure (green space, road, tunnel, drinking and sewage water, etc.) with big data as database (DB).

6.3.11 Research Needs for Connected Smart Factory (CSF)

1. Product-process coevolution;
2. Integrated work flow with short path-no zig-zagging, less cycle time and less energy;
3. Manufacturing revolution through smart services—Internet of Services;

Fig. 6.12 Solar LED garden lighting, Jeju Island, Korea

4. Development of CSF standard model;
5. Collaborative workplace design—a virtual round table is needed for interactive virtual conference;
6. Development of 3D physical/digital gaming interface;
7. Development and operation of CSF testbeds—creation of CSF hardware and software platforms;
8. Development of cyber-physical production system (CPS); and
9. Development of core ICT-integrated reference model based on characteristics of demand industries.

6.3.12 Research Needs for Carbon Financing

1. Climate change aspects of gentrification;
2. Refinement of Urban CDM tools—further research should be performed to systematically apply the Urban CDM in smart city projects;
3. Policy implications of low-carbon, circular economy for planning of climate resilient and low-carbon smart cities;
4. Activation of carbon climate registry platform;
5. NMMs for climate smart city development goals including alternative incentive and penalty systems to achieve connectivity goals;
6. Strategy, policy, and good practices on a variety of carbon markets for the implementation of the NDC;

Fig. 6.13 Wind power generators, Seoraksan National Park, Korea

7. Refinement of emission trading scheme (ETS);
8. Commercialization of green property and incentive with particular reference to climate change mitigation and adaptation;
9. Incentive system for renewable energy (Fig. 6.13);
10. Finance to solve decentralization issue of water supply;
11. Development of national and local inventory system/baseline which include discharge and leaking of HFC, and non-CO_2 generated from incinerator, semi-conductor and transportation which are not currently included in the inventory system in many countries;
12. Definition of nearly zero energy building and analysis of cost optimal;
13. Good practices for GHG emission for CDM and other types of CER;
14. Good practices of responsible green investment;
15. Refinement of green financial mechanism (e.g., carbon trust, carbon bond, etc.); and
16. Real estate pricing of green modeling and certified green buildings.

6.3.13 IoT-Based Smart City Testbed Projects in Korea: An Integrated Solution

Very recently, "IoT Korea Exhibition 2016" was held in Seoul, Korea. It aimed at connecting all the dots of the smart city ecosystem and empowering all visitors and exhibitors. It was an opportunity to gain extensive know-how from cities, companies, and joint pavilions striving to shape the cities of the future. It has enabled stakeholders to exchange experiences and ideas, to form valuable connections, and to make business deals.

The IoT-based smart city testbed projects focus on the partnerships of public and private sector and technologies related to IoT. They will lead to development of new business industries in cities.

A close look to the event is taken below:

1. **Smart City Testbed**.

The smart city testbed aims to be an Iot-based global ICT hub. It includes one MZM-based IoT infra, city-to-city platform, and 3D GIS-based city service control (Fig. 6.14).

2. **Smart City Testbed**.

The smart home testbed aims to build an integrated energy-saving management system. It includes electricity and other energy monitoring, integrated energy management system, and connection with a smart grid. Smart homes are equipped with connected devices including Wi-Fi, door sensor, temperature, humidity and shock sensor, gas valve, smart plug, and z-wave Dongle + STB (Fig. 6.15).

Smart home, AI, and IoT can connect home appliances such as clocks, coffee pots, stereos, planters, refrigerators, and solar LED lightings with cars and their

Fig. 6.14 Smart city testbed, Busan City, Korea

Fig. 6.15 Smart home testbed, SK Telecom, Korea

parking lots which contribute to promote the power of urban connectivity (Fig. 6.16).

3. **Smart Ecology Testbed**.

The smart ecology testbed aims to provide ecology and environment services. It includes air, pollution, water, plants and soil monitoring, and biodiversity maintenance (Fig. 6.17).

4. **Smart Farming Testbed**.

The smart farming testbed aims to provide services for energy self-sufficient smart farms in cities. It includes HMI platform, remote mobile monitoring system, and IoT-based solar lighting system (Fig. 6.18).

5. **Smart Factory Testbed**.

The testbed includes new automation control system for factories. It includes integration and applications in products and management systems for value added (Fig. 6.19).

6. **Environmental Monitoring Testbed**.

The environmental monitoring testbed aims to monitor meteorological information, particulate pollution, water level, soil information, and indoor and outdoor temperature and humidity information. It includes IoT-based environmental sensors, and big data and analytics (Fig. 6.20).

Fig. 6.16 New world in which everything is connected with smart home, AI, and IoT for smart city life. *Source* Chosun Daily Newspaper, A21, No. 29821, November, 25, 2016

Fig. 6.17 Smart ecology testbed, Kiban, Korea

Fig. 6.18 Smart farming testbed to export strawberries: long-term storage and transport technique

Fig. 6.19 Smart factory testbed, iEi, Korea: new automation control system for industries

Fig. 6.20 Environmental monitoring testbed, SK tech-X, Korea

Fig. 6.21 Smart car talk, TEJING, Korea

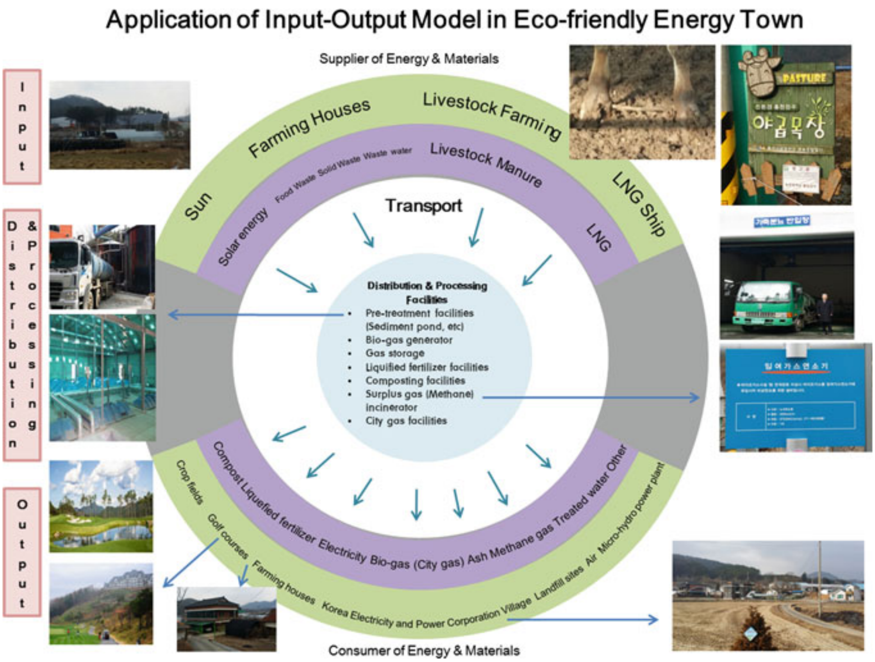


Fig. 6.22 Application of input–output model in eco-friendly energy town

7. **Smart Car Talk**.

The smart car talk is a smart phone-based automatic system. It includes more diverse and convenient techniques (Fig. 6.21).

6.3.14 Application of Input–Output Model in Eco-Friendly Energy Town: Waste to Energy

Starting in 2014, the Korean Ministry of Environment is actively pursuing a project to create eco-friendly energy towns, which are designed to return profits to the residents by combining the production of new and renewable energy such as waste energy and solar photovoltaic energy. The ministry developed a project model aimed at improving the well-being and income of local residents by using waste resources such as food waste, and livestock manure and biomass to produce energy, including heat and electricity, or by providing or selling the gas and heat generated from landfills or incineration facilities to the surrounding areas, and conducted a pilot project in Hongcheon-gun, Korea (Fig. 6.22). The Hongcheon experience will be replicated with solid waste as a success project of innovation in Inje, Gangwon province, Korea.

Reference

Townsend AM (2014) Smart cities: big data, civic hackers, and the quest for a new utopia. W.W. Norton & Company Ltd., New York, p 11

Chapter 7
Implementation of Climate Smart City Planning: Global Climate Smart City Platform Solution

Abstract This chapter describes the implementation of climate smart cities through a global climate smart city platform solution. There are huge investment opportunities associated with new implementation of climate smart cities in four distinct areas: framework, partnership, financial plan, and implementation arrangements. A platform based on these four elements could provide guidance on how climate smart urban development and infrastructure projects can be integrated into smart city planning processes. It could be built in a way that unlocks the value added of a digitalized urban ecosystem that helps address sources of climate change, impacts, and solution. On the whole, the fusion of information and communication technologies and ubiquitous urban information seems to be key to enhancing the role and value of a platform to build climate smart cities. The platform suggests that cost-effective public–private partnership will be key to the development and promotion of responsible smarter investment models.

Keywords Platform · Climate smart city planning control · Planning framework · Innovation tech · Big data macro-platform · Partnership platform · Carbon financial plan · Financial modeling · Market opportunities · Public–private partnership · Budget preparation

Having established the strategic context and explored the planning and technical aspects of climate smart cities, we have to look at the investment opportunities associated with the implementation of climate smart cities in four distinct areas: framework, partnership, financial plan, and implementation arrangements.

It is expected that climate smart city theories will be translated into practices, both technically and commercially, through the establishment of a "Global Platform on Climate Smart City."

One thing is certain: There are many significant opportunities and challenges that must be faced as we continue the process of creating smarter, carbon-free, more resilient sustainable cities of the future.

K.-G. Kim, *Low-Carbon Smart Cities*, The Urban Book Series,
DOI 10.1007/978-3-319-59618-1_7

7.1 Background for a Proposal on Global Climate Smart City Platform

Planning a city has never been as complex as it is nowadays. It represents the nexus for managing efficiently energy, climate change, food, waste, etc. Simple city products and services quickly develop into multi-disciplinary implementations addressing multifaceted concerns.

Everything a city does needs to be addressed in light of the following movements:

- Climate change;
- Smart climate urbanism: a new tenet of urbanism;
- Fourth wave of industrial revolution;
- Smart connect-tech; and
- Responsible green investment.

Smart city project applicants can support local authorities and citizens in taking these diverse concerns in the city, and make it easier to mainstream sustainable innovation in every aspect of the urban planning for the digitalization of entire city and development process. They also help revitalize cities.

Only an integrated carbon-centered comprehensive (3Cs) approach to planning and development will offer an effective solution to today's climate smart city requirements. Collaboration between wide ranges of disciplines in a city can not be accomplished without a solid base of knowledge-based big data and process integration of climate.

The global smart cities market is estimated to reach $1.4 trillion by 2020, as cities embrace new advancements in smart lighting, energy efficiency, water and waste management (Climate Action, 5 July 2016). The emergence of climate urbanism could further accelerate the expansion of the market for smart city solutions.

The fourth industrial revolution is now being led by AI with support from big data. However, it is important to note that information for big data has to be provided by human beings. Therefore, we should have a close look at the relationships between man and machine.

It is hoped that the proposed platform will contribute to build a network of global leaders focused on urban sustainability, climate change, innovation, and smart connected technology solutions for cities, and write a new chapter for the smart eco-solutions to combat climate change in cities, even though it is not a statutory guideline.

7.2 Objectives and Scope of the Climate Smart City Project Platform

The main objective of this platform is to provide guidance as to how climate smart urban development and infrastructure projects can be integrated into smart city planning process and built in a way that unlocks the value of a digitalized urban ecosystem from climate change perspective.

