Environmental Engineering

Yuzuru Matsuoka
Mamoru Yoshida
*Editors*

# Challenges for Human Security Engineering

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## Environmental Engineering

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# Challenges for Human Security Engineering

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# Preface

There are multiple challenges confronting cities, such as provision of social infrastructure, improvement of sanitary conditions, securing of energy and water resources, and disaster prevention and mitigation. These challenges have not newly emerged in the twenty-first century; countless researchers and practitioners have long discussed and worked to solve the issues, and consider them traditional and perpetual problems endemic to cities.

There have been ongoing historic attempts to develop and implement technologies to solve these problems, and it remains the responsibility—the societal role—of current researchers and practitioners to take up the challenge.

In these early twenty first century decades, the traditional problems of cities have become more complex. The conditions amid which cities find themselves—characterized by exploding populations, advancing globalization, the emergence of new infectious diseases, and the rise of terrorism to name only a few aspects—have changed markedly since the end of the twentieth century. Researchers and practitioners previously applied various technologies to help solve urban problems. The advance of technology and expansion of knowledge, however, have resulted in the emergence of previously unnoted problems, and have even led to the emergence of new problems caused by the very application of the technologies developed. It is often the case that researchers and practitioners develop technologies in response to their application in the field.

Acknowledging these conditions, this book aims to build a new field of engineering—that of human security engineering. In this book, human security engineering is “a system of technologies for designing and managing a society that frees people from the threats of poor sanitation and unhealthy circumstances in daily life, as well as threats from major disasters and widespread environmental destruction, and enables the comfortable pursuit of life with dignity”. Human security engineering consists of four disciplines: urban governance, urban infrastructure management, health risk management, and disaster risk management. Each of these disciplines must contain four principles: (1) having the clear objective of ensuring the security of people that corresponds to social and economic conditions and to the general context of the times, (2) emphasis on on-site specific mechanisms and conditions reflects the unique situation of the locality, (3) a perspective of co-evolution of technology, institutions, and society that supports the approaches, and (4) looking at the role of multilayered governance structures and making active use of its complementarity.

The principles and objectives of human security engineering overlap in many ways with those of existing disciplines such as civil engineering, architecture, and environmental engineering. These disciplines tend to specialize in and concentrate on individual issues; hence, they pay inadequate attention to the development and application of technologies to comprehensively and systematically address the overall issues facing cities. Engineers are required to take into consideration of both rigorousness and the relevancy in the application of technologies. However, there is often discord between them; engineers can sometimes lose sight of the original objective. Specialization has made it difficult to rise to the challenge of solving the problems cities face in a forthright and comprehensive manner. Human security engineering must be a discipline that makes the problems faced by people living in cities the central concern and that aspires to develop and implement technologies for ensuring human security.

Summarizing the structure of this book, Chap. 1 (by Yuzuru Matsuoka), titled "Human Security Engineering," provides an overall perspective on the background of the discipline of human security engineering and on the problems faced by megacities generally and specifically those in Asia. It explains the principles and objectives of human security engineering and their relationship to human security. Chapter 2 (by Kiyoshi Kobayashi) is titled "Human Security Engineering as a Practical Approach" and, in light of the practical application that is inherent to human security engineering, it discusses the requirements human security engineering should fulfill as a discipline, together with methodologies and evaluation criteria. "Construction and Development of Public Infrastructure" is the title of Chap. 3 (by Hiroyasu Ohtsu). It explains the dynamic issues related to the construction and development of public infrastructure, drawing on ground subsidence and flooding, landslide disaster prevention measures, and other specific examples for illustration. Chapter 4 (by Hiroaki Tanaka), is titled "Co-evolution of Health Risk Management and Urban Environmental Infrastructure" and provides an overview of the causes of human health risks in Asia and other parts of the world. This chapter focuses on urban water resources and water hygiene conditions and examines urban environmental infrastructure construction and development with an eye toward recycling and sustainability. "Integrated Disaster Risk Management from the Perspective of Human Security Engineering" is the title of Chap. 5 (by Hirokazu Tatano and Mamoru Yoshida). It discusses the current and future features of global disasters and explains the overall disaster risk management and risk governance framework needed to deal with disasters. Chapter 6 (by Rajib Shaw) is titled "Community Dimension of Human Security in Urban Context" and explains the concept of human security. It addresses the Climate Disaster Resilience Initiative (CDRI) developed to examine the resilience of cities to climate and natural disasters from an overall perspective and provides examples of its actual application. Chapter 7 (by Kiyoshi Kobayashi), titled "Asset Management," focuses on asset management technology amid advancing globalization and intense international competition and explains the international standardization that serves as an institutional environment for that management framework and technology. Finally, Chap. 8 (by Minoru Yoneda), titled "Human Security Engineering Education Program," focuses on the educational aspects of human security engineering and explains the requirements from a human resource development perspective. It introduces the actual curriculum of the human resource engineering education program launched at Kyoto University with these requirements in mind and discusses student feedback.

The concept of human security engineering was developed and evolved based on the Global Center for Education and Research on Human Security Engineering for Asian Megacities program. This program was adopted as a Global Center of Excellence project supported by the Japanese Ministry of Education, Culture, Sports, Science and Technology. It involved the cooperation of professors whose specialties are architectural, civil, environmental and resources engineering, and numerous researchers and practitioners at bases established by the program at: Tsinghua University in Shenzhen, China; the Hanoi University of Science and Technology in Hanoi, Vietnam; the National University of Singapore in Singapore; the Asian Institute of Technology in Bangkok, Thailand; the Bandung Institute of Technology in Bandung, Indonesia; the School of Planning and Architecture in New Delhi, India; the Municipal Corporation of Greater Mumbai, India; and the University of Malaya in Kuala Lumpur, Malaysia. Valuable support applicable to the program was received from Professors Hong-Ying Hu and Yuntao Guan at Tsinghua University, China; Professors Le Van An and Ho Dac Thai Hoang at the Hue University of Agriculture and Forestry, Vietnam; Professors Huynh Trung Hai and Mai Thanh Tung at the Hanoi University of Science and Technology, Vietnam; Professor Tran Van Quang at the Danang University of Technology, Vietnam; Professors Bernard Tan Tiong Gie and Fwa Tien Fang at the National University of Singapore; Professors Djoko Santoso (Director General of Higher Education Directorate, Ministry of National Education and Culture, Republic of Indonesia) and Wawan Gunawan, and Lecturer Rachmat Sule at the Bandung Institute of Technology, Indonesia; Associate Professors Noppadol Phien-wej and Pham Huy Giao at the Asian Institute of Technology, Thailand; Professors Dato Mohd Jamil Maah, Nik Meriam Nik Sulaiman, and Noor Zalina Mahmood at the University of Malaya, Malaysia; Professor Vaidya Chetan Kumar Vanmanrao and Professor Emeritus Bijay Anand Misra at the School of Planning and Architecture, India; and Kayo Otani, Michiyo Brocket, and Hanae Hoshihara at the Kyoto University Global Center for Education and Research on Human Security Engineering for Asian Megacities, Japan; among many others. Mihoko Kumazawa and Ken Kimlicka of Springer Japan were tireless in providing advice throughout the process of publishing this book. The authors would like to take this opportunity to express their deepest gratitude to everyone who has had a hand in bringing this book to fruition.

Finally, the authors would like to add that any spelling, content, or other errors are due solely to their own shortcomings in preparation or understanding. With that, there will be no greater joy for the authors if this book can contribute, if even only slightly, to the building of human and intellectual networks for promoting the discipline of human security engineering and, more importantly, providing for the human security of people living in cities.

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# Contents

# Chapter 1
# Human Security Engineering

**Yuzuru Matsuoka**

**Abstract** Comprehending how people have battled disasters and environmental destruction is the first step in understanding human security. This chapter discusses this, describes current global threats, and examines the preventative actions taken against such threats on a world-wide basis. Four important points are introduced for securing global human security under the context of real world constraints. They are, (1) matching social infrastructure service levels to needs, (2) awareness by individuals of the importance of self-reliance and ownership, (3) establishment of partnerships among stakeholders, and (4) the implementation of a comprehensive approach toward global security issues and the development of capabilities for addressing them. As they are central to these concerns, the disciplines of traditional civil and environmental engineering are expanded to introduce Human Security Engineering, and the four underlying principles are explained.

**Keywords** Co-evolution of engineering and society • Human security engineering • Mode 2 • Multilayered governance structures

## 1.1 How People Have Battled Disasters and Environmental Destruction to Date

### *1.1.1 Current Threats from Disasters, Environmental Destruction, and Other Sources*

The Great East Japan Earthquake of 2011 refocused attention on the importance of having national structures and social systems that are resilient against disasters. It also acted as a reminder of human dependence on safe housing and stable

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supplies of energy, water, and food. This is true for people throughout the world; natural disasters, water and food shortages, and environmental destruction are issues of primary concern for all.

Dangers posed by natural disasters, urban disasters, radiation accidents, accidents that occur in daily life, work-related accidents, and the risks posed by environmental contamination, food additives, and pharmaceuticals are sources of serious concern. These can shorten life expectancy and have even led to the collapse of nations. The Italian historical demographer, Livi Bacci (2006), estimated that the average life expectancy of a human being was 20–26 years during the time of hunter-gatherers, 22–29 from ancient times through the Middle Ages, and 25–33 in eighteenth-century Europe. This figure now exceeds 80 years in leading industrialized nations and it hints at the severity of the threats faced by people in earlier times. However, this does not mean that people no longer face such threats. Currently, average life expectancy remains below 60 in many African countries. In Asia, the life expectancies for 2009 were 65 in India and 61 in Cambodia (World Health Organization 2012)—a gap of roughly 20 years compared with the industrialized country average. Furthermore, leading industrialized countries with life expectancies of over 80 years are not free of the dangers mentioned; one need not even refer to an event like the Great East Japan Earthquake to realize this. On the contrary, the development of advanced technologies, large-scale engineering projects, and novel chemical substances, and the advancing urbanization of society have given rise to many risks. These have made the risk environment more diverse and complicated and have increased in line with the elevation of economic conditions. Moreover, the economic globalization and the worsening of global environmental problems of recent years have given rise to global risks and issues including but not limited to global warming, environmental refugees, emerging infectious diseases, and coordinated terror attacks.

This section begins with a general overview of the current threats to humanity and examines the scale of the individual threats. Table 1.1 presents 2004 estimates of current mortality rates and the burden of disease from environmental factors and disasters, both on a worldwide scale and for specific regions such as the Western Pacific (East Asia, Southeast Asia, and Oceania). The crude global mortality rate[1] was a little less than 1,000 (per 100,000 people); given that the global population at that time was 6.4 billion, approximately 60 million people died in 2004. The table provides a breakdown of those who died from certain specific causes (World Health Organization 2009).

The mortality rates shown on the left of the table illustrate that on a global level factors such as a lack of clean water (access to a continuous source of safe drinking water), unsanitary conditions (access to appropriate hygiene facilities), indoor and outdoor air pollution, and other poor environmental conditions accounted for approximately 10 % of total deaths. Injuries resulting from causes such as disasters and accidents accounted for approximately another 10 %. Together, these causes

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[1] The number of deaths in a year divided by the total population.