This is important because:

- The platform tries to link the Urban CDM approach with smart connect-tech as well.
- Climate smart development and infrastructure projects often provide cost-effective opportunities to test and trial smart city products and services, and the business models and processes required to fund and operate them, before rolling them out citywide.
- The big data and analytics, and digital dynamic modeling including urban grid systems can not only enable cities, neighborhoods, and villages to be better designed for the people who use them, but also refer to the opportunities offered by renewal programs, major infrastructure projects and street works and improvements to the public realm. It is useful for everyone involved in the planning and implementation of climate smart development and infrastructure projects.

The scope of the activities proposed in this platform is initially focused on climate change rather than broad issues, in order to enable rapid progress on the activities and the achievement of specified deliverables within the expected time frame. Based on the progress made with initial set of activities, the objectives and scope of future activities may be expanded accordingly.

It is important to note that the smart city can be defined at two different levels to capitalize on it. They are the smart city by broad definition and the one by narrow definition.

A critical step in the designation and implementation of a climate smart city project will be to follow a clear planning control and implementation as depicted in Fig. 7.1.

Fig. 7.1 Climate smart city planning control and implementation

7.3 Challenges on Implementation for Climate Smart City Planning

7.3.1 Requirements for Regular Power Supply

The digitalization of entire city depends on consistent access to power. Internet is based on electricity. CCTV also requires electricity. Intermittent access to power causes huge problems. There is a need for adding backup power generators at buildings for uninterrupted power supply.

7.3.2 Reduction in Over-Dependency on ICT Gimmick

Cyber-hackings would be huge challenges. Proper balance should be maintained between ICT and conventional management and methods to mitigate risk in terms of cyber-hackings. Several measures need to be taken as follows:

- Development of backup systems and manuals;
- Retraining and management of workers; and
- Cost of managing challenges.

7.4 Framework

7.4.1 Overall Framework

This framework is based on the Post-2015 Sustainable Development Goals (SDGs) and Paris Climate Change Agreement, and more specifically, the low emission development strategy (LEDS) and nationally determined contribution (NDC).

The smart city planning can be used as a sustainable tool for green economic development with particular emphasis on climate-resilient and low-carbon cities as referred to in the SDGs and Paris Climate Change Agreement.

ICT such as virtual reality (VR) and augmented visualization technique is helping to achieve the SDGs and implement the Paris Climate Change Agreement in human settlements.

Our task now is to mainstream smart city climate planning into urban planning policy. This is only possible by creating the planning conditions necessary to integrate the full effects of climate change into the urban planning process, which is a new tenet of planning.

Figure 7.2 shows the overall framework for the implementation of climate smart city planning and development which contains key components and their connectivity.

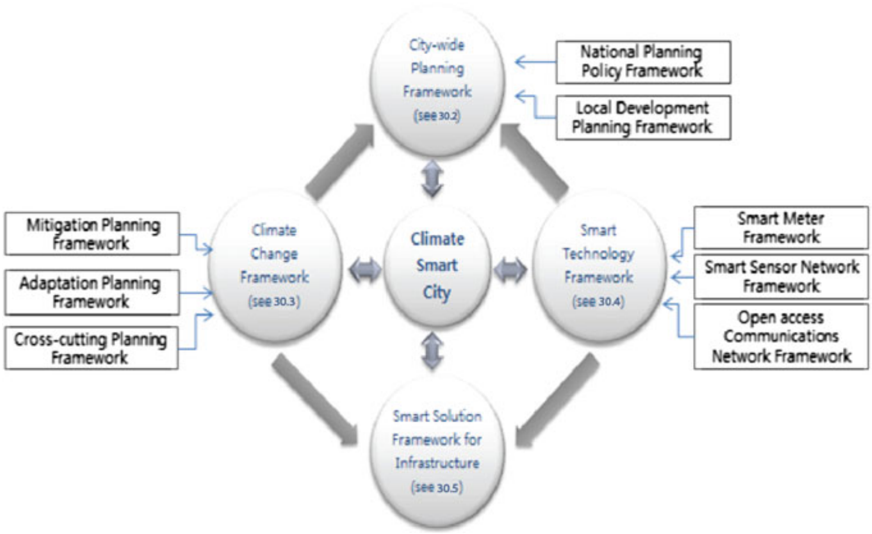


Fig. 7.2 Overall framework for the implementation climate smart city planning and development—key components and their connectivity

7.4.2 Enabling Planning Framework

Citywide planning framework (Fig. 7.3) aims to:

- Identify the strategic outcomes for a particular urban area (National Planning Policy Framework);
- Include measures that facilitate achieving the strategic outcomes;
- Coordinate and integrate community, state, and regional needs and wants (Local Development Framework);
- Include an urban infrastructure plan for major infrastructure projects;
- Include a structure plan for any master planned areas with the city government council area (master plan and site briefs); and
- Include detailed plans for site-specific areas (detailed plans)

City planning has to integrate and balance the economic, social, environmental, and climate needs and aspirations of the local community and climate change issues (Figs. 7.4 and 7.5)

Figures 7.4 and 7.5 seek to shift the focus from the planning process to delivering sustainable and smart planning outcomes with due considerations to climate change in cities.

Figure 7.4 shows two comprehensive climate-resilient and low-carbon smart city planning framework according to two different schools of planning theory for the climate change variables in terms of adaptive planning process, which means adapting to the future smart city issues. How ICT will be strategically integrated into this framework is described in Fig. 7.5.

Fig. 7.3 Integrated planning and reporting framework. *Source* http://haveyoursayrockdale.com.ad/draft-city-plan-2013-2025/photos7498

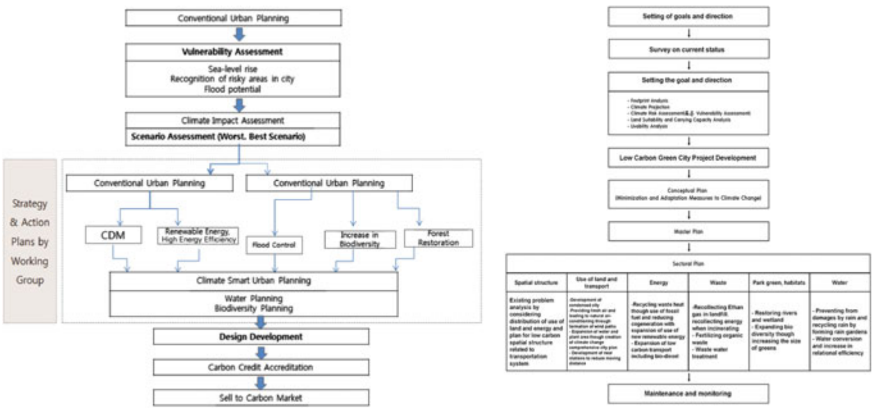


Fig. 7.4 Climate smart comprehensive urban planning model

As explained in Fig. 7.4, the new planning framework should also be accessible electronically, enabling Internet-based access to information in every aspect of the planning framework. Figure 7.5 also shows the interconnected nature of an integrated planning approach with meaningful collaboration among many disciplines or actors, bringing together planners, architects, engineers, scientists, and technology specialists who are key players, versed in the context of smart planning, as well as language of climate change.

Only by merging various ICT practices and utilizing the sustainable smart planning tools available to us can adaptation and mitigation for global climate change and smart solutions for infrastructure be strategically integrated into our future plans.

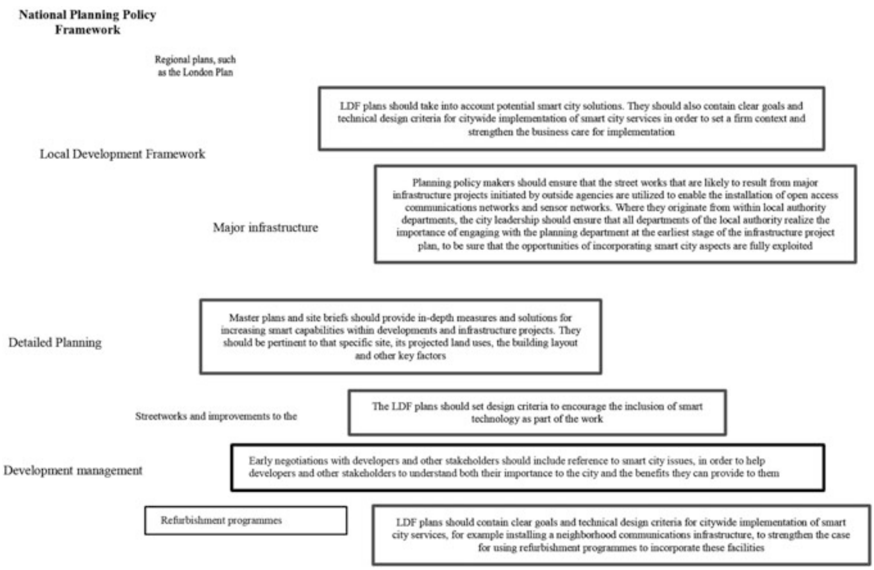


Fig. 7.5 Planning and development process—key recommendations. *Source* Fig. 150 from PD8101

Table 7.1 underneath shows how ICT and innovation tech can be used for smarter planning products. It includes the planning tools available in the broad context of planning framework described in this section. Many questions still remain to fill in empty boxes of Table 7.1. This table is a sample of mapping process, which obviously needs to be adjusted and refined to each case.

In Table 7.1, key ICT and innovation solutions provider is divided into hardware techniques, software programs, and networks and telecommunications. Network connectivity needs the necessary access facilities which consist of not only computer and telecommunication hardware, but also appropriate software (Web browsers, e-mail software, and so on), access to subscription service, maintenance, upgrade and repair service, and perhaps advice and technical consulting.

7.4.3 Enabling Climate Change Framework

Figure 7.6 shows a conceptual framework for a multi-dimensional urbanization climate change typology that considers the underlying causes of GHG emissions and climate change vulnerabilities. The framework can be used to guide global policy-makers, development agencies, and international associations of cities, researchers, and opinion-makers deciding which cities need the greatest support to face climate change challenges.

Land-use planning, urban transport, and housing policies are now recognized as major tools for the reduction of both greenhouse gases emission (climate change

Table 7.1 Illustrative application of ITC and innovation tech in planning framework

Planning framework	Planning tools	Key ICT and innovation tech solutions provider			Smarter planning products
		Hardware techniques	Software program	Networks and telecommunications	
Big data	Big data analytics	– Cloud computing or data center – Computer components – Power	– Application software (email, etc.) – System software (utilities and operating system) – Urban dynamic modeling – AR visualization – Scenario procedure – Renewal-time data inputs	– IoT – IoE – Wireless computing – Client server network	– Improving operational efficiency and competitive advantages over rival organization and other business benefits. – Changing fundamental aspects of life by giving it a quantitative dimension – Improving a database – Selling and sharing information and knowledge – Revolutionizing information – Identifying “criminals” before one actually commits a crime
Goals and technical design criteria for smart city services	Exploitation of opportunities of incorporating smart city aspects		– Smartphones – Webcams – Videos		– Revolutionizing information – Identifying “criminals” before one actually commits a crime
Site survey and analysis	– Collection of site-specific data – Data analysis – City GIS maps		– Real-time data inputs		– Increasing data volume
SWOT analysis					– Turning weaknesses into strengths – Turning threats into opportunities

(continued)

Table 7.1 (continued)

Planning framework	Planning tools	Key ICT and innovation tech solutions provider			Smarter planning products
		Hardware techniques	Software program	Networks and telecommunications	
Vulnerability assessment					– Feedback to implement additional security measures
Land-use planning	– Land sustainability and carrying capacity analysis – Land-use zoning – Smart growth management and control – Strategic environmental assessment(SEA)				– Feedback to smart zoning maps – Improving smart growth management and control plan – Increasing SEA value
Master plan	– The green building layout and other key factors – Smart capabilities within developments – Decision-making simulation		– Simulation procedure – AR visualization – Virtual climate smart city		Feedback to planning reflection of environmental and climate functions