**Table 1.1** Global health risks, mortality rates and burden of disease attributable to selected major threats in 2004 (World Health Organization 2009, 2002, 2004; Ezzati et al. 2004)

| | Mortality rate (per 100,000) | | | | Burden of disease (DALY, one million years) | | | |
|---|---|---|---|---|---|---|---|---|
| | World | | Western Pacific | | World | | Western Pacific | |
| | | % | High income[a] | Low and middle income[b] | | % | High income[a] | Low and middle income[b] |
| Population (million) | 6,437 | | 204 | 1,534 | 6,437 | | 204 | 1,534 |
| Total deaths (including other causes listed below) | 913.0 | 100.0 | 724.5 | 698.4 | 1,523.3 | 100.0 | 22.31 | 242.47 |
| Environmental risks | 82.5 | 9.03 | 23.5 | 70.7 | 128.4 | 8.4 | 0.33 | 13.64 |
| Unsafe water sanitation hygiene | 29.6 | 3.25 | 0.5 | 6.1 | 64.2 | 4.2 | 0.09 | 4.51 |
| Unsafe water sanitation hygiene | 17.9 | 1.96 | 23.0 | 24.3 | 8.7 | 0.6 | 0.23 | 2.41 |
| Indoor smoke from solid fuels | 30.5 | 3.34 | 0.0 | 38.5 | 41.0 | 2.7 | 0.00 | 5.00 |
| Lead exposure | 2.2 | 0.24 | 0.0 | 1.4 | 9.0 | 0.6 | 0.01 | 1.52 |
| Global climate change[c] | 2.2 | 0.24 | 0.0 | 0.3 | 5.4 | 0.4 | 0.00 | 0.19 |
| Injuries | 83.2 | 9.11 | 53.7 | 74.1 | 187.7 | 12.3 | 2.17 | 36.02 |
| Unintentional injuries | 57.8 | 6.33 | 30.5 | 50.7 | 137.7 | 9.0 | 1.31 | 27.34 |
| Road traffic accidents | 19.7 | 2.16 | 9.2 | 18.7 | 40.2 | 2.6 | 0.43 | 8.58 |
| Poisoning | 5.6 | 0.62 | 1.1 | 4.8 | 8.0 | 0.5 | 0.06 | 1.59 |
| Falls | 6.3 | 0.69 | 4.6 | 6.8 | 16.5 | 1.1 | 0.24 | 4.41 |
| Fires | 5.1 | 0.56 | 1.0 | 1.2 | 11.6 | 0.8 | 0.03 | 0.56 |
| Drownings | 6.7 | 0.73 | 4.0 | 8.7 | 12.7 | 0.8 | 0.09 | 4.07 |
| Other unintentional injuries | 14.4 | 1.57 | 10.6 | 10.5 | 48.6 | 3.2 | 0.46 | 8.12 |
| Intentional injuries | 25.4 | 2.78 | 23.2 | 23.4 | 50.2 | 3.3 | 0.86 | 8.68 |
| Self-inflicted injuries | 14.0 | 1.53 | 22.4 | 18.9 | 21.2 | 1.4 | 0.82 | 6.13 |
| Violence | 8.3 | 0.91 | 0.8 | 4.3 | 21.3 | 1.4 | 0.05 | 2.43 |
| War | 2.9 | 0.32 | 0.0 | 0.1 | 7.3 | 0.5 | 0.00 | 0.09 |
| Other unintentional injuries | 2.9 | 0.03 | 0.0 | 0.1 | 0.4 | 0.0 | 0.00 | 0.03 |

[a] Australia, Brunei Darussalam, Japan, Republic of Korea, New Zealand, Singapore

[b] Cambodia, China, Cook Islands, Fiji, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, Niue, Palau, Papua New Guinea, the Philippines, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, Vietnam

[c] Climate change figures given are based on actual carbon emissions and concentrations compared with average results for 1961–1990. Mortalities arise from diarrhea, flood injury, malaria, malnutrition and its associated diseases

accounted for slightly less than 20 % of total deaths, or about 170 per 100,000 people. By type of poor environmental condition, a lack of safe water, unsanitary conditions, and indoor air pollution each accounted for approximately 3 % of total deaths, with urban outdoor air pollution accounting for 2 %. Causes such as lead exposure and climate change had smaller impacts. Deaths resulting from injuries are broken into unintentional causes, over 6 % of the total, and intentional causes, 3 % of the total. The former is further divided into specific causes such as traffic accidents, 2 % of the total, and drowning, falls, poisoning, and burns.

Data for the Western Pacific are provided for high-income countries as one group, and for middle- and low-income countries as another. Rates of death here from all causes are lower than the global rates. Deaths from unsafe water and unsanitary conditions in high-income Western Pacific countries, at 0.5 per 100,000 (or one sixtieth the global rate of 29.6) were particularly low. However, deaths from indoor air pollution and lead exposure have been virtually eliminated. Deaths from intentional injuries (other than self-inflicted, fires, and poisoning) are a fifth of the global rate. Deaths from other causes generally mirror global rates, with the exceptions of deaths from urban outdoor air pollution and suicide both being markedly higher in high-income Western Pacific countries. The Disability-Adjusted Life Year (DALY) figures presented on the right of the table are shown by disease burden. DALY figures illustrate the years of healthy life lost because of early death from disease or lost as a result of ill-health. Compared with mortality rates, DALYs are more accurate when considering periods of ill health. An examination of the percentage comparisons of mortality rates and DALYs for most injury causes shows that the latter is slightly higher.

The injury data provided in Table 1.1 are for all injuries regardless of the scale of the injury event. Table 1.2 looks at large-scale events that cannot be responded to at an individual level from 2001–2010, and breaks this data down by type of event.

These data were compiled by the Centre for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Leuven (KU Leuven), Belgium. The 7,070 events examined met at least one of four conditions, (1) at least 10 deaths; (2) at least 100 people affected; (3) a state of emergency declared; or (4) international support was called for. The findings show that 1.8 people per 100,000 died in major disasters on a global scale each year between 2001 and 2010. The causes of these deaths, ranked from the highest mortality levels downward, were earthquake/tsunami, windstorms, and drought/food insecurity. From an individual country perspective, those with a low Human Development Index[2] (HDI) rank experienced

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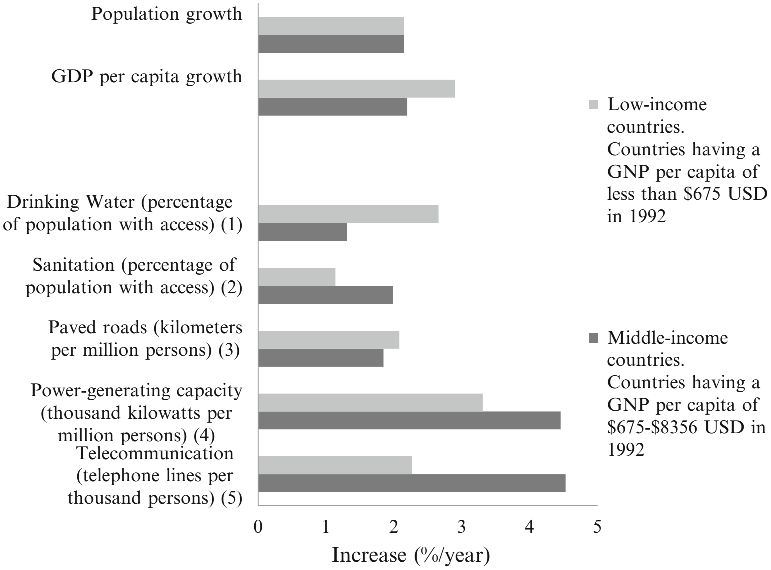
[2] The Human Development Index measures the degree of human development in individual countries by assigning decimal values between 0 and 1 determined by per capita GDP, average life expectancy, literacy rate, and school enrollment. Using these values, countries are divided into quartiles: “very high human development (VHHD),” “high human development (HHD),” “medium human development (MHD),” and “low human development (LHD).” Classifications are based on 2010 data.

**Table 1.2** Total number of people reported killed per 100,000 (2001–2010) (International Federation of Red Cross and Red Crescent Societies 2011)

| | Regional classification by human development index | | | | |
|---|---|---|---|---|---|
| Item | VHHD | HHD | MHD | LHD | Total |
| Total natural disasters | 0.866 | 1.109 | 1.110 | 14.223 | 1.831 |
| Climato-, hydro- and meteorological disasters | 0.862 | 0.760 | 0.142 | 8.393 | 0.810 |
| Droughts/food insecurity | n.a. | 0.000 | 0.001 | 3.986 | 0.231 |
| Windstorms | 0.058 | 0.010 | 0.037 | 3.883 | 0.258 |
| Extreme temperatures | 0.788 | 0.659 | 0.013 | 0.082 | 0.221 |
| Floods | 0.011 | 0.078 | 0.076 | 0.388 | 0.084 |
| Forest/scrub fires | 0.004 | 0.001 | 0.000 | 0.002 | 0.001 |
| Mass movement: wet | 0.001 | 0.013 | 0.015 | 0.052 | 0.015 |
| Geophysical disasters | 0.004 | 0.349 | 0.968 | 5.831 | 1.021 |
| Earthquakes/tsunamis | 0.004 | 0.348 | 0.967 | 5.825 | 1.020 |
| Mass movement: dry | n.a. | 0.001 | 0.000 | 0.000 | 0.000 |
| Volcanic eruptions | n.a. | 0.000 | 0.001 | 0.006 | 0.001 |
| Total technological disasters | 0.057 | 0.195 | 0.086 | 0.796 | 0.138 |
| Industrial accidents | 0.004 | 0.018 | 0.023 | 0.059 | 0.021 |
| Miscellaneous accidents | 0.013 | 0.035 | 0.016 | 0.090 | 0.022 |
| Transport accidents | 0.041 | 0.141 | 0.048 | 0.646 | 0.094 |
| Total | 0.924 | 1.304 | 1.196 | 15.019 | 1.969 |

mortality rates over ten times those of other countries, particularly for drought/ food insecurity, windstorms, and transport accidents. It should be noted that mortalities from earthquakes/tsunamis was high in countries with low human development (LHD) or medium human development (MHD) rankings; however the 2010 Haiti earthquake and 2004 Indian Ocean earthquake both occurred in this period and they were jointly responsible for one third of the 1,313,000 deaths from natural disasters during the first decade of the twenty-first century. Countries with high human development (HHD) or very high (VHHD) index rankings experienced high levels of extreme temperature mortalities when over 70,000 people died during the June–August 2003 European heat wave. If this single event is excluded, VHHD countries would have experienced a natural disaster mortality rate of 0.074 and HHD countries a rate of 0.101. The CRED's findings, therefore, show that mortality from disasters is dependent on human development. They also highlight the vulnerability of industrialized countries to the effects of unusually high temperatures.

Global society faces threats from extreme risks, with factors such as poor environment, disasters, and traffic accidents accounting for almost 20 % of total annual deaths. The current 12 million deaths a year arising from such risks exceeds the wartime losses of World War II where a total of 54 million people were killed in its 7 year duration (1939–1945) from combat, bombings, riot suppression, disease, and famine (i.e., the equivalent of 7.7 million deaths per year) (Sivard 1996).



Notes: (1), (2) and (5) show results for 1975-1990; (3) and (4) show results for 1960-1990

**Fig. 1.1** Average infrastructure development rates in developing countries during the 1970s and 1980s (World Bank 1994) [*GDP* gross domestic product, *GNP* gross national product, *USD* US dolloars]

Taken in perspective this means that poor environment, disasters, and traffic accidents, are currently killing more people each year than were lost on an annual basis during World War II.

### 1.1.2 *What Has the World Done to Date to Prevent These Threats?*

The world is not unresponsive to the threats it faces. European countries, the United States (US), and Japan (VHHD countries shown in column 1 of Table 1.2), for instance, have implemented various measures over the past 100 years. The fruits of such measures are seen in the low mortality rates from unsafe water and unsanitary conditions in Western Pacific high-income countries in Table 1.1, and in the low mortality rates from disasters in HHD countries. Figure 1.1 Average infrastructure development rates in developing countries during the 1970s and 1980s (World Bank 1994).

However, the situation is somewhat different in less developed countries. As developed countries gradually recovered from the disorder following World War II and decolonization in the 1960s and 1970s, they could focus on problems of poverty and basic human needs (BHN),[3] and hence the international community began providing aid to less developed countries. The International Development Association (IDA),[4] which was founded in 1960, and the Development Assistance Group [(DAG), later the Organization for Economic Co-operation and Development's (OECD), Development Assistance Committee (DAC)][5] were among the leaders of aid initiatives. International assistance began to pay off in the 1970s and 1980s as progress was made on the construction of the basic infrastructure needed for daily life in less developed countries. Figure 1.1 shows the annual improvement rates for various measures of infrastructure in the 1970s and 1980s (World Bank 1994).

It was an era of great hope that development would free humanity from the threats discussed earlier. At the United Nations (UN) Water Conference held in March 1977 at Mar del Plata in Argentina, a commitment was made to supply safe water and build appropriate sanitation facilities on a global scale, and the 1980s were designated the "International Drinking-Water Supply and Sanitation Decade" (IDWSSD). Moreover, the UN General Assembly set forth specific global goals (known as "Water and Sanitation for All") calling for 100 % access to safe water and appropriate sanitation facilities by 1990.

Similar goals were set for health. The World Health Organization (WHO) and the UN Children's Fund (UNICEF) held the first international conference on primary health care in Alma-Ata, Kazakhstan in September 1978. This conference emphasized the importance of urgent action for the protection of the health of all people, and made a commitment known as "Health for All" (HFA) with a planned fulfillment date of 2000.

The targets of both, however, could not be achieved. Despite HFA efforts, millions of people continue to die from easily preventable and easily treatable infectious diseases and other maladies in the twenty-first century. Access to safe water and sanitation facilities aims also proved impossible to meet, but the challenge was too daunting from the outset. Immediately following the Mar del Plata conference, the WHO and World Bank estimated that of the 2.2 billion people living in over 100 developing countries (excluding China), 1.2 billion did not have access to safe drinking water and 1.7 billion lacked appropriate sanitation facilities. Estimates put the number of people dying from these conditions at ten million per year (Water, Engineering and Development Centre 1998). Eliminating deaths arising from a lack of safe drinking water alone during the IDWSSD would have entailed increasing access to safe drinking water at a rate of 5.5 % of the developing world population

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[3] BHN covers minimum food, housing, clothing, other goods, safe drinking water, sanitation facilities, health care, and education requirements that are among the basic needs for human life.

[4] The IDA is an institution affiliated with the World Bank Group established in 1960. It provides long-term interest-free loans to the world's poorest countries.

[5] The Development Assistance Committee (DAC) was organized by the OECD as a forum for discussing the provision of assistance to developing countries. It examines and provides advice on effective methods for providing bilateral assistance and functions as a forum for reporting on aid results.

[(1.2/2.2 billion) × (1/10) = 0.055] each year, without considering population growth. Taking population growth (2 % points a year) into account, the necessary rate of increased access would have been 7.5 %; over three times the 1–2.5 % actually achieved as shown in Fig. 1.1. Data here show that the developing country population growth rate (with the exception of access to safe drinking water in the lowest income countries) surpassed the growth rates achieved for access to safe drinking water and appropriate sanitation facilities. Hence, the number of people living with these basic needs unfilled, actually increased.

In addition to the overwhelming size of the initial challenge, there are several other reasons for these failures. A collapse in primary product prices, rising interest rates, and other factors conspired to create unfavorable fiscal circumstances for the governments of developing nations in the 1980s, leading to a decrease in their water and sanitation facilities investments.

Critical issues included: (1) excessive new investments driven by the desire to demonstrate political presence; (2) failure to meet needs appropriately; (3) setting service prices at inappropriate levels; and (4) inadequate and/or inefficient infrastructure maintenance and management. Although on the surface, excessive new investment may seem positive, it was poorly planned and actually negatively impacted on facility efficiency and usurped capital needed for maintenance and management, equipment upgrades, and service quality improvements. The failure to meet needs appropriately resulted in instances whereby low prices also meant low quality and thus discouraged use, and contrasting instances where the quality was good but the prices exceeded affordable levels. The inappropriate setting of service prices occurred, for example, in cases of service provision or provider monopolies, where prices were set significantly below the actual cost of supply. The service providers thereafter depended continually on government subsidies to operate. Such critical issues were connected to unsound management and a lack of social equality in developing countries that impacted significantly on the sustainability of the undertaking.

These problems were by no means exceptional and occurred throughout the world. In the early 1990s, Ingram et al. (World Bank 1994) estimated the additional costs in the developing regions resulting from the inappropriate setting of service price levels and inadequate and/or inefficient maintenance and management (see Fig. 1.2). For the former, they calculated an annual cost of $123 billion USD, and for the latter, $55 billion USD. These figures respectively represented 62 % and 28 % of the $200 billion USD annual investment then being made on developing country infrastructure. They accounted for 10 % and 5 %, respectively, of the national government revenue.

Problems such as needs gaps and inefficiencies have made it difficult to achieve the objectives, have undermined policy and management motivation, and have impacted on sustainability. These points have been the focus of considerable debate at international conferences on assistance to developing countries in the 2000s. Experiences to date have highlighted the importance of flexible adaption to social progress and economic conditions, the matching of user needs and willingness to pay, and technically sustainable operation and management for the implementation of infrastructure development plans.

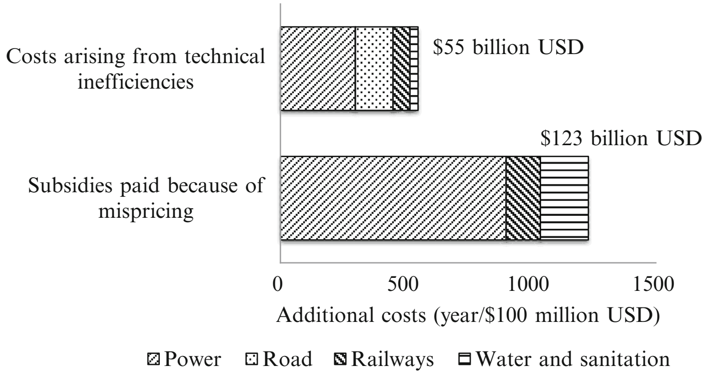

**Fig. 1.2** Additional expenses caused by improper maintenance and management of infrastructure (World Bank 1994)

### 1.1.3 *What Has Experience Taught Us?*

1. Importance of matching service level to needs
   There are various service levels in the provision of safe drinking water and sanitation services. For example, water can be provided through a shared community tap, through individual in-home taps, or can even be made safe to drink without undergoing disinfection. The costs, and technical skills necessary for maintenance and management, differ significantly depending on the individual situation and chosen solution. The IDWSSD officially ended in 1990, at which time 1.1 billion people had no access to safe drinking water and 2.4 billion people were without appropriate sanitation facilities. However, several important lessons were learned. One was that providing safe water and sanitation services is expensive. Using safe water for drinking, cooking, hand-washing, laundry, bathing, and other purposes can eliminate the risks of diarrhea and other potentially serious conditions, but it costs money. If a shortage of capital precludes that level of service, it is sufficient to begin by supplying approximately 20 L of safe water per person per day, which is the amount considered necessary for drinking, cooking, and hand-washing. This initial 20 L would have a dramatic impact on improving health. When conditions allow, the system could be enhanced to provide 50 L of safe water per person per day, enough for ordinary daily use, or even the 100 L or more used in the most developed countries. This approach was strongly advocated by the IDWSSD through affordable low-cost technology, but, in many cases, it could not be implemented.
2. Importance of self-reliance and ownership
   In situations where infrastructure is provided and service provision begins, it is important to note that the people who are being served must maintain and operate the service on an ongoing basis. This is made possible by financial and technical wherewithal, and the desire to maintain it. If the facilities and equipment provided are inconsistent with the intentions of those being served, if the

management and operation are not taken seriously, or if the required capabilities are absent, then the business that took such effort to start would not work. Such discrepancies frequently occur, and there are many cases where there has been excessive reliance on support from foreign countries and national or regional government, and a lack of willingness among local people to support themselves. This situation is recurrent across many sectors. The provision of disaster prevention equipment by a national or regional government for example, often results in a weakening of self-reliance in local communities. Such self-reliance is key to human security and has been repeatedly emphasized over the years. The Declaration of Alma Ata adopted at the Kazakhstan conference in 1978, called for "the attainment by all peoples of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life," and positioned communities and their individual members as primary actors, stressing their sense of self-reliance. In Japan, the experience of the Great East Japan Earthquake has led to legal revisions aimed at refocusing attention on the importance of self-reliance. How to enhance the self-reliance of not only individuals but also communities, regions, countries, and the international community is an issue of paramount importance for human security that has gained renewed awareness.

3. Importance of partnerships[6]

   Self-reliance and ownership are important, but not sufficient. Cooperation between related parties is generally needed to accomplish tasks, or can at the very least lead to enhanced outcomes. The Declaration of Alma Ata, for example, emphasized the importance of self-reliance, but in recognition that individual efforts alone were not sufficient and that community involvement was necessary, the 1986 Ottawa Declaration was later adopted to rectify health improvement efforts. It emphasized that building and strengthening partnerships combining the strengths of nations, regions, communities, individuals, the private sector, international institutions, and groups of experts is essential for human security, and that partnerships of various forms are critical at both the macro and micro level. This included global partnerships such as those between donor countries and aid institutions and aid recipients, national arrangements such as private-public partnerships (PPP) between governments and private sector parties, and microcredit[7] agreements. Other partnership models also demonstrate the importance of partnerships for disaster-responses and social security needs including public assistance (government assistance), cooperative and mutual aid (assistance through local and family organizations), and self-reliance (families and individual community members).

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[6] Partnership is a relationship in which different entities cooperate and share responsibility in pursuit of common objectives.

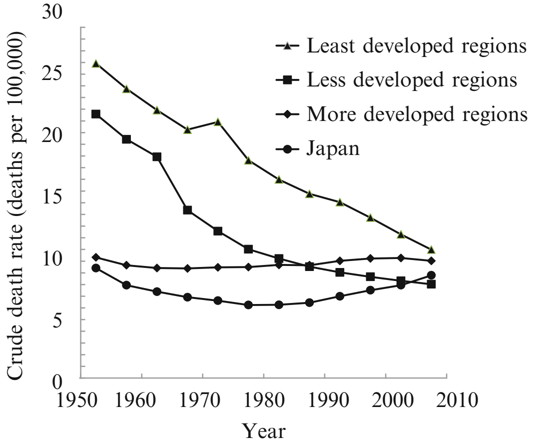
[7] Microcredit is very small loans provided to the unemployed, entrepreneurs lacking capital, and the poor—people who cannot gain access to financing from traditional banks. Microcredit has gained attention as an effective approach for relieving poverty. Grameen Bank, which started in the 1970s, operates in Bangladesh and is a well-known provider of microcredit.

4. Project-level management limitations, the importance of a comprehensive approach, and the broad ability to address issues
   Building infrastructure and making it available for use does not fulfill the primary objective of making daily life safer and more convenient. This only becomes possible by providing related support systems and organizations, and establishing organic ties to future projects. Nevertheless, during the course of such work there may be changes in political administrations, economic or technological conditions, or even the attitudes of those involved. Various project management approaches have been implemented in response to these risks including Project Cycle Management (PCM). However, PCM lacks flexibility and gives insufficient attention to the long-term view of endogenous development despite its importance (Japan International Cooperation Agency 2006).

   As emphasized in the discussion above; addressing projects individually does not solve problems. Hence, achieving the primary objective of making daily life secure and more convenient requires not only effective management of individual projects, but, equally importantly, an objective–guided overall perspective. This big-picture outlook considers related projects, policies, and institutions to be an organic system, and recognizes the powerful interactions of factor ownerships and partnerships. In other words, it is necessary to develop and implement a strategy that marshals the relevant organizations and people in ways that will achieve the objectives of safer or convenient daily life. This is not possible without the capabilities of players in the developing and implementing of strategies. Cultivating these capabilities requires not only fostering the abilities of individual policy decision makers, government administrators, and experts, it also requires developing the problem-solving capacities of organizations or the society as a whole (capacity development). Strong leadership enabling the achievement of the chosen strategy is also essential. The OECD's DAC (Organisation for Economic Co-operation and Development and Development Assistance 1991) and the UN Development Programme (UNDP) (Fukuda-Parr et al. 2002) have stressed these points, emphasizing the fundamental importance of developing the capacities of people, organizations, and systems, versus physical goods and infrastructure.