(continued)

Table 7.1 (continued)

Planning framework	Planning tools	Key ICT and innovation tech solutions provider			Smarter planning products
		Hardware techniques	Software program	Networks and telecommunications	
Detailed plan for action areas	– Installment of a neighborhood communications infrastructure – Digital village and community – Smart transport – Smart parking – Smart park and green space system		– Installation of open access communications networks, digital meter, and sensor networks	– Mobile App – Platform	– Securing smart communication access
Development management	– Estate management – Cost-effectiveness analysis	Formulation of an effective hardware facilities for estate management	– Formulation of cohesive, sustainable, and innovative management structure		– Increasing value assets

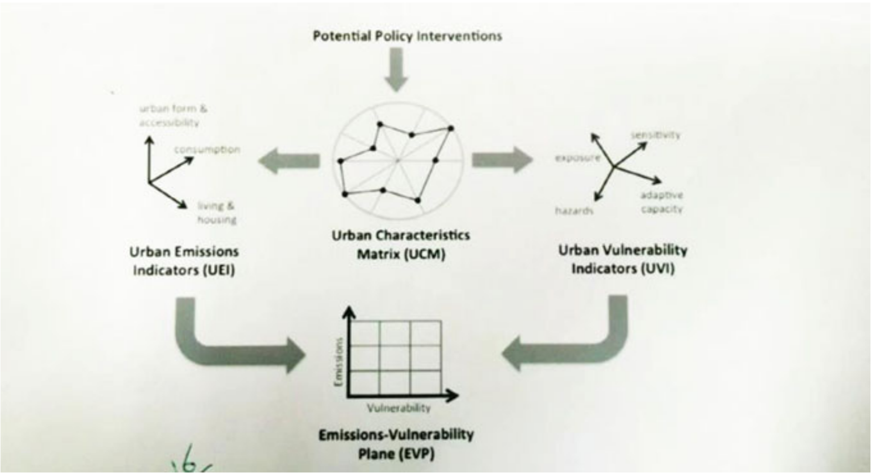


Fig. 7.6 Schematic of urbanization climate change typology framework (*UTF*). *Source* Solecki et al. (2015)

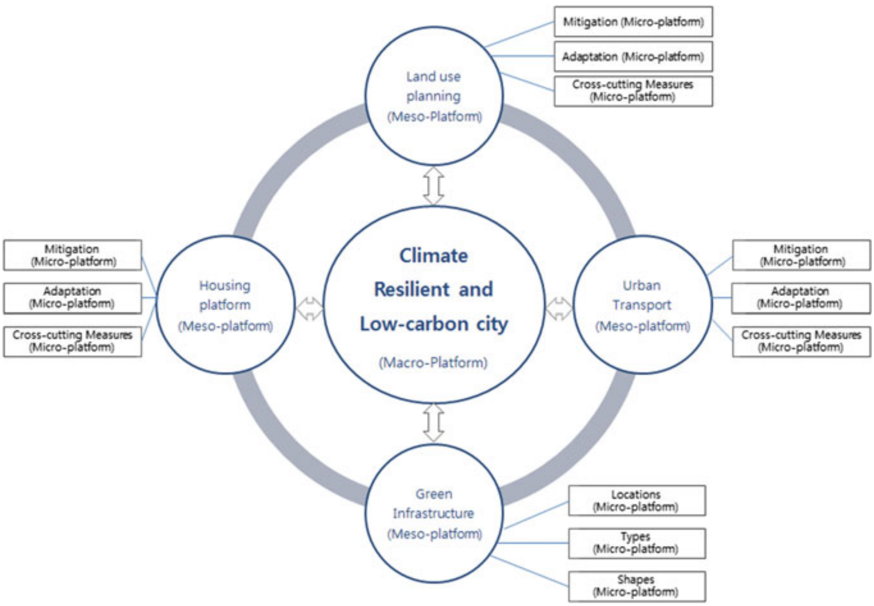


Fig. 7.7 Climate change framework

"mitigation") and vulnerability to climate change impacts ("adaptation" to climate change) (Fig. 7.7).

Table 7.2 indicates what ICT and innovation tech can be used for climate change action planning products. It includes the climate change action planning tools in the broad context of climate change framework depicted in Fig. 7.7.

Table 7.2 Application of ITC and innovation tech in climate change framework

Climate change framework		Climate change action tools	Key ICT and innovation tech solutions			Smarter climate planning products
			Hardware techniques	Software program	Networks and telecommunications	
Overall planning		– Climate prediction modeling – Carbon footprint – Climate action plan	– Tele-monitoring system of GHG emissions			– Feedback to improve urban ecosystem services – Improving GIS overlay with carbon overlay
Mitigation	Land-use planning	– Climate smart master plan – Climate smart land-use plan				– Feedback to improve local development plan
	Urban transport	– Climate smart traffic system	– Electric vehicles – U-Bike			
	Housing	– Energy efficient and green building – Eco-labeling	– Smart building system			
	Green infrastructure	– Energy and heat recovery from green infrastructure				
Adaptation		Integrated disaster risk management plan				
		– Early warning system	– Smartphone and I-phone	– Tele-monitoring program		– Providing smarter early warning system
		– Personal and equipment mobilization plan				
		– Emergency medical center availability				
		– Rescue operation				
		– Ambulance drivers				
		– Evacuation plan including precautionary evacuation	Precautionary evacuation			– Improving crime response rate – Raising cyber-defense
		– Crime prevention				
		– Food supply				
		– Blood supply				
		– Restoration projects				
		– Damage information		Big data analytics on damage information		Improving big data platform on damage information

Table 7.3 Climate tools and techniques suitable for Gangneung low-carbon green city

Climate change	Tools	Note
Mitigation	Renewable energy	Existing
	Heat and energy recovery from sewage treatment plant	Existing
	Bioethanol	Existing
	Geothermal energy generation	Existing
	LED light	Existing
	Reuse of rainwater and gray water	Existing
	U-Bike	Existing
	U-Eco-city	Existing
	Electric bus	Existing
	Subway	Existing
	Bio-mimicry	Existing
	Heat recovery	Existing
Adaptation	Bio-structural technique	
	Ecological conservation and restoration	Existing
	Greening	Existing
	Non-bio-structural	
	Ecological conservation and restoration	Existing

(continued)

Table 7.3 (continued)

Climate change	Tools	Note
Climate design	Climate smart urban basic plan	New
	Adaptive design	
	Total energy system design	
	Blue network design	
	White network design	
	Urban greening and green network design	
	Urban forestry plan	
	Climate smart traffic design	
	Water-sensitive design	
	Climate smart design	
	Resource circulation urban design	
	Habitat-sensitive design	
	Local identity creation	
	Smart eco-city	
	Cultural and ecological tourism city planning	
Climate tools	Climate prediction modeling	New
	Urban vulnerability and opportunity assessment	New
	Mitigation, adaptation, and crosscutting tools	New

(continued)

Table 7.3 (continued)

Climate change	Tools	Note
Implementation tools	Environmental and energy management audit system	New
	Economic tools (incentive, etc)	New
	Climate impact assessment	New
	Low-carbon green city fund	New
	Carbon footprint of city, complex, and building	New
	Accreditation system for building, housing and building complex and city	New
	Zero-carbon credit	New
	Eco-labeling	New
	Green electricity certificate	New
	Green thermal certificate	New
	Biodiversity credit	New
	Emission trading scheme(ETS) Carbon banking system Carbon bond Green Climate Fund(GCF)	New

Table 7.3 indicates what interventions were used for Gangneung low-carbon green city. In addition to the climate tools and techniques included in the low-carbon green city creation plan, new climate tools are added.

The Gangneung low-carbon green city comprehensive plan includes 10 specialized projects:

- Wetland ecological park and wetland ecological resource exhibition with coastal wetland, lagoon and freshwater wetland;
- Green growth development complex leading solar industrialization;
- Green growth industry complex;
- Low-carbon green hotels and Anhyun Solar ZED Valley;
- Solar building pilot complex (Gangneung Zed Beach Village);
- Green growth experience and learning center, as a landmark;
- Low-carbon green communities;
- Testbed for experimental low-carbon green technology;
- Demonstration areas of ecological restoration; and
- Company-owned Zed condominiums and a convention center.

7.4.4 Enabling Smart Technology Framework

According to the Climate Action newsletter (5 July 2016), Columbus in Ohio, USA, has beaten 78 other US cities to win the government's new Smart City Challenge. Several leading technology companies will assist Columbus in developing its smart city infrastructure, including Amazon Web Services, AT&T, DC Solar, Alphabets Sidewalk Labs, and NXP semiconductors.

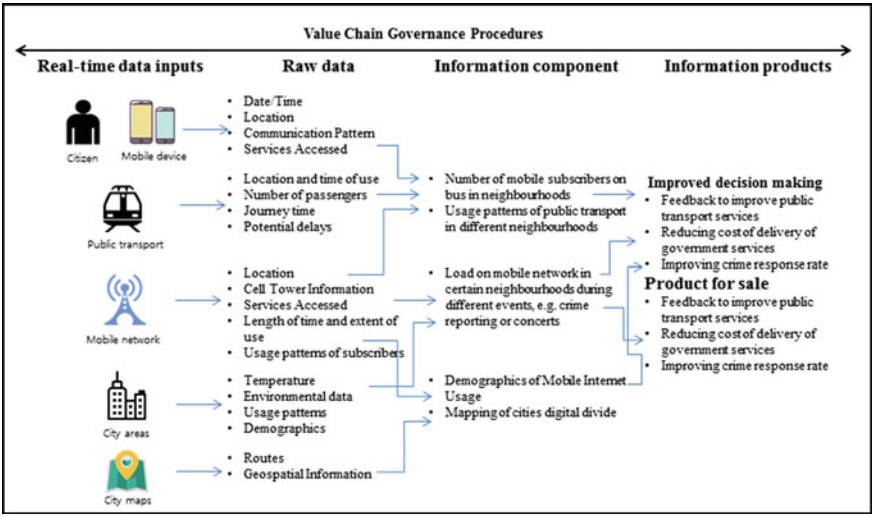
The smart technologies used in Columbus include data transportation analytics, building a rapid transit system (a 100 percent autonomous electric bus on three dedicated routes), smart LED lighting systems, EV charging stations, and vehicle to vehicle wireless communication data. One of the main features of Columbus Smart City is that the Midwestern city was up against seven finalists to win the US Department of Transportation's new award. To be a real climate smart city, smart technology framework for the city has to be expanded to include smart technologies for other sectors including land use, housing, and green infrastructure in an integrated holistic manner.

Table 7.4 depicts a complex system of smart cities which shows value chain governance procedures, while Tables 7.1, 7.2, and 7.5 are an extension of the system to include the ICT and innovation tech for planning, climate change, and infrastructure.

The tables shall be improved with emerging technology, innovative ideas from around the world, digital business transformation with respect to the tech industry and its worldview.

Other real-time data inputs and innovation tech may include smart grid applications, free backup software, high-speed telecommunications infrastructure, ESS, highly efficient solar photovoltaics, fuel cell, electric vehicle battery/charger, smart LED/OLED lightings, smart air-conditioner, highly efficient insulation

Table 7.4 Smart cities—a complex system



Source Information marketplaces, the new economics of cities

system, drone deliveries, digital signage, smart sensor, smart manufacturing, digital door locker, cameras (closed-circuit television: CCTV), and green car solutions.

Devices for real-time data inputs described in Table 7.4 can be deployed for the whole community with more smart connected systems of innovation and invention for a better life, as shown in Fig. 7.8.