### *1.1.4 Not All Projects Have Been Failures: Japan's Experience*

The points discussed so far refer mainly to experiences in developing countries over the past 50 years. Nevertheless, even the most developed countries had similar experiences and results that more often than not differed from initial expectations. Despite the difficulties and frustrations, however, there is no doubt that human security across the globe has generally improved. As Fig. 1.3 shows, mortality in developing countries declined from an annual rate of approximately 2,500 per 100,000 in the early 1950s, to approximately 1,000 per 100,000 by the late 2000s.



Least developed regions include Afghanistan, Angola, and Yemen
Less developed regions include Melanesia, Micronesia and Polynesia
More developed regions include all of Europe, North America, Australia, New Zealand and Japan.

**Fig. 1.3** Global crude death rates 1950–2010 (United Nations, Department of Economic and Social Affairs, Population Division 2011)

Mortality rates in most developed countries (including Japan) in the same period show change because of the negating impact of aging populations; Japanese life expectancy rose from 62 to 83 in that period.

The spike in the first half of the 1970s in the least developed countries reflects famines in Bangladesh and Ethiopia—events that inspired Muhammad Yunus[8] to establish the Grameen Bank.

The crude mortality rate in Japan was approximately 1,000 in 1950, following a half-century of concerted efforts to reduce it from a rate of over 2,000 at the end of the nineteenth century. The successful reduction resulted largely from a partnership between citizens and the government. Sensai Nagayo,[9] who was central to the development of Japan's modern medical and water systems following the Meiji Restoration, clearly recognized the importance of self-reliance and partnerships in the field of hygiene. Even as the Japanese government was attempting to impose a top-down style of hygiene management, Nagayo established the Japan Association of Hygiene as a private sector alternative.

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[8] Born in 1940, Muhammad Yunus is a Bangladeshi economist and banker awarded the 2006 Nobel Peace Prize for helping to build the Grameen Bank, one of the economic and social foundations helping those living in poverty to better themselves.

[9] 1838–1902. Sensai Nagayo was a Japanese doctor and statesman who established a modern administration management system of hygiene in Japan.

> With the advancement of civilization and enlightenment, we have seen the flourishing of transportation systems, the long-awaited emergence and blossoming of industry, rapid growth of population density in the cities, and, for student and teachers, the nearly overwhelming expansion of school curricula.
>
> None of these 'developments of civilization' can be excluded from the possibility of becoming the cause of a health problem. … I don't know about other fields, but, with regard to hygiene, without the unity and sincerity of citizens, desired results cannot be obtained, regardless of the excellence of laws. That must never be doubted in either theory or experiment; there is absolutely no room for doubt.
>
> (Sensai Nagayo, Address at the inaugural meeting of the Japan Private Association of Hygiene, 1883)

Bottom-up approaches of this type characterized hygiene advances in Japan, particularly in the 1920s when tuberculosis and maternal and child health services were significant concerns. This approach was initiated in Japan a full century before the 1978 Declaration of Alma Ata emphasized the importance of self-reliance and cooperation in the field of health care.

Figure 1.4 shows the development of Japan's safe water system since 1890. The safe water coverage rate reached 97.5 % in 2010, and the vast majority of people currently enjoy the benefits of clean water, except in times of disaster. However, this has only been the case for the past 40 years; prior to that, individuals and communities across the country devoted significant efforts to securing safe water. The concept of mutual assistance whereby households with wells shared water with households without had long been observed throughout Japan. This custom played an important complementary role to the national waterworks system up until the 1970s, when the coverage rate was still relatively low and service was often suspended. In mountain villages and other areas where the construction of a large-scale water system was particularly difficult, entire communities worked together to train in the necessary skills and knowledge, provide the labor, and construct and operate small-scale rural water systems.[10] Such systems spread rapidly throughout Japan upon introduction of a subsidy program (covering one quarter of the development costs) in 1952. In addition to the subsidy payment, community members volunteered their labor, and women's groups and youth organizations played important roles in raising the additional finance. This local ownership and self-reliance related to water systems was one of the primary factors behind the leap in water system coverage between the years 1950 and 1970 (Komazawa 2004) as shown in Fig. 1.4

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[10] Small-scale rural water systems are those serving populations of 100–5,000. These systems provide safe water through disinfection and other simple water processing. They are exceptionally easy to manage and fund when the service population is not large.

## Column 1: Infrastructure Development to Enforce Human Security in Japan

After the Meiji Restoration (which instigated the emergence of Japan as a modernized nation) was initiated in 1868, Japan began to actively engage with Western countries. Unfortunately, this contact led to an outbreak of cholera and hence the death of tens of thousands of its people. Safe water supply systems were proposed as a method of fighting the disease, and their construction began in Yokohama and other port cities. There was a debate on whether water supply systems or, alternatively, sewage systems should be given priority in promoting urban hygiene and suppressing the emergence of infectious diseases: water supply systems won out because of fiscal concerns. In 1940, before Japan's involvement in World War II, the water system penetration rate (population connected to a system divided by total population) exceeded 25 %. It subsequently declined slightly, partly because of the effects of the war. However, from the early 1950s the promotion of small-scale rural water systems and other factors led to a sharp increase in the penetration rate, with it surpassing 80 % in 1970 and reaching 97.5 % in 2010. This growth in the water supply system penetration is shown in Fig. 1.4. This figure illustrates that as the water supply system penetration rose, deaths from typhoid fever and dysentery declined.

Construction of infrastructure other than water supply systems, particularly those built through public efforts, varied by type. Figure 1.5 covers the 40 years of development up to the present time. Although opinions vary on how to set infrastructure targets, the figure reveals that approximately half of Japan's infrastructure objectives have been achieved.

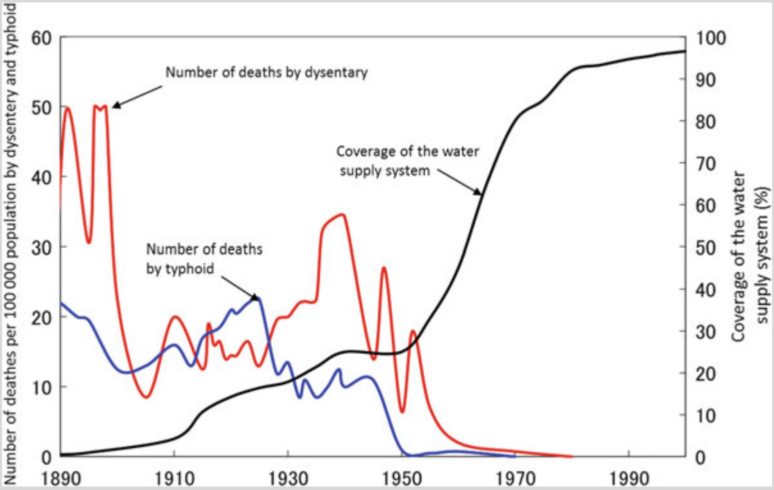

**Fig. 1.4** Japan's water supply system coverage and changes in waterborne infectious diseases levels, 1890–2000 (Japan Statistical Association 2006)

(continued)

## **Column 1** (continued)

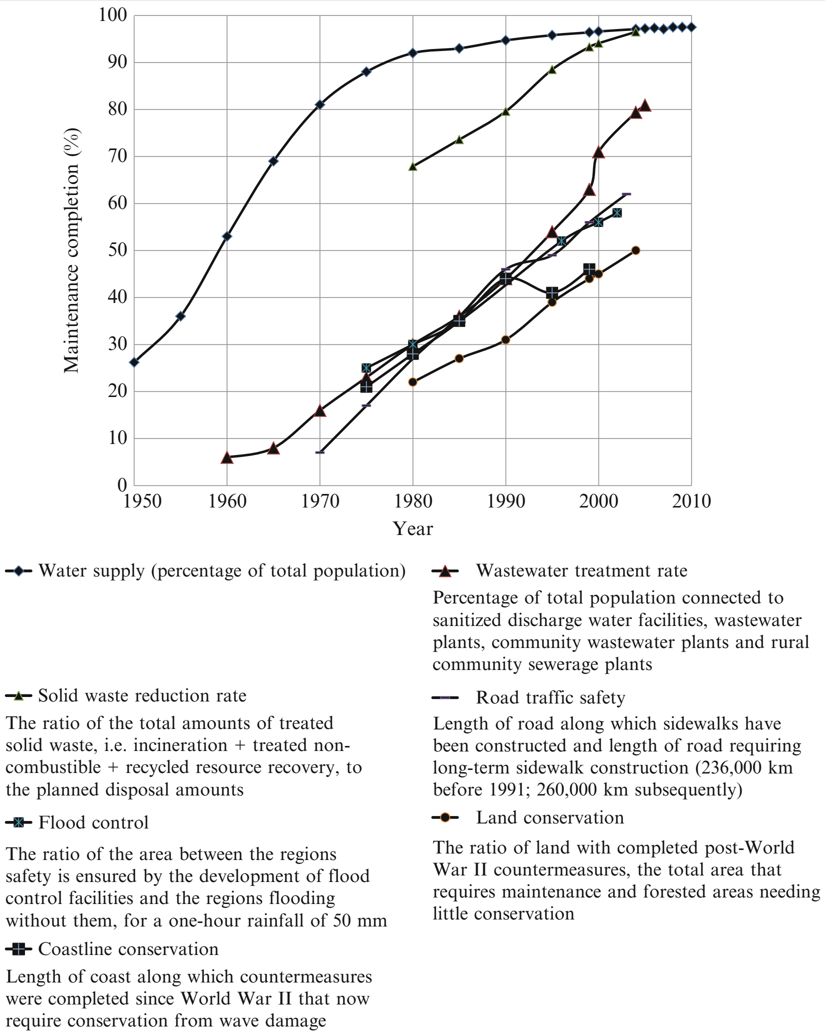

**Fig. 1.5** Infrastructure construction progress in Japan, 1950–2010 (Social Capital of Japan 2007)

Similar developments were observed regarding sanitation facilities. In Japan, sewage systems cost more to build than water systems, so they were introduced at a much slower rate. Because the cost efficiency of sewage systems was low in sparsely populated areas, inexpensive septic tanks[11] were suggested as an alternative and their spread was aided by strong demands for flush toilets. Initially, septic tanks handling human waste only were installed, however in cases where other household wastewater was directly discharged into the environment, a switch was made to combined septic tanks that handle all household wastewater. As was the case for water systems, subsidies played an important role in promoting adoption; however, in the case of sanitation facilities, the establishment of systems for installing and maintaining the quality of operations was also an important factor. The spread of septic tanks in Japan was an example of starting with low-cost affordable technology and subsequently moving to higher levels of technological specifications, in line with demand changes over time. It was also considered a successful integrated technological and societal development that included elements such as the specific equipment in conjunction with systems for its manufacture, installation, and management and with monitoring systems for controlling environmental pollution.

The general pattern of behavior is that social systems and rules change to benefit from evolving technologies. However, there are contrasting examples where systems and institutions, intended to meet prescribed safety targets, are designed first, and force the development of technology to comply with the targets. Japan's version of the US Clean Air Muskie Act of 1970, is an example.

A rapid expansion of motorization began in Japan in the early 1960s and quickly gave rise to air pollution, noise, vibration, and other problems. By 1965, serious air pollution from vehicle exhausts led to calls for stricter environmental controls on cars. Other developed countries were dealing with similar problems. In 1970 the US passed a law proposed by Democratic Senator Edmund Muskie that required a 90 % reduction by 1975 of nitrogen oxide and other pollutants emitted by gasoline vehicles and imposed traffic volume reductions when unable to comply with the target. The central Japanese government believed that Japan would face serious health problems if similar action was not taken, and decided that regulations of vehicle emissions would begin in 1976. However, it was unable to overcome the targets technically for automobile manufacturers with already developed ones. Moreover, within government circles the Japanese Ministry of International Trade and Industry considered that the planned regulation would result in higher automobile prices and significant economic losses. This situation remained in place for a number of years until automobile manufacturers developed the required technologies thus enabling the regulation to finally be implemented in 1978. In contrast, in the US, vehicle emission regulation was postponed multiple times and was finally implemented in 1994. This illustrates the positive results that can be

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[11] Septic tanks are devices that process small amounts of wastewater using anaerobic and aerobic bacteria.

achieved through the successful coupling of strong government leadership and industry partnership (automobile manufacturers in this instance). From the perspective of the automobile manufacturers: overcoming the challenge of cleaning up automobile exhaust became a prime opportunity to outclass competitors, and, additionally, second-tier manufacturers made laudable efforts during that period. In the end, this experience was of great benefit as it significantly increased the fuel efficiency and reliability of Japanese cars.

Several examples have been discussed where not only technology but also related systems and institutions were used in an effort to improve human security. Such efforts are not limited to specific countries but are observable throughout the world and there have been countless efforts to improve human security to date. Many have succeeded and many have not, but both successes and failures serve as valuable references when considering what can be achieved through "Human Security Engineering," the theme of this chapter.

## 1.2 Recommendations for Human Security Engineering

### *1.2.1 What is Human Security Engineering?*

Section 1.1 examined the threats facing humanity and the actions taken to reduce them to date. The key points of the latter included having a strong focus on threats and the will to reduce them as much as possible; the systemic combination of technologies, institutions, organizations, and approaches for the execution of that will with the self-reliance and partnerships of parties aimed at achieving that objective; and the development of capabilities enabling and supporting the sustainability of efforts to reduce risks.

This chapter discusses the system of technologies needed for those efforts and streamlines their advancement as "human security engineering"—engineering that supports human security. From the perspective of its application, human security engineering is a system of technologies for designing and managing a society that frees people from the threats of poor sanitation and unhealthy circumstances in daily life, as well as from threats from major disasters and widespread environmental destruction, and enables the comfortable pursuit of life with dignity.

It is important to note here that threats are not necessarily limited to those posing risks of physical harm, and that technologies go beyond engineering approaches aimed at reducing threats. As its original meaning intended, the word "technology" should be interpreted as an approach, method, or skill used for handling or processing something. Elements of human security include comfort, convenience, sustainability, economic rationality, and social rationality in addition to those having to do with physical security. Human security engineering must also address concerns arising from those elements. Consequently, the majority of technologies comprising human security engineering and its components should be based on disciplines that deal with such elements. In other words, human security engineering must implement relevant technologies or an organic combination of relevant technologies, to the extent that they help to achieve the objective of freeing people from threats to their lives and livelihoods, regardless of the disciplines upon which they are based.

The objective of human security engineering—freeing "people from the threats of poor sanitation and unhealthy circumstances in daily life, as well as threats from major disasters and widespread environmental destruction"—has considerable overlaps with those of civil engineering, architecture, and environmental engineering. The Japan Society of Civil Engineers (JSCE), for example, describes civil engineering as "the overall endeavor to improve society by bringing about the natural and human environments and the various conditions in which people can live and pursue various activities, secure from the threats of hunger and poverty" (Japan Society of Civil Engineers 2011). Civil engineering technologies are central to this endeavor, and the discipline systematically supporting the technology is civil engineering. The exact scope of "overall endeavor" is not defined, but Koi Furuichi,[12] the first president of the JSCE, emphasized the importance of not limiting the scope of civil engineering and of eagerly undertaking challenges as situations warranted.

> Civil engineering works, in general terms, apply knowledge from various academic disciplines. Engineers in civil engineering, therefore, must have the ability to work with engineers who are specialists in areas other than civil engineering. Furthermore, they must be able to freely communicate with people in not only the closely related mechanical, electrical, and architectural fields but also with people from other fields as well... This engineering society, therefore, must pursue research in not only areas directly related to civil engineering works but in areas found throughout the spectrum of engineering disciplines. Differentiating this engineering society from others is that its research endeavors, treating no academic disciplines as more important than others, must all ultimately contribute to the advancement of civil engineering works. Stated differently, this civil engineering society's research must develop in all directions from the core of civil engineering works. This is the approach and the degree of commitment by professionals that I have emphasized for this civil engineering society. The research endeavors of this engineering society shall not be limited to matters of engineering. While engineering universities include in their civil engineering curricular topics like industrial economics and the law of civil engineering works, they pay no attention to industrial hygiene. However, hygiene and sanitation issues as they relate to civil engineering works are extremely important.
>
> President Koi Furuichi's address at the inaugural meeting of the JSCE, 1913

Furuichi's address and past lessons both tell us, in no uncertain terms, that improving society so that people can live with a sense of security requires the enthusiastic incorporation of the related areas of science and technology, and the social sciences. Furthermore, protection against natural disaster, water shortage, environmental destruction, and other threats requires not only the preparation of physical facilities but also the development of the ability of people and society to respond to such threats. Such efforts must necessarily be included among the "overall endeavors" referred to by the JSCE.

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[12] 1854–1934. Koi Furuichi was a Japanese civil engineer who contributed to the establishment of modern engineering and civil engineering in Japan.

In the fields of civil engineering and environmental engineering, more so than in others, physical infrastructure has been the primary tool for improving human security. While there is no doubt that roads, harbors, water and sewer systems, electricity, gas, and telecommunications systems play useful roles in improving safety and security, they can do so only when people desire them and can make effective use of them, and when social conditions are amenable.

Based on this primary description of infrastructure, the Japan International Cooperation Agency (JICA) defines infrastructure as follows:

> Infrastructure is a fundamental common foundation for protecting the lives and livelihoods of people and ensuring their rights to pursue their lives in safety and good health, and plays the role of enabling people to exercise their innate abilities and realize their potential (Japan International Cooperation Agency (JICA) 2004).

By this definition, if physical facilities are not developed to fulfill the primary objective of "enabling people to exercise their innate abilities and realize their potential," they are meaningless in protecting people's lives and livelihoods, and in ensuring safe, healthy lives.

Such diligent levels of attention have not been paid in the past several decades in the fields of civil engineering, architecture, and environmental engineering. With the satisfaction on fulfilling basic human needs in the most developed countries, and the rapid development of engineering and scientific knowledge, the engineers' interest were more devoted to these developments, and the fervent desire for the fulfillment of the original objective of infrastructure—creating societies in which people can live with a sense of security—tended to be neglected.

Human security engineering can be interpreted as a pragmatic endeavor that is: (1) founded on disciplines such as civil engineering, architecture, and environmental engineering that focus on creating societies and spaces in which people can live in safety; (2) explicitly emphasizes the concrete objective of establishing human security; and (3) actively addresses and comprehends related science and engineering disciplines and the social sciences, as warranted, for a (4) more efficient and pragmatic approach to its objective. This can also be seen in the often quoted definition of engineering in Japan, "an academic discipline the objective of which is to construct—from mathematics and natural sciences, and if necessary the social sciences as the foundation,—products and comfortable environments that are useful for public safety, health, and welfare" (Committee for the Investigation of Curricula in Faculties of Engineering 1998).

### *1.2.2 Human Security and Human Security Engineering*

As discussed in Sect. 1.2.1, human security engineering as advanced in this chapter is "a system of technologies for designing and managing a secure society that frees people from the threats of poor sanitation and unhealthy circumstances in their daily lives." This is, in fact, the primary purpose of engineering in general. Hence, the phrase "human security" was proposed and promoted in the 1994 Human

Development Report (United Nations Development Programme (UNDP) 1994) issued by the UNDP. This section provides a brief explanation of the concept of human security and summarizes its relationship to human security engineering.

The 1994 UNDP report advocated the need to address hunger, poverty, natural disasters, environmental destruction, economic disparities, drugs, international terrorism, and other threats to present human existence. It proposed seven action areas—food, environmental, health, personal, community, political, and economic security—to promote "freedom from want" and "freedom from fear" (the two key components of human security) and to contribute to the broadening of the range of choices available to people, which is the goal of human development. In other words, the traditional view of security, one in which nations as the principal actors use military power and diplomacy as the primary tools for pursuing territorial security, is insufficient for ensuring the security of people. Such security requires proactive, multifaceted action on the part of international institutions other than governments, non-governmental organizations (NGOs), and other similar parties.

In 1998 the then-Prime Minister of Japan Keizo Obuchi in expressing his ideas on the subject said that it was necessary to take a comprehensive view of all types of threats to human existence, livelihoods, and dignity and that fighting them with great resolve is a core element of human security. While stating that Japan would include this as a central concept in providing aid to developing countries, he went on to announce the establishment of the "Trust Fund for Human Security" with an initial contribution from Japan. In September 2000, at the UN's Millennium Summit, Yoshiro Mori, then Prime Minister of Japan, announced that human security would be a guiding principle of Japan's foreign policy and proposed the establishment of the "Commission on Human Security." Co-chaired by Sadako Ogata,[13] a former UN High Commissioner for Refugees, and the Indian economist Amartya Sen,[14] and with the enthusiastic support of the then-UN General Secretary Kofi Annan, the committee began its work in 2001 and presented a final report of its activities titled "Human Security Now" (Commission on Human Security 2003) to General Secretary Annan in 2003. This report, echoing the views expressed in the 1994 UNDP report, defined human security as protecting the "vital core of all human lives in ways that enhance human freedoms and human fulfillment". However, it also expressed the view that poverty and conflict are the two major threats to security and emphasized that they must be addressed through "empowerment" and "protection"—two bottom-up perspectives where action begins at an individual level—and through action rendered through international cooperation and at state levels.

As shown in Table 1.1, humanity faces various threats. The list includes threats from disasters, disease, environmental degradation, and accidents. However, war

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[13] Born in 1927. Sadako Ogata is a Japanese political scientist, who, among other roles, has served as president of the Japan International Cooperation Agency (JICA).

[14] Born in 1933. Amartya Sen was awarded the 1988 Nobel Peace Prize for his contributions to the field of welfare economics.

and civil conflict, inadequate public security, and economic instability also pose threats. States are obliged to respond to these latter threats, and that proved the impetus for the original definition of security from a principally national perspective. The top-down approach of a state, however, cannot guarantee the security of individuals; that requires a grass root level self-reliance and cooperation on the part of individuals and communities. Although problems differ in how they may best be solved, they should all be approached with states, regions, communities, and individuals each taking ownership of their part of the problem at hand and working together. Security, originally viewed as the responsibility of states, then, can actually extend to be a matter of joint responsibility.

In recent years, large earthquakes; extreme climate change; international movements of people, goods, and money; and the worsening of international organized crime engendered by globalization have given rise to large-scale disasters, international terrorism, pandemic influenza, and other threats that cannot be successfully handled at the national level. Such nontraditional security problems cannot be addressed by traditional state-centered security, and non-state actors from the international community play critical roles. The critical importance of partnership among the key actors implies that human security is a pivotal problem to address and a key concern of human security engineering.

The discussion thus far has focused principally on the conceptual aspects of human security. In contrast the Millennium Development Goals (MDGs) approaches the topic from the perspective of concrete objectives for improving current conditions particularly in developing countries. The MDGs emerged from the September 2000 UN Millennium Summit's compilation of discussions held at several international conferences in the 1990s and were mainly based on the "New Development Strategy"[15] formulated by the OECD's DAC in 1996. There are eight development goals, addressing mainly the reduction of poverty, improvement of health and education, and protection of the environment; with 21 targets (originally 18), and 60 indicators (originally 48). These goals, which are to be achieved by 2015, were supported by 189 UN member states. The MDGs, the targets for achieving them, and their progress as of 2010 are presented in Table 1.3. Some goals are viewed as realistically achievable, while others are not. The second goal (addressing education), and the fourth, fifth, and sixth goals (addressing health) all require substantially more effort.

The UN sees the achievement of the MDGs as a matter of the highest priority for the international community and has drawn upon most of the resources at its disposal in supporting the effort. In 2002, UN General Secretary Annan commissioned the Millennium Project to propose strategies for achieving the MDGs.