7.4.5 Enabling Infrastructure Framework

The core elements/platforms of infrastructure framework for a climate smart city would include:

- Smart land use;
- Adequate water supply;
- Storm water management;
- Assured electricity supply;
- Wastewater and sanitation;
- Rainwater gardens;
- Solid waste management;
- Efficient urban mobility and public transport;
- Affordable housing, especially for the poor;
- Robust IT connectivity, digitalization, and visualization of virtual city (VR and AR);

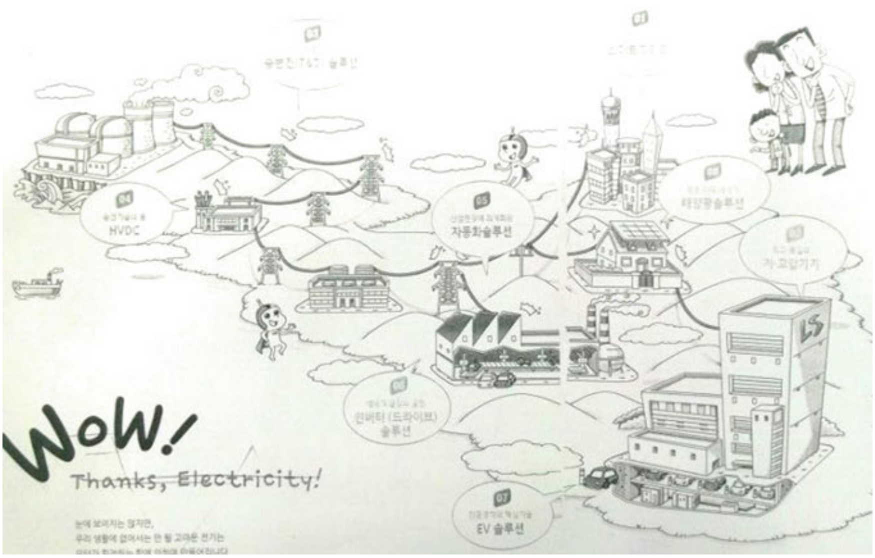


Fig. 7.8 Real-time data input developments. *Source* LS Industrial Electricity Company

- Good governance, especially e-Governance and Smart Citizen participation;
- Sustainable environment and climate change response (less GHG emissions and less vulnerability);
- Safety and security of citizens, particularly women, children, and the elderly;
- Smart healthcare and tele-education;
- Green space, parks, and ecological corridor; and
- Carbon financing.

As far as climate smart solutions are concerned, an illustrative list is given above and the connectivity of smart city elements is shown in Fig. 7.9. This is not, however, an exhaustive list, and cities are free to add more applications.

The climate smart city aims to the clarity, equity, and consistency of the local government infrastructure planning and development, and could best support a growing, sustainable, climate friendly, and prosperous city. There is a close relationship between planning, climate change, ICT, and infrastructure framework.

Table 7.5 contains possible areas for application of ICT and innovation tech in infrastructure framework that strikes a balance between climate change, sustainability innovation, and property development feasibility in the city planning schemes.

A local government climate smart infrastructure plan is the part of a planning scheme that identifies the city's plans for trunk infrastructure that are necessary to urban development at the desired, safe, and carbon-free standard of service in a coordinated, efficient, and financially sustainable manner. Table 7.5 also shows possible smarter infrastructure products which can be obtained with key ICT and innovation tech for infrastructure framework and tools contained in Figs. 7.10 and 7.11.

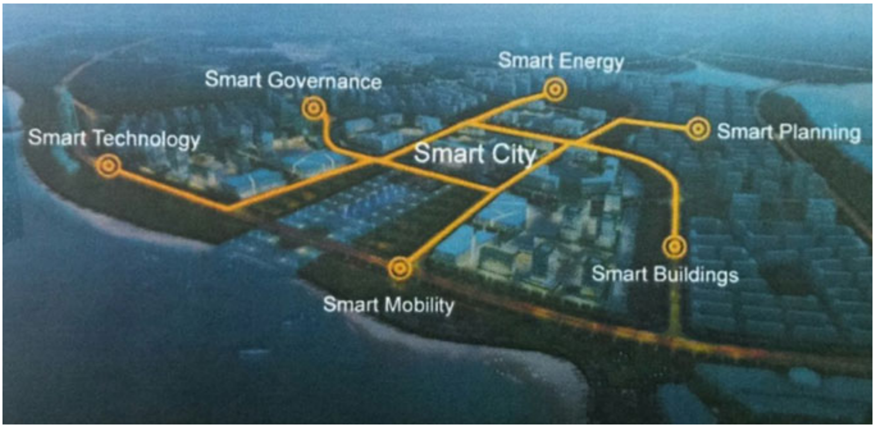


Fig. 7.9 Overlay of smart city elements. Source http://www.livetradingnews.com/kuwait-plans-smart-environmentally-friendly-city-1000

The fusion of information technology (IT) and ubiquitous urban information is necessary to enhance climate smart cities' role as a platform (Fig. 7.12).

7.5 Partnership Platform

Partnership platform can provide logistic solutions for better planning, responsive climate change actions, efficient infrastructure, and ICT innovation in an inspiring and proactive participatory approach. It seeks to significantly accelerate the city-scale rollout of climate smart city solutions integrating technologies from energy, transport, buildings, and city planning. This is where there are considerable untapped innovation potentials and climatic and socioeconomic benefits to be gained.

There are important linkages between the sustainable development, climate change impacts, infrastructure, and strategic use of ICT issues each city confronts. The interconnected nature of these issues requires an integrated planning approach with meaningful collaboration among many disciplines. The diversity of disciplines would be a great strength for the creation of climate smart cities (Fig. 7.13).

The Open Innovation Call initiative was developed by Climate-KIC in partnership with one of its Nordic partners, the City of Copenhagen. Climate-KIC is the EU's largest public–private partnership addressing climate change through innovation to build a zero-carbon economy, supported by the European Institute of Technology. It brings together cities, industry, and researcher to provide solutions on how urban life can improve through more practical and sustainable integrated solutions. The model of the partnership around the initiative is illustrated below (Fig. 7.14).

Figure 7.14 conceptual model over partnership: smart citizen platform developed by Climate KIC that is depicted in the form of macro, meso, and micro-platforms

Table 7.5 Application of ICT and innovation tech in infrastructure framework

Infrastructure framework	Infrastructure tools	Key ICT and innovation tech solutions provider			Smarter infrastructure products
		Hardware techniques	Software program	Networks and telecommunications	
Land use	• Growth management and control • Zoning • Digital village and community design	• Digital meters • Digital sensor tech		• Heat distribution network • Electricity supply network • Internet	• Feedback to fragmentation and recombination of established arrangements, building types, and urban and regional land-use patterns • Increasing privacy and own spaces • Separating incompatible activities
E-Governance and citizen services	• Both wired and wireless networks for transfer of information				• Transferring technology • Loosening the linkages between activities that had previously required face-to-face interaction
Water management	• Smart meter grid system • Pipe and duct networks for water supply • Water, energy, and food nexus analysis			Tele-monitoring system of water quality	• Tapping climatic and socioeconomic benefits • Feedback to local government-integrated efficient water infrastructure plan • Feedback to heat, energy, and resource recovery plan • Improving water big data
Waste management	• Waste disposal	• Landfill gas power generation project technique			
Energy infrastructure management	• Gas supply • Wire networks for electrical energy distribution	• Energy information technology		• Innovation in computer networking	Reducing cost of energy

(continued)

Table 7.5 (continued)

Infrastructure framework	Infrastructure tools	Key ICT and innovation tech solutions provider			Smarter infrastructure products
		Hardware techniques	Software program	Networks and telecommunications	
Green buildings	• Smart materials • Insulation • Renewable energy				• Increasing real estate value • Increasing building resilience
Urban smart mobility	• zero-emission electric motorcycle • Integrated transport system			Techniques for a network infrastructure that connects city together	• Feedback to improve transport services
Climate planning and management	• Integrated disaster risk management • Climate action plan	• Low-cost air pollution monitoring sensors			• Making climate smart planning and management decision
Green space and parks	• Smart connected green space and park system				• Capitalizing views of natural features and landscaped open spaces, and greeneries as a form of value creation within the master plan • Increasing the ecological value of a development site

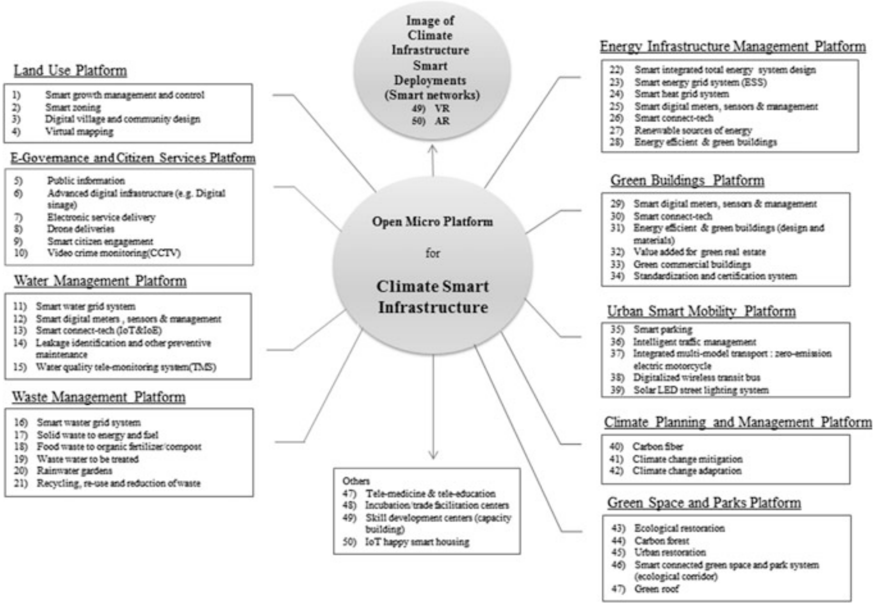
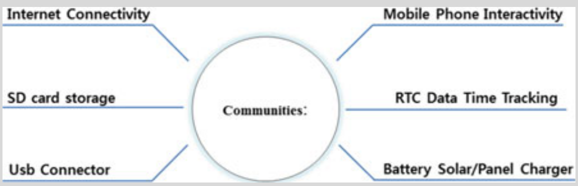


Fig. 7.10 Infrastructure framework for climate smart city planning and development

for schools, citizen science, and comminities. *Source* http://www.climate-kic.org/news/smart-building-and-city-logistics/.

Smart Citizen (Fig. 7.15) is a platform to promote participatory processes of people in the cities through connecting data, people, and knowledge. The objective of the platform is to serve as a node for building productive and open indicators, and distributed tools, and thereafter the collective construction of the digital city for its own inhabitants, as described below.

Schools (Meso-Platform)
Data could be a very powerful education tool. Use Smart Citizen hardware and software tools to teach computer science and environmentalism in your classroom. Open discussions about the environment quality at schools. Sensors and data should be used in the education sector. Some applications: Smart Schools Workshop at TEN Centre.



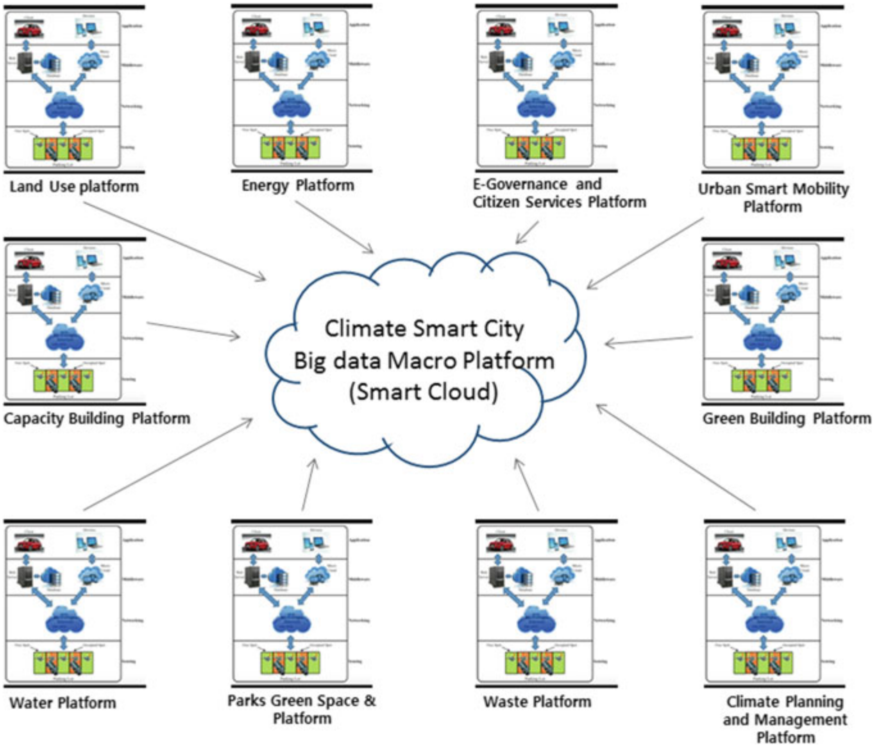


Fig. 7.11 Climate smart city big data macro-platform (smart cloud)

Citizen Science (Meso-Platform)
Reduce the gaps to get data captured and streamed by sensors. No more cables, shields, and libraries in order to get valuable data from the environment. Analyze the data online, or download it to put it in your preferred tool. Some applications being used as a tool for citizen science: CitSciKS, Waag Society (noise levels evaluation).

Communities
Launch a crowd sensing initiative in your neighborhood. Use our sensors and platform to create local maps of air quality or sound problems; use them to report to your city council or to raise awareness of issues that matter for your community. Some applications: University of Glasgow and Kosovo science for change.

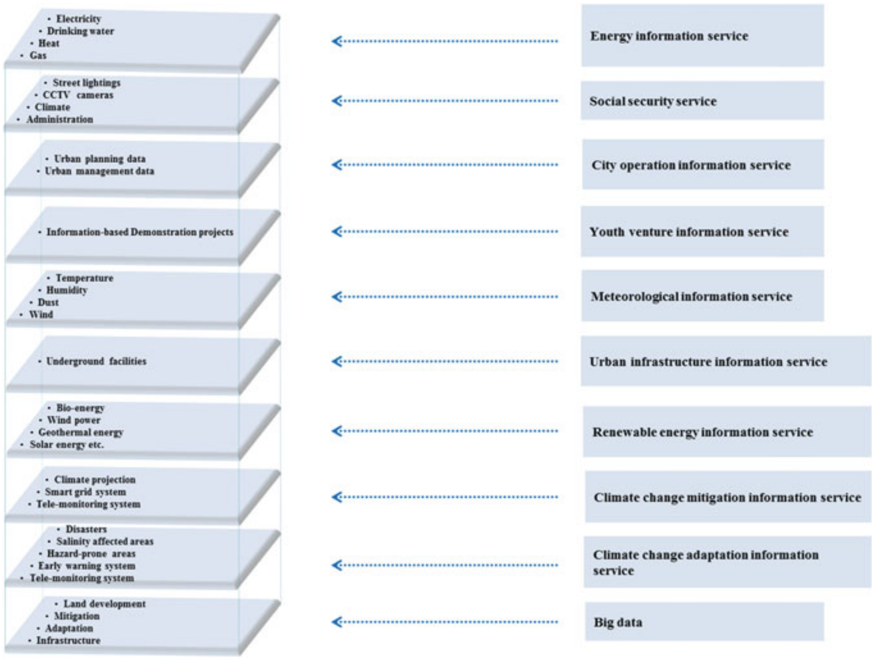


Fig. 7.12 Fusion of information technology (IT) and ubiquitous urban information: the digitalized connection of climate smart cities: an example

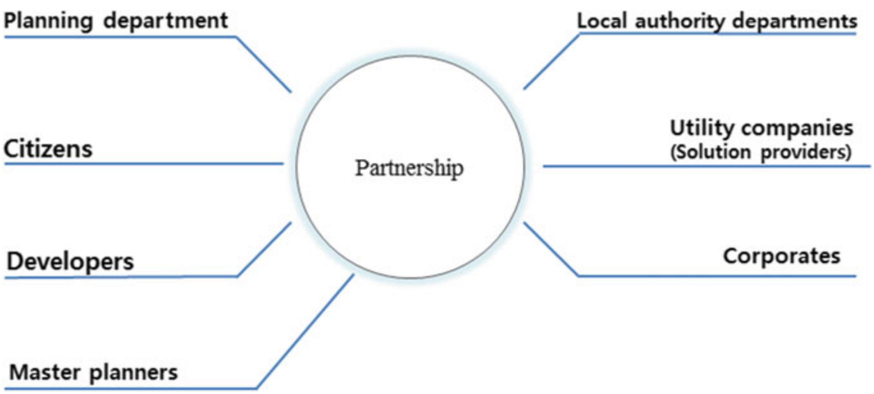


Fig. 7.13 Partnership platform

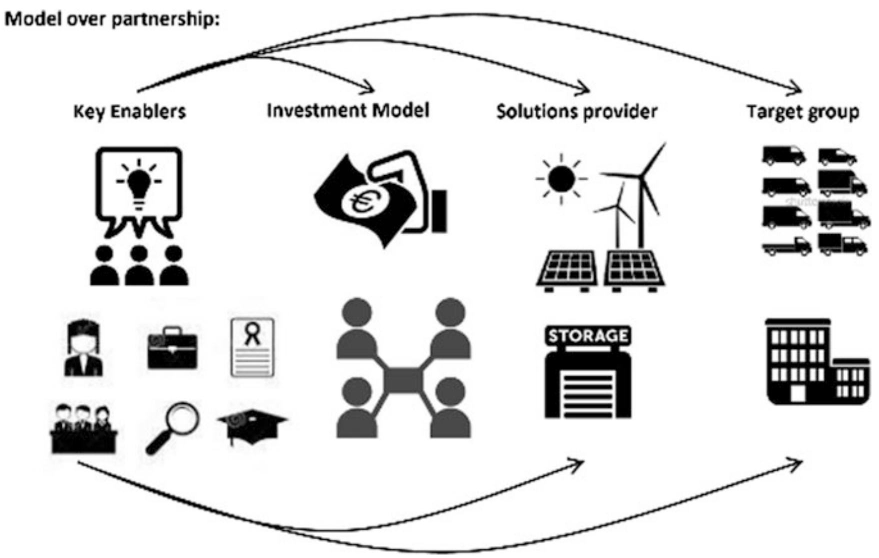


Fig. 7.14 Conceptual model over partnership. *Source* http://www.climatic-kic.org/news/smart-building-and-city-logistics/

Fig. 7.15 Smart Citizen platform example: macro-, meso-, and micro-platforms. *Source* Smart citizen: open source technology for citizens political participation in smarter cities (http://smartcitizen.me/)

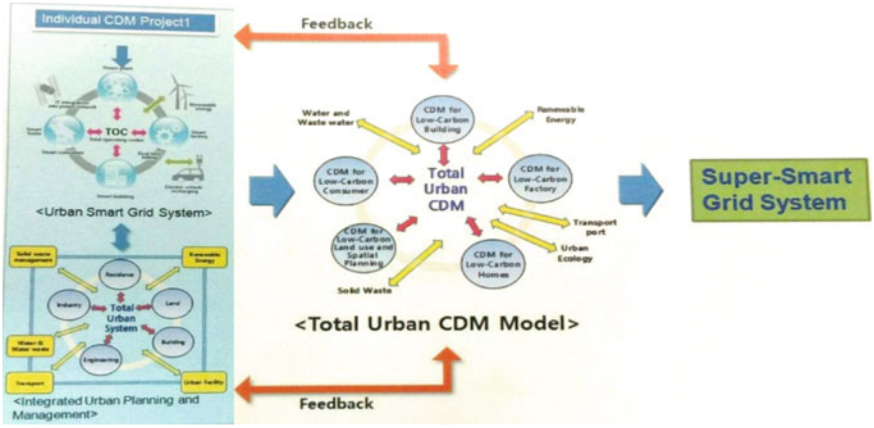


Fig. 7.16 Integration of a total Urban CDM model with super smart grid system

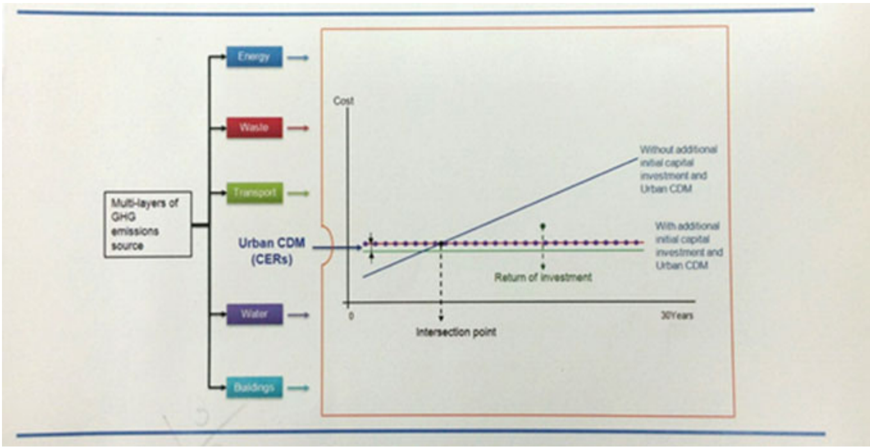


Fig. 7.17 Conceptual multilayers of financial modeling by GHG emission source

Real-time ambient monitoring for climate data by sensors includes:

- Temperature: Micro-platform
  (Web site:)
- Light: Micro-platform
  (Web site:)
- Carbon Monoxide: Micro-platform
  (Web site:)
- Nets: Micro-platform
  (Web site:)