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[15] The common name for the report titled, "Shaping the twenty-first century: The Contribution of Development Co-operation," adopted at a High-Level Meeting of the OECD/DAC. The report analyzes the experience of development assistance by advanced countries and the role of international society over the past 50 years, and puts forth proposals for development assistance going forward.

**Table 1.3** Millennium development goals: current status and achievements, 2010 (United Nations Department of Economic and Social Affairs (DESA) 2010)

| Goals and targets | | Progress in 2010 |
|---|---|---|
| *Goal 1: Eradicate extreme poverty and hunger* | | |
| 1-A | Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day | The number of people in extreme poverty fell from 2.0 billion in 1990 to 1.3 billion in 2008. The poverty rate dropped from 47 % to 24 %. The target seems likely to be achieved by 2015 |
| 1-B | Achieve full and productive employment and decent work for all, including women and young people | The proportion of the "working poor"—employed workers who live in households where individual members subsist on less than $1.25 a day—had been on a downward trend. However, due to economic and financial crises, the rate of improvement has slowed down since 2008 |
| 1-C | Halve, between 1990 and 2015, the proportion of people who suffer from hunger | The number of people who are undernourished reached 1 billion in 2009 |
| *Goal 2: Achieve universal primary education* | | |
| 2-A | Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling | In Sub-Saharan Africa, the school enrollment rate in primary education increased to 76 % in 2010 from 58 % in 1999. It also rose to 93 % from 77 % in Southern Asia |
| | | Even as the number of school-age children continues to rise, the total number of children out of school is decreasing—from 106 million in 1999 to 61 million in 2010 |
| | | High dropout rates have been impeding the achievement of universal primary education. However, the ratio of children who reach the final year of primary education in developing regions improved to 90 % in 2010 from 81 % in 1999 |
| | | Over 70 % of out-of-school children in the world in 2010 are in Sub-Saharan Africa and Southern Asia (33 million in the former region and 13 million in the latter) |
| *Goal 3: Promote gender equality and empower women* | | |
| 3-A | Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015 | In the developing region, 97 girls were enrolled in primary school for every 100 boys in 2010, up from 91 girls in 1999. In secondary school, the ratio of girls to boys to boys was 96:100 in 2008, compared to 88:100 in 1999 |

| | | |
|---|---|---|
| *Goal 4: Reduce child mortality* | | |
| 4-A | Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate | The under-five mortality rate dropped from 97 per 1,000 live births in 1990 to 63 per 1,000 live births in 2010 in developing countries |
| *Goal 5: Improve maternal health* | | |
| 5-A | Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio | The maternal mortality rate per 100,000 births in developing regions dropped from 440 deaths in 1990 to 240 deaths in 2010, but it is still substantially higher than the goal |
| 5-B | Achieve, by 2015, universal access to reproductive health | In developing regions the proportion of pregnant women who received health examination at least once before birth, increased to 80 % in 2008–64 % in 1990. However, pregnant women who received health examination at least four times, which is less than half the recommended |
| *Goal 6: Combat HIV/AIDS, malaria and other diseases* | | |
| 6-A | Have halted by 2015 and begun to reverse the spread of HIV/AIDS | The number of new HIV infection worldwide in 2008, declined to 2.7 million from 3.5 million people in 1996 reached a peak |
| 6-B | Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it | The number of HIV-infected individuals who receive antiretroviral therapy had reached about 6.5 million in 2010. However, this is still far from the goal set by the United Nations high-level meeting on HIV/AIDS, which is to provide treatment for 15 million people by 2015 |
| 6-C | Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases | About 650,000 people died from malaria in 2010, and Sub-Saharan Africa accounted for 91 % of these deaths. The number of children using bed nets in the region had jumped to 39 % in 2010 from 2 % in 2000 |
| *Goal 7: Ensure environmental sustainability* | | |
| 7-A | Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources | The net loss of forest area over the last decade was reduced to 5.2 million hectares per year, down from 8.3 million hectares per year in the 1990s |
| 7-B | Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss | The goal to reduce the rate of biodiversity loss by 2010 has not been achieved. Approximately 19,000 species of plants and animals are known to be threatened with extinction |
| 7-C | Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation | |

(continued)

**Table 1.3** (continued)

| Goals and targets | | Progress in 2010 |
|---|---|---|
| | | About 2.5 billion people still did not have access to improved sanitation facilities in 2010, and it is apparent that this goal will be difficult to achieve |
| 7-D | By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers | In developing countries, the proportion of the urban population living in slums has declined from 39 % in 2000 to 32.7 % in 2010. The living conditions of 200 million slum dwellers were improved |
| *Goal 8: Develop a global partnership for development* | | |
| 8-A | Develop further an open, rule-based, predictable, non-discriminatory trading and financial system | The rate of products without tariffs greatly increased in exports from developing countries to developed countries from 54 % in 1998 to 80 % in 2010 |
| | Includes a commitment to good governance, development and poverty reduction—both nationally and internationally | |
| 8-B | Address the special needs of the least developed countries | In 2011, a net amount of ODA expenditures totaled 133.5 billion dollars. While constituting an increase in absolute dollars, this was a 2.7 % drop in real terms over 2010 |
| | Includes: tariff and quota free access for the least developed countries' exports; enhanced programme of debt relief for heavily indebted poor countries (HIPC) and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction | The ODA/GNI ratio was 0.31 % and only five countries achieved 0.7 % (the target ratio) in 2011 |
| 8-C | Address the special needs of landlocked developing countries and small island developing States (through the programme of action for the sustainable development of small island developing states and the outcome of the twenty-second special session of the general assembly) | |
| 8-D | Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long | External debt repayment in 2000 accounted for roughly 13 % of export revenues among developing countries, but dropped to 3 % in 2010 |
| 8-E | In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries | |
| 8-F | In cooperation with the private sector, make available the benefits of new technologies, especially information and communications | |

The project, chaired by American economist Jeffrey Sachs, disclosed its recommendations in a report titled, "Investing in Development: A Practical Plan to Achieve the Millennium Development Goals" (Millennium Project 2005). The report emphasized that accumulation of four types of capital—Human, Infrastructure, Knowledge, and Natural—play critical roles in the achievement of the MDGs. It also pointed out that, although they are not included in the MDG targets, energy services, transport services, and sexual/reproductive health are indispensable for MDG achievement.

Developing these four capital types has often been emphasized as critical for achieving the MDGs. Tables 1.4, 1.5, and 1.6 gives examples of how the development of roads, water, and electrical and energy systems, can contribute to the achievement of the MDGs. It must be noted, however, that whether these capital investments can contribute to MDG achievement depends on the matching of needs and institutions, and of maintenance and management capabilities. In this light, the four types of capital identified by Sachs, closely overlap with the definition of "infrastructure" put forth by the JICA. Their accumulation, management, and operation mirror the JSCE's definition of civil engineering work as "the overall endeavor to improve society in ways that allow people to live secure from the threats of hunger and poverty". To that extent, human security engineering is profoundly connected to the MDGs.

### *1.2.3 Four Principles of Human Security Engineering*

If the purpose of engineering is to make life safer and more comfortable and as, in particular, civil engineering, architecture, and environmental engineering focus on this purpose, wherein lies the worth to establish and organize human security engineering as an independent engineering discipline?

The answer to that lies in the attempt to review existing technologies from the perspective of four principles that have been elicited from the experiences described in previous sections, and to establish organic relationships among them.

The first principle is that human security engineering methods and approaches have the clear objective of ensuring the security of people that both corresponds to prevailing social and economic conditions, and to the general context of the times. In human security engineering, the problems, the details thereof to be dealt with, and the priorities of each differ depending on the particular circumstances at hand. This, in turn, entails a significant variance in the specific measures or approaches required.

Michael Gibbons et al. (1994) refer to the form of knowledge production that is greatly influenced by social and economic contexts, as "mode 2" knowledge production. This is in contrast with "mode 1" knowledge production that is academic, investigator-initiated, and discipline-based. Like natural sciences, mode 2 is segregated into independent specialized areas where research is pursued in individual disciplines along lines determined by the internal logic of the discipline. Gibbons et al. proposed four features of mode 2 knowledge production. The first is

**Table 1.4** Effects of infrastructure development on MDGs (Willoughby 2004)

| | | Transport–local (village to township or main road) | | Transport–trunk (beyond the township) | |
|---|---|---|---|---|---|
| Goals | | Impact | Effects | Impact | Effects |
| Goal 1 | Eradicate extreme hunger and poverty | High | Improvement to low-volume local roads and associated networks of village tracks/paths can significantly reduce poor farmers' transaction costs and expand their production possibilities (including non-farm) | High | Availability of competitive transport services on adequately maintained trunk network is critical to the effective participation of an area in national and international markets |
| Goal 2 | Achieve universal primary education | Medium | Village roads significantly affect school enrolment and attendance | Low | Quality of link to regional center significantly affects quality of teachers who can be attracted and his/her attendance |
| Goal 3 | Promote gender equality and empower | Low | Girls' attendance significantly increased by safer roads | Low | Help securing better quality of teachers |
| Goal 4 | Reduce child mortality | Low | Increase use of primary healthcare facilities and facilitates access to better water | Medium | Vaccines/drugs supply and visits of more skilled health personnel and emergency evacuations |
| Goal 5 | Improve maternal health | Low | Positively affects antenatal care and share of deliveries professionally attended | Low | Increase in-hospital deliveries and often critical when emergency obstetrics required |
| Goal 6 | Combat HIV/AIDS, malaria and other disease | | | Low | Important for drug supply and higher level diagnostics care needed to avoid stimulating AIDS spread |
| Goal 7 | Ensure environmental sustainability | Low | Care needed to maximize compatibility of engineering design with local environment | Possible adverse effects | Great care needed in fragile ecological environments to minimize risks and compensate people who suffer |
| Goal 8 | Develop a global partnership | Low | Work on local roads/transport can generate much youth employment | High | Essential facility to enable area to benefit from international trade opportunities |

**Table 1.5** Effects of infrastructure development on MDGs (Willoughby 2004)

| | | Modern energy | | Communication infrastructure | |
|---|---|---|---|---|---|
| Goals | | Impact | Effects | Impact | Effects |
| Goal 1 | Eradicate extreme hunger and poverty | High | Rural electrification often correlates with sharp increase in regional incomes and growth of non-farm activity. Reliability of modern energy supply strongly affects investment in and competiveness of local enterprises | Medium | Communication infrastructure improves the efficiency of the services sector and in most cases the government. Facilitates the transfer of information to the poorer people for improving their economic situation |
| Goal 2 | Achieve universal primary education | Low | Availability of modern energy increases enrollment and attendance rates, and home electrification raises time devoted to study | Low | Improve teacher training, and can make classes more interesting |
| Goal 3 | Promote gender | Medium | Modern energy helps families release girls for school, less time for collecting fuel-wood and water, and schools improved | Low | Increase efficiency of study, making school more worth while attending by strengthening students' performance |
| Goal 4 | Reduce child mortality | Medium | Sharply reduces indoor smoke pollution and impurities in water/food consumed | Low | Can promote better health practices and ensure timely availability of life critical diagnostic information and drugs |
| Goal 5 | Improve maternal health | Low | Reduced stress of household chores, and electricity improves medical services | Low | Enables efficient arrangements for emergency treatment |
| Goal 6 | Combat HIV/AIDS, malaria and other diseases | Low | Improved medical services, including from attraction of more qualified personnel | Low | Reduces drug stock-outs and make efficient referrals to higher medical institutions |
| Goal 7 | Ensure environmental sustainability | Medium | Reduces pressure on land resources by moving water and reducing fuel wood need, but care needed to avoid ill effects of large dams | Low | Record-keeping and retrieval services of importance for environmental protection |
| Goal 8 | Develop a global partnership for development | Low | Small quantities of electricity are essential for use of modern Information and Communication Technology | Medium | Crucial for meeting the communication infrastructure target under this goal, and for participation in international economic opportunities |