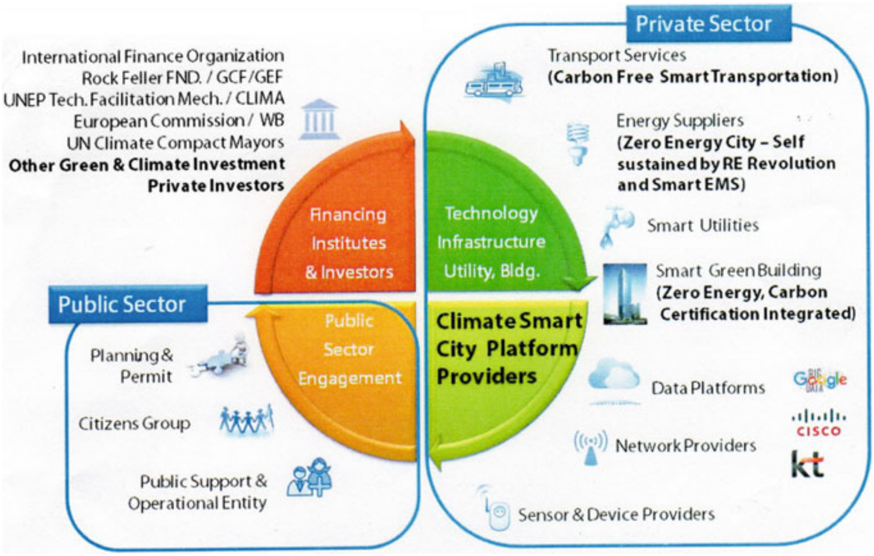


Fig. 7.18 Integration for the climate smart city platform partners

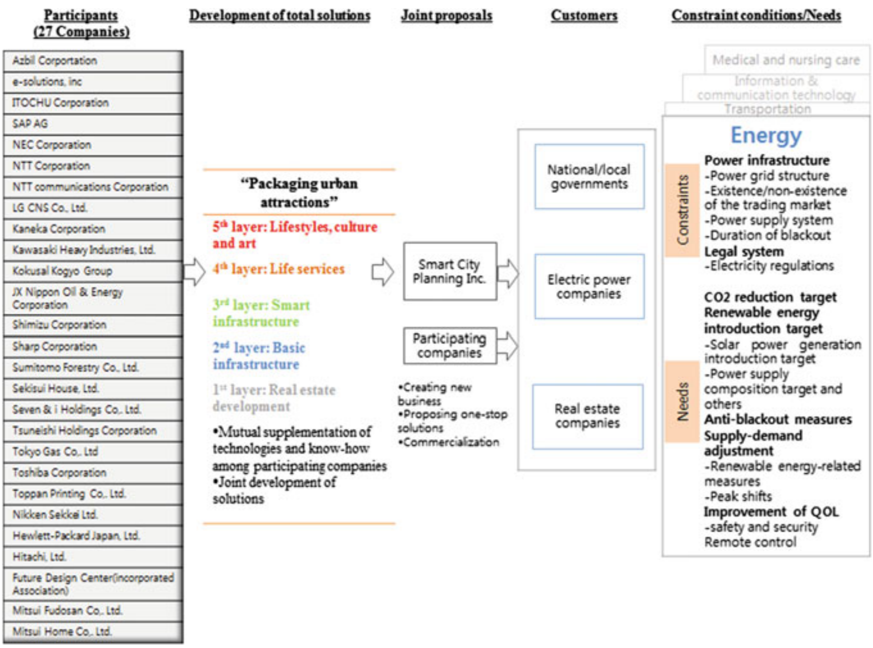


Fig. 7.19 Business model provided by the smart city project. *Source* http://www.smartcity-planning.co.jp/en/outline/03.html

- Humidity: Micro-platform
  (Web site:)
- Sound: Micro-platform
  (Web site:)
- Nitrogen Dioxide: Micro-platform
  (Web site:)
- Solar Panel: Micro-platform
  (Web site:)

Cities (Meso-Platform)
Smart cities should be built together with Smart Citizens. The construction of new infrastructure is not only possible thanks to a massive investment on new technologies, but also could be done through the better optimization of the existing resources. Co-create with your citizens, and include participation in the political life in the everyday city. Cities participants: Amsterdam, Manchester, and Barcelona

Developers (Meso-Platform)
You can build on top of our platform and hardware. Smart Citizen is totally open source, so feel free to download our frameworks and designs, and build new ones on top of them. Share your contribution with all the community, build your own solutions and be part of the development team.

7.6 Preparation of Carbon Financial Plan for Application of ICT and Innovation Tech in Climate Smart City Planning and Development

Cities are driving the economy. Cities are where people want to live, invest, and work. That is why cities are focal points in a future digital economy. Strategic use of urban CDM (U-CDM) and new carbon market mechanisms can help to implement climate smart cities by lessening economic burden and will be an efficient stimulus for digital transformation. They can be used as a mechanism of value capture to finance smart urban planning which integrates climate change, ICT, and infrastructure for streamlined market. This is good use of ICT.

The urban smart technologies that every climate smart city should have can secure additionality for the urban CDM. However, it has to be scientifically evidenced according to the new CDM rules and regulations.

The urban CDM modality and procedure are compared with conventional CDM, GHG projection diagnostics program (GPD), and carbon banking system, and expanded PoA in terms of inventory, monitoring, reporting, and verification (MRV), etc. (Table 7.6).

Table 7.6 Comparison of Urban CDM modality and procedure with conventional CDM, GHG projection diagnostics program and carbon banking system, and expanded PoA

Contents	Conventional CDM	Urban CDM	GPD and CBS	Expanded POA
Inventory	• Selection of inventory year • Selection of scope of GHG (direct/indirect emissions) • Measurement with equipment	• Calculation • Modeling estimation by situation analysis	• Billing system	• Selection of inventory year • Selection of scope of GHG among expanded projects (direct/indirect emissions) • Combination of measurements with equipment
Standardized baseline	• Constant level of emission	• Considerations for population and economic growth, etc.		
Reduction activities	• Prioritizing reduction projects	• By project • By sector • By multi-sector • Expanded or combined		• By project • By sector • By multi-sector • Expanded or combined
Modeling and regression	• Use of existing methods approved by UNFCCC	• Use of existing methods approved by UNFCCC • New methodology	• Analysis on projected GHG emission by using GPD • Development of projection equation through analysis of electricity/city gas/drinking water consumption	• Use of existing methods approved by UNFCCC • New methodology – Approach in the aspect of urban aggregation
Accounting	• Carbon markets implemented at the national or regional level	• Carbon markets to be implemented at the city level – Compliance market – Voluntary market	• Preparation for the access to carbon market	
Additionality	• Additional initial capital investment	• Additional initial capital investment	• Additional initial capital investment	• Additional initial capital investment
MRV	• Submission of MRV report • Verification/certification	• Submission of MRV report • Verification/certification	• Submission of MRV report • Verification/certification	• Submission of MRV report • Verification/certification

The integrated total Urban CDM model can be extended to include the model at regional, continental, and global levels with super smart grid system as depicted in Fig. 7.16.

As shown in Fig. 7.16, the integrated total Urban CDM model is very useful to understand interrelationship between energy suppliers and consumers, and between built form, urban infrastructure, and CDM and technology mechanism for them. The Urban CDM is a business. Therefore, the methodology of financial modeling of the Urban CDM incorporates the basic project approach of firstly identifying the carbon reduction solutions and quantifying the associated emissions, and then modeling the identified additional cost (additionality) to be credited with the Urban CDM.

Conceptual multilayers of financial modeling by GHG emission source are shown in Fig. 7.17. Financial calculations include internal rates of return (IRR), payback periods, net present value, cash flow, cost-effectiveness analysis, and extended cost-benefit analysis (Fig. 1.34).

This model can be used for solution to reduction actions viability decision. If the cost of reducing CO_2 emissions from the traditional technology is included in the cost calculations, an environmentally better solution would be more cost-effective than the traditional one from a macro- and/or micro- economic point of view in the long run.

There should be new streamlined ways for international and national designated entities to amend their schemes, to reflect these changed circumstances, to compensate the mainstream of planning, and thus to combat climate change at the city-scale.

Additional funding should be directed at emissions reduction in the form of the Urban CDM to create opportunities for achieving a less carbon-intensive and less vulnerable future for cities.

7.7 Implementation Arrangements: A Climate Smart Business Model

Smart cities are booming all over the world and becoming a global business from which profit rises. Climate smart city ideas are becoming reality with digital business transformation.

7.7.1 Market Opportunities

Mobile business booms. The smart city concept is not only a series of technical issues, but also social and business issues. Sustainable investment is progressively growing as stated below:

- The UNEP inquiry concluded that $53 trillion needs to be invested to achieve the aims of the Paris Climate Change Agreement.

- Ban Ki-moon has urged global business leaders to double investment in wind and solar energy to $600 billion a year by 2020.
- The Green Infrastructure Investment Coalition aims to scale green bond investment from $40 billion to $1 trillion (Climate Action, 20 July 2016).
- The global smart cities market is estimated to reach $1.4 trillion by 2020, as cities embrace new advancements in smart lighting, energy efficiency, water and waste management (Climate Action, 5 July 2016).

7.7.2 Responsible Smarter Investment Model

Establishing the business model for climate smart cities might mean thinking and advertising concepts and approaches that might not sound very enticing to investors.

Investment models need to embrace supply and demand change management, solid return-on-investment solutions, smart grid deployments, smart meter infrastructures, and digital communications networks. There should be real business mechanisms for implementing these components into a climate smart city, as already described in the previous chapters. The proposed grid model is the key to define and coordinate for a smart planet.

Example modalities of smarter investment with ICT solutions are given below for value added:

- Knowledge-based economy
  - ICT investments promote building of big data.
  - ICT investments attempt to transform the city into a knowledge-based economy by nurturing innovation and creativity in all citizens.
  - ICT investments accelerate economy and connect citizens to business.
- Sustainability, Circularity, and Connectivity improvements
  - ICT investments achieve Post-2015 Sustainability Development Goals and implement Paris Climate Change Agreement.
  - ICT improves IoT and IoE connection.
  - ICT promotes circular economy.
- Climate Economy
  - ICT investments promote climate change solutions.
  - ICT investments attract more green bank businesses.
  - ICT investments transform smart city into climate smart city.
- Planning Innovation
  - ICT investments stimulate interactive planning innovation solutions to anticipate future challenges.

- ICT investments provide opportunities for smart grid testbed including smart power grid, smart electricity service, smart places, smart transportation, and smart renewable.
- ICT investments replace the use of fossil fuel and cut GHG emissions.

• Cost Cutting/Efficiency Improvements

- ICT investments relate to reduction in GHG emissions and vulnerability, and enhance industrial competitiveness.
- ICT investments promote cost-effective public–private partnership (P3s).

• High Market Value Addition

- ICT investments create added value to goods and services and also generate positive externalities of low-carbon economy for the private sector.

• Integrated Solutions for Urban Development and Infrastructure Projects

- ICT investments promote the cross-benefits or nexus of energy, transportation, buildings, food, water, and waste toward sustainable urban development.
- ICT investments secure smart energy and water deployments for supply and demand change management.
- ICT investments facilitate transformation of energy system and standardization of integrated solutions.

• Additionality of climate projects

- ICT investments develop cutting-edge green technology, including carbon calculators for carbon accounting and carbon pricing and use of VR and augmented reality (AR) for digital cities.
- ICT investments increase real estate value of green infrastructure and buildings.
- ICT investments increase technical additionality of Urban CDM projects, carbon banking system, and compensate their cost.

• Revenue Generation

- ICT investments generate new or increased revenue streams for private sector companies.

• Job Creation

- ICT investments create new jobs for public and private sector companies.

• Global Research and Development

- ICT investments encourage more global research and development on climate smart city software and hardware industry.

- Standardization and Optimization of Urban Services
  - ICT investments standardize climate smart city industry.
  - ICT investments optimize dynamic modeling for climate smart city projects.
  - ICT investments provide “Total Optimization” through the provision of a “One-Stop Total Solution” suitable for the city.
- Law and Guideline Establishments
  - ICT investments establish statutory guidelines for climate smart cities.
- Virtual Reality (VR) and Augmented Reality (AR)
  - ICT investments reduce social cost of diverse experiences.
  - ICT investments promote development of platform for VR and AR experiences, VR and AR commerce, VR and AR entertainment, etc.
  - ICT investments enable the fusion of VR and other technologies.
  - ICT investments make city smarter.
- Digital Economy
  - ICT investments realize the fourth industrial revolution with AI for social goods.
  - ICT investments promote FINTECH OPEN PLATFORM.

7.7.3 Public–Private Partnership (P3s): Cost-Effective PPP Business Model

Climate smart city offers new solutions to climate change and investment issues. To efficiently implement smart innovation projects, we have to look at new mechanisms to improve the economic value of a city.

In traditional urban planning, developers invest their own funds to develop a city, after obtaining the necessary permission and approval from the national and local governments. The developers can add value to the city by creating and implementing attractive plans including strategic and master plan, detailed plan, and action area plan.