**Table 1.6** Effects of infrastructure development on MDGs (Willoughby 2004)

| Goals | | Household water | | Improvements of sanitation facilities | | Water management structures | |
|---|---|---|---|---|---|---|---|
| | | Impacts | Effects | Impacts | Effects | Impacts | Effects |
| Goal 1 | Eradicate extreme hunger and poverty | Medium | Substantially reduce morbidity and mortality, time spent for fetching water, and enterprise interruptions, and improve nutrition, with significant effects on poor people's productivity | Low | Sharply reduces illness and expenditure on medical treatment, especially causes a large impact to poverty | High | Irrigation and flood control structures can greatly increase incomes and nutrition levels of the poor if they are managed to maximize benefits to the community as a whole, and especially if they support production of labour intensive crops |
| Goal 2 | Achieve universal primary education | Medium | Increase school attendance and increases learning capacity | Low | Help to attract good teachers | | |
| Goal 3 | Promote gender | Low | Women's housework burden reduction | Medium | Increase of girl's attendance | Low | Less drudgery for women in obtaining water for household needs |
| Goal 4 | Reduce child mortality | High | Greatly reduces child mortality, especially if mother is literate | Low | Decreases child mortality and improves nutrition | Low | More ample supplies of water for household use |
| Goal 5 | Improve maternal health | Low | Improves general maternal health and deliveries | Low | Reduces maternal illness | | |
| Goal 6 | Combat HIV/AIDS, malaria and other diseases | Low | Important for disease treatment | Low | Reduces malaria mosquito breeding | Possible adverse effects | Care need to avoid adverse health consequences of man-made changes in water regimes |
| Goal 7 | Ensure environmental sustainability | High | Crucial for meeting the household water target under this goal | Medium | Crucial for meeting the sanitation target and combating urban environmental degradation | Medium | Sound planning, design and operation of water-related structures are key in protecting environmental resources and accommodations growing populations |
| Goal 8 | Develop a global partnership for development | Low | Especially necessary for least developed countries | Low | Especially necessary for least developed countries | | |

"trans-disciplinarily" that goes beyond multi-disciplinarily (cooperation among different disciplines) and inter-disciplinarily (the sharing of experiences or concepts). Trans-disciplinarily means not being restricted by boundaries and thus invading traditionally separated disciplines. The second feature is that the people and places producing knowledge are not necessarily located within universities or research institutes; they may be in private companies, governmental organizations or NGOs or may be private citizens acting on their own. The people and places producing knowledge are widely dispersed. The third feature is that the producers of knowledge attempt to solve problems through a repetitive "reflexive process" between the objectives, their own specialties, roles, value standards, and the contexts of problems. The fourth feature is how the quality of the knowledge produced is managed. In mode 1 knowledge production the consensus among experts specialized in the particular discipline is critical. In contrast, mode 2 emphasizes standards required by the context corresponding to the storyline of the problem at hand and social application of the knowledge produced.

Most of these characteristics of mode 2 knowledge production are those of human security engineering. Therefore, if human security engineering is to be regarded as a new independent knowledge production endeavor, it faces the same fundamental, pragmatic questions posed of mode 2—questions on how to verify the knowledge produced and on how to establish this trans-disciplinary effect as a taught discipline. Alternatively, one could ask whether it would be sufficient for human security engineering to remain in the mode 1 realm of civil engineering, architecture, and environmental engineering. The answer is "no." These three disciplines should have naturally oriented to mode 2 endeavors, and human security engineering, in particular, extracts the mode 2 aspects of these disciplines. Hence, human security engineering should be considered to acknowledge and trans-disciplinarily integrate the human-security-related aspects of civil engineering, architecture, and environmental engineering, in addition to the social sciences and other disciplines. The experts, researchers, and students educated in these disciplines, therefore, should bring their knowledge and experience into the realm of human security engineering. Here they should embrace the trans-disciplinary effect and should be innovative and committed in responding to the objectives of human security. They should undertake this while considering whether the knowledge in which they have specialized to date is appropriate for the qualities and the context of the area and the issues they are facing. Human security engineering also intrinsically calls for participants to take back to their original disciplines the knowledge gained from human security engineering work, given the need.

The second principle of human security engineering is that emphasis is placed on site-specific mechanisms and ensuring that conditions appropriately reflect the unique situation of the locality. Table 1.7 provides an overview of infrastructure needs, related technologies and system requirements by economic development stage. The relationships between infrastructure needs and technology needs differ greatly depending on the natural environment, customs and norms, governance, value standards, and other factors. Inference based solely on previous information that has been subsequently stylized (i.e., formalized descriptions based on prior

**Table 1.7** Economic development and infrastructure needs

| Low income | | | Lower middle income | High middle income |
|---|---|---|---|---|
| Urbanization (%) | | 30 | 49 | 78 |
| Per capita infra stock (USD per capita) | | 730 | 1,245 | 9,342 |
| Expected infrastructure needs | | Social infrastructure and economic infrastructure for primary industry:<br>• Water resources development, irrigation, drinking water, sewerage, health care, and education<br>• Roads, bridges, and energy | Urban infrastructure and industrial infrastructure:<br>• Water and sewage<br>• Roads, airports, ports, communication, and energy<br>• Environmental conservation | High-tech infrastructure, safety- and amenity–related infrastructure and facility renovation:<br>• Flood and landslide control, sewerage, solid waste treatment<br>• Traffic control, distribution facilities, asset management<br>• Environmental conservation, recycling |
| Expected technical needs | | (Establishment of core system) | (Systems integration. Efficiency improvement) | (Absorption of advanced technology, reduction of external diseconomies) |
| Institutions and organizations planning | | • Development of basic systems: law, taxation, finance, etc. | • Institutional development for financing infra development and for project preparation and implementation<br>• Institutional measures to attract private investment in infrastructure, creation of a favorable climate for industrial investment | • Management of project cycle, and system of operation and maintenance<br>• Methods for evaluating infrastructure investment<br>• Institutional development for financing infra development and for project preparation and implementation |
| Infra-related technology | Planning | Preparation of basic information needed for infrastructure development (e.g. maps) | Building standards for infrastructure | • Methods of impact assessment and regulation<br>• Consensus building among actors |
| | Implementation and construction | Development of basic technical capacity for the sub-sectors mentioned above | Participatory approach | • R&D on construction technology<br>• Participatory approach, social impact consideration |
| | Operation and maintenance | Development of basic technical capacity | • Techniques of operation and maintenance<br>• Database compilation | • Introduction of asset management<br>• Development of management system |

research and theories) and technical rationality (methodological rationality) may prove a mistake in "framing" (Goffman 1974) problems to be addressed as they often differ significantly from the actual facts or physical reality. Actual natural and social environments, and combinations of service levels and acceptable payment for services, have a significant influence on what technologies are appropriate. Good practices for one area may not necessarily be good practices for another. Actual conditions differ substantially from textbook prerequisites and requirements; however, this is frequently overlooked. Hence, it becomes necessary to pursue courses of action that not only make technical sense, but also social and managerial sense. The actors involved must engage in a dialogue (both within and among themselves) encapsulating knowledge from formal disciplines combined with an understanding of the actual circumstances, and "local knowledge",[16] and collaboratively address the problems at hand. This approach was referred to as "reflective practice" (Schön 1984). The information gained and experience created through actual circumstantial interactions become the essential contents of human security engineering, and are useful for the capacity development of each of the actors involved in this process.

The third principle is the perspective of the "co-evolution" of technology, institutions, and society that support the chosen approach. Technology, institutions, and their management ability can have a great effect when the relationships are well balanced with an appropriate level of tension. New technologies require conforming systems, institutions, and approaches, and conversely they give rise to conforming technologies. In the Japanese examples discussed in Sect. 1.1.4, restricted budgets gave rise to small-scale water systems and septic tanks, and serious concerns about air pollution led to innovative technologies for reducing automobile emissions. Skillful manipulation of the co-evolution between laws and economic regulations on the one hand, and technology on the other, was applied for the benefit of achieving certain goals. This type of strategic perspective is critical in advancing human security.

The fourth and final principle of human security engineering is to examine the role of "multilayered governance structures" and make active use of its complementarity. States, individuals, or other parties acting alone are limited in what they can accomplish in human security. International organizations, central governments, regional governments, communities, local residents, private companies, NGOs and the various other actors must recognize their roles and carry them out in cooperation with others. In other words, how best to design and manage the multilayered governance structures is an important element of human security engineering. The 2003 Commission on Human Security report emphasized the importance of "empowerment" and "protection"—the two approaches for ensuring

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[16] Local knowledge is knowledge that is dependent upon local conditions and includes intuitions of local circumstances asserted in a way that is consistent with first-hand, local experience. (Yuko Fujigaki, 2012, Knowledge, Authority, and Politics, Social Technology Theory, Revised Edition, Chapter 10, Shinichi Kobayashi, ed., The Society for the Promotion of the Open University of Japan.)

human safety. Empowerment gives rise to grassroots actions by individuals and families, and harbors the possibility of even more robust actions through community or local networks. Protection, viewed from a traditional perspective, is the most important role of the state and is the rationale for allocating large amounts of capital and human capabilities to the state. However, national governments are frequently at a distance from circumstances impacting local communities, and hence are unaware of the urgency of their problems and fail to act in a timely fashion.

Public assistance, mutual aid, and self-reliance are phrases that express how national governments, regional governments, communities, and individuals and families combine their roles and capabilities in a complementary way to respond to disasters. Foreign assistance (Japan International Cooperation Agency 2003) from the international community also plays an important role as was seen following the 2011 Great East Japan Earthquake and the 2004 Asian Tsunami. Individual actors in such disasters have different time and space perspectives, and their priorities and preferred countermeasures differ for the problems at hand. There is much that human security engineering must address in determining how best to combine the strengths of individual actors and to recognize their weaknesses to create a cooperative approach for reliably securing human safety.

### *1.2.4 The Contents of Human Security Engineering*

This final subsection discusses methods for developing human security engineering capabilities.

It is useful to begin by recalling that human security engineering, for the reasons discussed in Sect. 1.2.1, relies on knowledge from the disciplines of civil engineering, architecture, and environmental engineering. Each of these disciplines has the objective of producing knowledge for improving society in ways that allow people to live securely and safely, and have already accumulated a considerable knowledge-base. With this in mind, and in light of the threats discussed previously and experiences to date, the following four sub-disciplines can be considered as the roots of human security engineering.

1. Urban/Regional Governance: Development of strategies and methods for the cooperation of a diverse set of actors (including individuals) in establishing human security (e.g., securing safety, health, convenience, amenities) based on the specific characteristics of the local area.
2. Social/Urban Infrastructure Management: Development of strategies and methods for the construction and development of social and urban infrastructure management. This is based on social/economic/financial perspectives and taking into account fiscal management concerns and society's priorities in preventing or minimizing disasters and environmental destruction.
3. Health Risk Management: Development of innovative and localized sanitary facilities, environmental technologies and strategies for human security.

4. Disaster Risk Management: Development of strategies for managing national and urban risks, and the methodologies for implementing them.

In light of the four principles discussed earlier, human security engineering, based on these four sub-disciplines, is a discipline that seeks to achieve the goal of improving human security. In realizing this target it seeks to advance human security by enthusiastically incorporating knowledge and approaches from other relevant fields as necessary (mode 2). It implements measures that are broadly appropriate (mode 2 and local emphasis)—not only from an engineering perspective, but also socially and procedurally—and are suitable for the specific characteristics of the target region, the problems at hand, and the underlying social and economic contexts. It pays particular attention to dynamic dependencies among technologies, institutions, and supporting frameworks (co-evolution) and cooperation among various actors including individuals, regional, national, and international communities, and among governments and the private sectors (multilayered governance). In determining what is appropriate and how it should be pursued, previously accumulated knowledge must be used as a starting point and cognizance taken of existing knowledge and dialogs between actors. Existing knowledge and experiences to date are valuable when they match contingencies; however, they frequently do not. Strategic knowledge of the approaches to take in specific situations can be cultivated in the course of developing expertise in the disciplines and sub-disciplines discussed above, and through the experience of dealing with actual problems while having clear problem awareness and a sense of ownership.