In climate smart city projects which aim to transform smart city into climate smart city, participating companies can propose a joint proposal for “one-stop total solution” for the creation of a climate smart city as solution providers, thereby adding even more value to the city (Fig. 7.18). With this global business model, new industry platforms for climate smart city planning and development can be developed through package programs of big data, financial consulting, and public–private partnership.

7.7.3.1 Potential International Participating Organizations for Funding

Funding climate city projects is the key for implementation of the PPP business model. The proposed platform for climate smart city could provide the Rock feller Foundations, GCF, GEF, UNEP Technology Facilitation Mechanism, Director General of CLIMA, European Commission, World Bank, the U.N. Climate Summit Compact of Mayors, green funds, and interested cities additional information for funding directed at emissions or vulnerability reduction, and create opportunities for achieving a less carbon-intensive and less vulnerable future for cities.

7.7.3.2 Examples of P3s for Model of Green Business/City Consortium

Business model provided by the Smart City Project for Flagship Project "Kashiwa-no-ha Smart City," Japan

In order to provide a model for solving a problem commonly faced by world cities, Kashiwa-no-ha Smart City was created under the Smart City Project in 2014, through collaboration between the public sector (Chiba Prefecture and Kashiwa City), private sector (companies and citizens), and academia (the University of Tokyo and Chiba University) (Fig. 7.19). Based on the three themes "Environmental-Symbiotic City," "City of Health and Longevity," and "City of New Industry Creation," Kashiwa-no-ha Smart City was to be developed as a sustainable smart city, where people of all age groups, including both children and the elderly, can lead their lives safely and with ease of mind.

Model of Columbus, Ohio, USA

Columbus, Ohio, USA, will be a model city to provide innovation solutions for new smart city challenges through P3s. Example companies which will assist Columbus city in developing its smart city infrastructure include:

- Amazon Web servers;
- AT&T;
- DC solar;
- Alphabets Sidewalk Labs; and
- NXP semiconductors.

Model of Goyang City and Ministry of Science, ICT and Future Planning, Korea

This is a bold, new initiative. In order to provide a tested model for creating a sustainable IoT-integrated smart city, Goyang city will implement well-established urban IoT service package program.

This program aims to solve problems commonly faced by cities through the strategic use of open smart city platform.

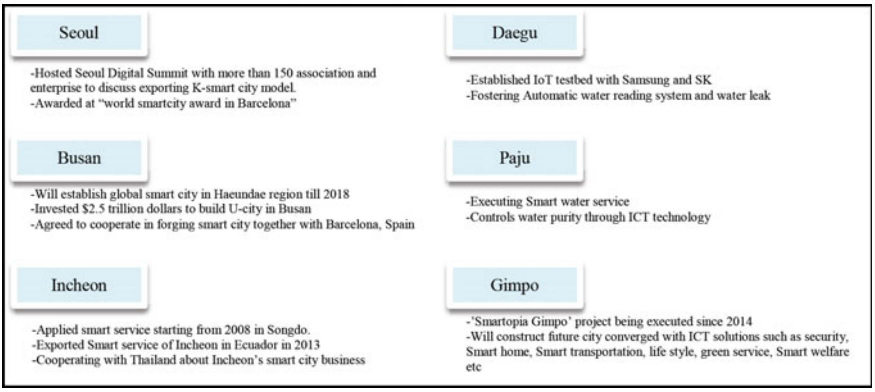
Goyang Smart City will be created under the Smart City Project supported by the Ministry of Science, ICT and Future Planning of Korea, through the consortium of six companies and institutes between the public sector (Goyang city and Goyang Knowledge and Information Industry Promotion Institute), private sector (LG U+), and research institutes. Based on the four themes "City of Smartness," "City of Safety," "Environment City," and "Energy Saving City," the city will be developed as an IoT-integrated city, which will be a smart solution provider.

Goyang city agreed to establish "Happy hope city" as a smart city supporting IoT solutions in May 2016 and was selected by the government in June 2016.

The city will foster the Korean Silicon Valley (Goyang Techno-Valley) and has hosted the Smart Cities Innovation Summit Asia, for the first time in Korea, in September 2016.

Model of Other Smart City Projects in Korea

The achievements and milestone of smart cities promoted by Korean cities include:



In a recent seminar on climate change preparation projects (CCPP) utilizing the GCF in Korea, climate change business models have been suggested as follows:

- Project for combining new and renewable energy and ESS;
- Environment-friendly energy town project;
- Electric vehicle project;
- Smart farming project;
- Water resources management project;
- Forest project; and
- Knowledge-based economy

Source: Korea Ministry of Strategy and Finance, Convention center, Songdo, 6 September 2016.

Model of Digital Neighborhood Project, Kabul, Afghanistan

In order to provide a model for solving postwar housing shortage problem in Afghanistan, the Kabul Digital Neighborhood Project is expected to be created under the Korea International Cooperation Agency (KOICA) Program, through collaboration between the public sector (Afghanistan Government and KOICA), private sector (companies and citizens), and research and training institutes (International Urban Training Center and Afghanistan Housing and Urban Development Institute.)

This project requires the development and application of a digital neighborhood model designed for total solutions for social change and resource availability as the result of the war. The model will incorporate fabricated housing techniques which is one of the appropriate technologies in Afghanistan. Other sub-models may be developed for land-use allocation and land-use activity management, site and building design.

Model of Smart, Environmental-Friendly City, Kuwait

Kuwait has unveiled plans for what is claimed to be the first smart, environment-friendly city in the Middle East.

South Saad Al-Abdullah city has been designed to accommodate 400,000 people over an area of 59 km^2 with more than 30,000 housing units, according to state news agency KUNA.

The government has signed a memorandum of understanding with the LH to conduct a feasibility analysis of the project and form a joint company with the Public Authority for Housing Welfare (PAHW) for design, construction, and operation.

The new city will be 40 km west of the center of Kuwait and is estimated to cost $4-B, according to reports earlier 2016.

It is described as including an Internet network that will connect all of its inhabitants with public services.

Solar cells are also being considered to power the project, and the overall design is described as avoiding “visual pollution” by forcing inhabitants to use specific colors for buildings.

Restrictions on building design and construction materials also be imposed.

Implementation began in February 2017.

The Kuwait government plans to provide 120,000 housing units for citizens annually over the next 10 years, according to KUNA.

Other major projects include South Multa, which will house 400,000 citizens with 30,000 housing units. Building of infrastructure and roads for the project is expected to cost KD 288 m ($954.7-M).

> Under the deal, LH will draw up a comprehensive plan and conduct a feasibility analysis in creating the city and, together with PAHW, set up a special purpose vehicle (SPV) to jointly invest and build the development. The SPV Company will be in charge of designing, construction, and operation of the city.

http://www.livetradingnews.com/kuwait-plans-smart-environmentally-friendly-city-1

7.7.4 Timeline and Budget

7.7.4.1 Timeline

It is suggested that proposals to implement the activities described in this proposed platform will be prepared as early as possible in many cities around the world on the basis of international partnerships. With the smartest techniques available, many things could happen at the city-scale under the Paris Agreement and other international agreements in due course.

7.7.4.2 Budget Preparation

An indicative budget for the activities described in this platform can be prepared by using Table 7.7.

We live in the digital era with the fourth industrial revolution. Let's connect cities to the digital economy solutions. In this regard, smart city can be defined at two different levels to capitalize on it:

1. Smart city by broad definition
   - City of New Industry Creation
     - Supporting local start-ups that employ smart technologies;
     - Fostering new industries that can underpin a digital economy;
     - Operating smart connected factories; and
     - Creating a world leading city of innovation and invention start-ups.
   - Climate Smart City
     - Facilitating low carbon and less vulnerable urban infrastructure;
     - Climate-related measures; and
     - Creating new market mechanisms for carbon financing.

Table 7.7 Step, activities, responsible or participating agency, budget, and timeline: an investment proposal

Step	Activity	Participating agency	Budget	Timeline
1. Pre-planning	1. Formation of project team (climate smart city consortium) 2. Capacity building training			
2. Project planning & design	3. Identification of participating cities 4. Preparation of the master plan and site briefs for the selected climate smart city 5. Preparation of the detailed plan for the action area 6. Selection and design of infrastructure projects			
3. Financial analysis	7. Cost-effective analysis 8. Additionality analysis • Technical additionality & non-technical additionality • Financial additionality			
4. Development management	9. Construction 10. Supervision			
5. Operation	11. Overall project operation/maintenance 12. ICT operation			
6. Monitoring	13. Monitoring of ICT operation 14. Monitoring of GHG reduction activities 15. Quantification or estimation of the cumulative volume of the reduced emissions, compared with the "business-as-usual (BAU)" baseline level of emissions 16. Reporting and validation of monitoring data/information.			
7. Marketing	17. Selling and transfer of development products 18. Selling and trading of certified emission reductions (CERs)			
8. Evaluation	19. Periodic project evaluation 20. Feedback to project operation			
9. Project finalization	21. Final project reporting			

- Smart Eco-city
  - Creating a city of coexistence and coevolution of nature and human beings; and
  - Enhancing urban ecosystem goods and services using information and communication technologies.

2. Smart city by narrow definition
   - Centralizing regional energy and resources management;
   - Conserving, creating, and storing energy;
   - Encouraging sustainable localization in food, energy, water and waste nexus; and
   - Maintaining lifetimes even during disasters.

This platform proposed in this chapter has suggested a number of programs and projects that could be implemented through climate smart city policy. It is expected that the climate smart city platform will be transmitted into practices, both technically and commercially.

References

Climate Action, 5 July 2016
Climate Action, 20 July 2016
Soleki W et al (2015) A conceptual framework for an urban areas typology to integrate climate change mitigation and adaptation. Urban Climate. doi:10.1016/j.uclim.2015.07.001

Chapter 8
Future of Climate Smart Cities

Abstract This chapter considers possible future developments in climate smart cities. Some positive directions to move forward will be characterized by a shift in global planning paradigms, more development of smart connect-tech and testbeds, political will, new guidelines and legislation for climate smart city planning, active public participation in all phases of climate smart city planning processes, current and future research development efforts. Increased connectivity and use of IT platforms, Internet-based data and analytics will increase cyber-vulnerabilities. As such, cities, city governments and planners, and citizens will have to actively explore and devise ways to prepare and protect themselves against cyber-threats. How governments can respond to these new multilayer threats will be a particular challenge.

Keywords The fourth industrial revolution · Basics · Socioeconomic divide · Digital neighborhoods · Laws · Sustainable innovation · Climate smart city indicators · De-risking cities · Driverless cars · Digital interactive design · Moral imperative · Testbeds

Cities could be much smarter with the introduction of smart digital techniques including artificial intelligence which has been evolving through self-learning in order to respond to the fourth industrial revolution. It is time to find innovative and effective ways of connecting smart-tech with the eco-city ideas and challenges of climate change. Smart climate urbanism is a new tenet of urbanism for urban planning. Connections between climate, smartness, and business in cities are a tripod but their developments are still at the infant stage.

Open dialogues are needed for debate on challenges and opportunities for climate smart cities.

8.1 Basics

Basic components of climate smart city planning include guidelines and acts, knowledge of the planning, framework, planning methodology and tools, technologies, financing, and an interdisciplinary team for implementation.

K.-G. Kim, *Low-Carbon Smart Cities*, The Urban Book Series,
DOI 10.1007/978-3-319-59618-1_8

We live in the beginning of smart era with eco-technology. The future of smart city will be characterized by manifold activities.

More development of smart connect-tech and guidelines of climate smart city planning will result in the preparation of more climate smart city plans.

Public participation in all phases of climate smart city planning process will increasingly occur in the future. Current and future research and development efforts will provide more information relevant to climate resilient and low-carbon smart city planning and development for promoting a shift in global planning paradigm from conventional city planning to climate smart city planning.

The continuing evolvement of innovation technologies leads to the conclusion that the number of climate smart city projects will continue to increase. These projects should be tested and proven in terms of climate change mitigation and adaptation. National, provincial, and local climate smart city legislation will help to direct attention to the planning of climate resilient and low-carbon smart city for private developments as well as for public developments.

A New York City study on a digital divide has revealed that neighborhoods that are not digitally oriented tend to have higher proportion of minorities and lower incomes, highlighting the socioeconomic divide in how social media is used in the city. It concluded that understanding the differences in these neighborhoods can help city planners interested in generating economic development proposals, civic management strategies, and urban design ideas that target these areas (Anselin and Williams 2015) (Fig. 8.1).

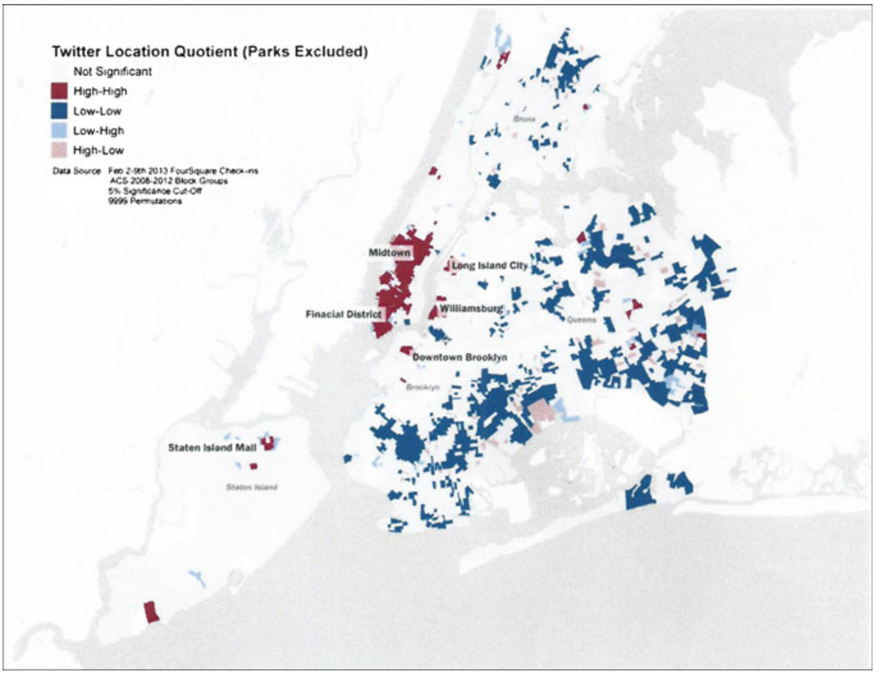


Fig. 8.1 LISA analysis of Twitter using the population location quotient, NYC. *Source* Anselin and Williams (2015, p. 12)

In response to the requirements for an interdisciplinary approach to smart city planning, mainstreaming of smart techniques in every aspect of climate city planning and design, implementation, monitoring and evaluation are becoming increasingly important.

8.2 Future Innovation Planning Challenges and Opportunities

8.2.1 Guidelines and Laws

Climate change regulations are increasing.

Smart city planning guidelines should be devised based on the carbon footprint concept and approach. It should include the carbon index and its standard in the city planning laws, and carbon footprint analysis.

Mandatory climate action plans should be formulated that incorporate smart technologies at all levels, spanning from global to local, to reach the goals for sustained prosperity for ourselves and all future generations.

This is where technology for urban reforms can provide the tools to deliver the expected results.

The British Standard Institute (BSI) has developed detailed guidelines (PD 8101: 2014) for preparing smarter development plans (BSI 2014).

The purpose of PD 8101 is to provide guidance as to how development and infrastructure projects can be designed and built in a way that facilitates a city's progress toward becoming smarter.

It has suggested five key areas for supporting smart city developments (Fig. 8.2).

Future climate smart city development plans will become more comprehensive with innovative, practical and effective approaches. Acceptable framework, methodologies, and tools for climate smart cities will become better developed.

New streamlined ways for local government is needed to amend their planning scheme to reflect these changed circumstances.

In Korea, the establishment of the Basic Law on Intelligence and Information Society is currently under way. According to the proposed law, a new Ministry of Climate, Energy and Smart City is expected to be set up as a control tower for planning and implementation of climate smart cities in an integrated way.

8.2.2 Sustainable Innovation: Bringing the Private on Board

The fourth wave of industrial revolution is represented by AI with big data.

There is every indication that the impact of big data to our lives is set to continue. It is expected that a new wave of climate action and smart city activities powered by

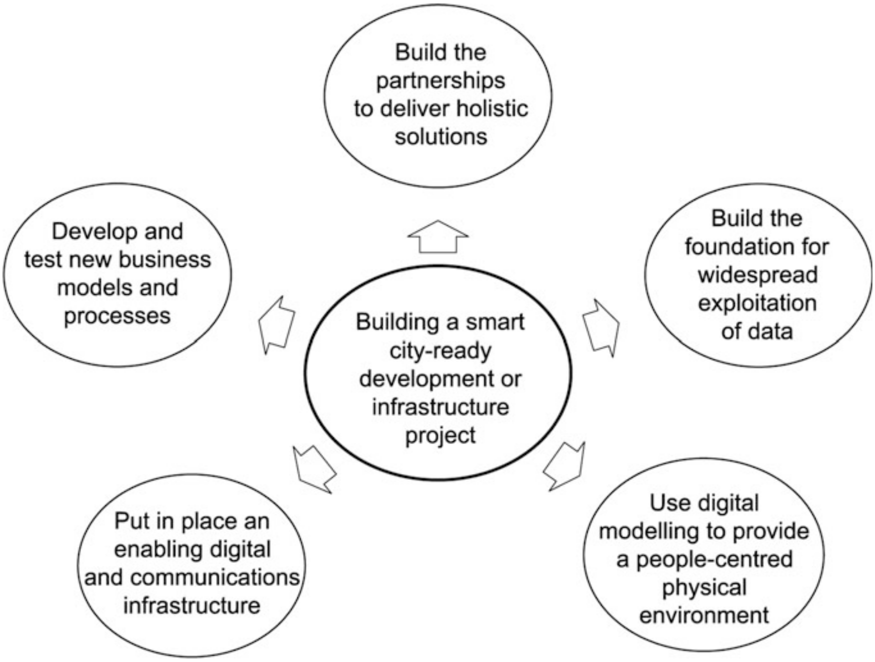


Fig. 8.2 Five key areas supporting smart city developments. *Source* Fig. 3 from PD 8101

big data and analytics will be emerging. Schwab (2016, p. 56) argues that data-based services require new forms of collaboration, particularly given the speed at which innovation and disruption taking place. The fourth industrial revolution forces cities to think about how offline and online worlds work together in practice.

Success of climate smart city policy instruments to bring the private on board will depend much on whether the private sector feels the instruments are useful and beneficial.

8.2.3 Building Globally Agreed Upon Climate Smart City Indicators

It appears that politicians have created a storm by picking up the word "smartness" which is intended to be the driving force for the climate smart development effort.

Although many have tried to quantify smartness—with the comparative analysis of case studies—when looked more closely at the approaches, it does not seem to work well (ITU 2014; ISO 2016).

There are several reasons for that:

Firstly, the approach to measurement is based on an individual's vision of smartness, which in turn can be changed depending on the measurement mindset.

Secondly, smartness is not a thing to be simply measured. It can be explained by elements and technology of circularity, sustainability, efficiency, resiliency, and connectivity.

Thirdly, measuring the immeasurable indicators is very problematic in a more holistic, realistic, participatory, and systemic approach to the quantification of smartness.

Lastly, to assist the decision makers, the climate smart city indicators should be intended to relate directly to action-oriented issues. What is agreed to be "smart"? "What effort" can make the urban infrastructure information service smart as an example? What is the long-term cost of this smartness? What is a viable system?

Cities are now engaged in the global implementation of ISO 37120—the first international standard for sustainable cities—and World Council on City Data (WCCD) is providing ISO certification to cities on the basis of their data conformity to this new ISO standard. The WCCD is currently developing a new ISO standard on indicators for smart cities—ISO 37122 (McCarney 2016).

There should be great need for fuller debates/considerations on user-friendly climate smart city indicators to suggest ways forward with climate smartness of cities. We have to strive to develop climate smart city indicators to get cities onto a zero-emission pathway and open to debate them with the public.

8.2.4 De-Risking Cities: Partnerships for Cyber-Security

Cities around the world are faced with great opportunities and challenges represented by urbanization, globalization, climate change, and cyber-risks. To be better prepared and respond to these opportunities and challenges, cities are adopting new alliances, partnerships, and citizen-inclusive approaches to planning, governance, operations, budget, climate change, and security. The overarching lens that unifies these issue areas is "risk" management, and in particular how city leaders, partners, and citizens, in increasingly integrated and technology reliant ecosystems, can "de-risk" urban environments, leading to more livable, resilient, and competitive places (Meeting of the Minds 2016). Citizen-inclusive approaches to security can help to balance opportunities and risk for climate smart cities and AI.

Lessons about cyber-vulnerabilities should be extracted from the experience of climate smart city experiments. Cities and citizens have to prepare cyber-threats as the Internet of Things proliferates.

8.2.5 Urban Mobility Future

As emerging tech creates new space innovation, we have to take a look at the transition to a more sustainable city. For example, the massive allocations of scarce urban land to parking should be avoided for the new world of safer and cleaner mobility.

We must look at how intelligent vehicle technology and iRoad will impact the design of future cities.

For example, driverless cars will enable:

- Rethinking of how our urban centers are designed and built
- Relocation of parking lots and gas stations. They will be converted into parks and green spaces.
- Reduction of single passenger use
- Reduction of curb-side parking
- Making everything electrical, point-to-point, pollution free
- Maintaining of freshness of data
- Sending data and reassembling data in cloud source
- Connecting of Internet technology and built form
- Providing of pedestrian-only zones with less noise, better air quality, and safer streets and roads.

Here, question is how government could respond to multilayer issues for the urban mobility future of iRoad and other mobility options.

The third revolution of the automotive sector includes “1st assembly line manufacture”, “2nd low-carbon technologies” and “3rd connectivity and autonomy” in order of revolution (Fig. 8.3). The standards to address the challenges of cyber-physical environments include:

- ISO 26262 “Road vehicles—Functional safety” is an international standard for functional safety of electric systems in vehicles.
- General IT security standards ISO 15408, ISO 27001.
- SAE J3061 Cyber-security Guidebook for Cyber-Physical Vehicle Systems.

The aligned development processes for functional safety and cyber-security of autonomous vehicles include:

- Risk management and requirements management
- System design based on defence-in-depth strategy
- Comprehensive verification and validation (Reeves 2016).

Fig. 8.3 Third revolution of the automotive sector. *Source* Reeves (2016, p. 4)

8.2.6 Digital Interactive Design and Public Space Management

Rebuilding and revitalizing urban spaces of all kinds need to respond to data flows, connection of neighborhoods, challenges to the notion and definition of parks and meaningful engagement of public spaces.

A lot of system thinking is going on for climate smart city including GIS mapping projects, flooding zones, soil maps, data for climate and green mapping.

Right choices should be made between technology and nature. Technology in the nature should be one option.

Interactive design for public space is necessary to make public space meaningful. Civic innovative digital tools can be used for interconnected ecosystem which connects one space with another space.

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