## 1.3 Conclusion

This chapter discussed the background of, need for, and features of human security engineering. Humanity is exposed to a large number of threats. Meeting these threats involves “empowerment” of individuals and “protection” by countries and governments: human security requires both. Within that context, infrastructure has been redefined as a “common platform for human security, and it encourages people to exercise their innate abilities and realize their potential”. Civil engineering has been redefined as “the overall effort to improve society to eliminate hunger and poverty and to allow people to live in security”.

Minimizing threats and creating a safe society has been a constant desire throughout history and, although significant efforts have been devoted to this, the desired results have yet to be achieved. Would it not be possible, however, to combine the knowledge gained through these efforts with that developed in civil engineering, architecture, environmental engineering, and other disciplines? This knowledge could then be devoted in essence to providing daily safety and comfort, while enthusiastically incorporating effective approaches from across disciplinary boundaries as necessary, to make the fight against threats to humanity a more fruitful one. The significance of human security engineering lies in the affirmative answer to this question.

Through efforts such as those described above, civil engineering, architecture, and environmental engineering, which tended to be expertized and radicalized as mode 1 disciplines, can be elevated to new heights and gain social significance in terms of the original definition of civil engineering, “the engineering for civil society”.

## References

Commission on Human Security (2003) Human security now. United Nations Commission on Human Security, New York

Committee for the Investigation of Curricula in Faculties of Engineering (1998) A review of engineering education programs of the engineering faculties of eight universities, Committee Report of Engineering Education Program, Hachi-daigaku Kougaku-bucyou Kondankai

Director-General for Policy Planning Cabinet Office of Japan (in Charge of Economic and Social Systems) (2007) Social capital of Japan. National Printing Bureau, Tokyo

Ezzati M, Lopez D, Rodgers A, Murray C (eds) (2004) Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. World Health Organization, Geneva

Fukuda-Parr S, Lopes C, Malik K (2002) Capacity for development: new solutions to old problems. Earthscan, New York

Gibbons M, Limoges C, Nowotny H, Schwartzman S, Scott P, Trow M (1994) The new production of knowledge: the dynamics of science and research in contemporary societies. Sage, London

Goffman E (1974) Frame analysis: an essay on the organization of experience. Harvard University Press, Cambridge

International Federation of Red Cross and Red Crescent Societies (2011) World Disasters report. International Federation of Red Cross and Red Crescent Societies, Geneva

Japan International Cooperation Agency (2003) Disasters and development: toward improvement of society’s ability to cope with disasters (Bosai to Kaihatsu: Shakai no Bosai-ryoku no Kojo wo Mezashite). JICA Research Institute, Tokyo

Japan International Cooperation Agency (2006) Capacity development. JICA Research Institute, Tokyo

Japan International Cooperation Agency (JICA) (2004) A new dimension of infrastructure. Japan International Cooperation Agency, Tokyo

Japan Society of Civil Engineers (2011) Declaration: on transition to a public interest incorporated association. http://www.jsce.or.jp/strategy/association.shtml. Accessed 25 September 2013

Japan Statistical Association (2006) Historical statistics of Japan, Newth edn. Japan Statistical Association, Tokyo

Komazawa M (2004) Addendum environmental hygiene – focusing on water and sewer systems and sanitary sewage – the experience of health care in Japan – considering ways for improving health care in developing countries. Japan International Cooperation Agency, JICA Research Institute, Tokyo

Livi-Bacci M (2006) Concise history of world population, 4th edn. Wiley-Blackwell, Oxford

Organization for Economic Co-operation and Development, Development Assistance Committee (1991) Principles for new orientations in technical cooperation. Publications Unit Development Cooperation Directorate, Organization for Economic Cooperation and Development, Paris

Schön D (1984) The reflective practitioner: how professionals think in action. Basic Books, USA

Sivard R (1996) World military and social expenditures, 16th edn. World Priorities, Washington, DC

UN Millennium Project (2005) Investing in development: a practical plan to achieve the millennium development goals. United Nations Development Programme, Earthscan, New York

United Nations Department of Economic and Social Affairs (DESA) (2010) The millennium development goals report 2010. http://www.un.org/en/development/desa/publications/millennium-development-goals-report-2010.html

United Nations Development Programme (UNDP) (1994) Human development report 1994: new dimensions of human security. Oxford University Press, New York

United Nations, Department of Economic and Social Affairs, Population Division (2011) United World population prospects: the 2010 revision. United Nations, Department of Economic and Social Affairs, Population Division, New York

Water, Engineering and Development Centre (1998) Guidance manual on water supply and sanitation programmes. Department for International Development, WEDC, London

Willoughby C (2004) Infrastructure and the millennium development goals, Session on complementarity of infrastructure for achieving the MDGs. Berlin, 27 Oct 2004

World Bank (1994) World development report 1994: infrastructure for development. World Bank, Washington, DC

World Health Organization (2002) Causes of death and burden of disease estimates by country. World Health Organization, Geneva

World Health Organization (2004) Disease and injury regional estimates for 2004. World Health Organization, Geneva

World Health Organization (2009) Global health risks: mortality and burden of disease attributable to selected major risks. World Health Organization, Geneva

World Health Organization (2012) World health statistics 2012. World Health Organization, Geneva

# Chapter 2
# Human Security Engineering as a Practical Approach

**Kiyoshi Kobayashi**

**Abstract** The practical issues to be resolved by human security engineers require that thinking goes far beyond both the traditional "engineering" scopes and the compound structures of various associated disciplines. Practical research involves thoughtfully considering one's own experiences in applying knowledge to practice, while learning from professionals in the discipline. Practical research integrates the technological rationality characterized by universality, logicality, and objectivity, and the systems of professional thoughts managing specific, symbolic, and active practice. This chapter summarizes the contemporary aspects surrounding practices in human security engineering and presents the fundamental practical research requirements, thought processes, and evaluation schemes.

**Keywords** Field knowledge • Practical research • Reflection • Technological rationality

## 2.1 Engineers as Practitioners

Professional engineers (henceforth referred to as engineers) face considerable practical responsibilities and ethical demands. In modern society, with its high levels of competition, the problems engineers confront in practice extend far beyond the boundaries of individual engineering fields and subsume issues that would be best handled from other fields. When examining problems, engineers encounter complexities and uncertainties and must work with a certain degree of

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insecurity. Therefore, resolving the related value conflicts is no simple matter; engineers are required to apply an amalgam of innovation, expertise, and judgment in solving problems. To address the interdisciplinary and complex demands being made of engineers, there needs to be a reevaluation of their knowledge requirements and a new archetype of the engineer as a professional should be established.

Discussions on the “conversion of knowledge” previously attracted significant attention. Attempts were made to locate the basic principles upon which existing academic disciplines rely from universality, logicality, and objectivity perspectives, and to examine ways of transitioning to academic discourses in areas that did not comfortably fit with these scientific concepts (Nakamura 1981). Psychiatry, ethology, nursing science, education, early childhood care and education, and other clinical disciplines centered on a core of personal interactions with subjects, and individualistic fields such as regional studies and cultural anthropology were given new status as academic disciplines. There were questions on the extent to which learning could be established in clinical and individualistic fields. Each of these disciplines, with their respective ambiguity of subjects across locations and time, require field-oriented concepts that enable the comprehension of events or circumstances through exchanges with said subjects. Human security engineering, as a response to the various real-world threats, dangers, and risks to human existence, is an extremely practical field of engineering. It takes a local perspective in developing a comprehensive understanding of the pathology and inconsistencies facing local actors, and seeks solutions by devising concrete recommendations in conjunction with people on the ground. Human security engineering specialists must acquire an understanding of the field-oriented concepts required by practical engineering, and be able to mobilize their own experience and knowledge to solve the problems they confront. They must be able to work with people having different perceptions, experiences, knowledge, and sensibilities to their own, and must acquire the skills and methodologies required for taking action to solve problems. In this sense, human security engineering must cross the divides separating the individual engineering fields that respond to the threats, dangers, and risks confronting human existence, and incorporate their methods for acquiring field knowledge and practical methodologies for solving problems. This chapter addresses two questions based on the premise that human security engineering is or could be considered a practical engineering field. The first is, “To what extent can human security engineering be recognized as a field of engineering?” and the second is, “What does it mean to study human security engineering?” Human security engineering is a new discipline and is not systematized as a field of engineering. This chapter, therefore, presents personal ideas on the topic of human security engineering as a starting point for future discussion.

## 2.2 Field Knowledge Required of Engineers

### *2.2.1 Basic Principles of Traditional Academic Disciplines*

Field knowledge and practice are closely related. In academic disciplines related to real world practice, discussions focus on the following pairs of principles: (1) universality and uniqueness; (2) logicality and symbolism; and (3) objectivity and activity. The practical academic disciplines, rather than addressing abstract spaces characterized by the anonymity of a mathematical model, focus on unique fields in designated time and space (the principle of uniqueness). The problems addressed are characterized by intervening domains that cannot be reduced to simple mathematical models or cause-and-effect relationships. Problems in unique fields are idiosyncratic as they are addressed as an integral unit incorporating various meanings (the principle of symbolism). Additionally, there are occasions where engineers actively engage with an event or circumstance and its characteristics, having been discerned, subsequently change their engagement. In such cases, strictly distinguishing subjectivity from objectivity and subject from object is impossible, but engineers themselves have the intent of engaging the object (the principle of activity). Traditional academic disciplines have willfully eliminated the concepts of uniqueness, symbolism, and activity. However, to the extent that practice is the object, these three concepts must necessarily be positioned at the core of the academic perspective.

The practical problem of regional activation is illustrative. In solving the problems at hand, engineers must identify real-world problems currently active in the region (the object) and develop solutions. The task facing engineers is not to identify viable policy theories that are generally applicable, but to present a unique prescription that will be useful for resolving the problems at hand. To solve problems, engineers create demand forecast and analysis models and thus acquire information useful for making final decisions. However, as they are specifically developed to discount some of the problem aspects and as they undergo processes that make them conceptual and abstract, the models produced, regardless of how elaborately they have been formulated, cannot address the entirety of the problems at hand. By this argument, creating such elaborate models would seem to be meaningless. Regional problems incorporate various constituent parts. In solving these problems engineers must endeavor to develop an overall understanding of them in their entirety. They must not observe conditions objectively from a distance, but must actively engage with the region and act with the intent of bringing change to it. Furthermore, faced with various opinions and responses from the region—the object of their efforts—engineers must judge whether their efforts are correct on an ongoing basis and make changes as necessary.

### 2.2.2 Tacit Field Knowledge

The principles of uniqueness, symbolism, and activity should always be included in engineering practice. Making this type of engagement the object of a practical academic discipline requires the systematization of field knowledge and the build-up of intellectual enterprise for the solving of problems. Since the publication of Descartes' "Discours de la Methode (Descartes 1637)", positive science has been structured around method concepts and methodologies. In constructing method concepts and methodologies, the manipulation of universality, logicality, and objectivity is unavoidable. These three principles are essential to both traditional and practical academic disciplines. For communication to take place among people with different experiences, knowledge, and values, tacit knowledge (Polanyi 1958) must be converted to formal knowledge. There is a premise in the practical engineering that the systematization of knowledge can be made explicit in a logical and anonymous fashion and that the correctness of propositions can be proved. In practical engineering, however, there are more than a few cases where important knowledge components comprise experience and it is not possible to prove their correctness using the methods applied in the positive sciences. In contrast with logic, experience is indistinct and proving the solidity of its foundation is difficult. The practical application of this type of field knowledge as an academic discipline object must be addressed.

### 2.2.3 Objectivization and the Objectivization of Objectivization

As discussed in Sect. 2.2.2, for a practical academic discipline to be established as a formal academic discipline, it is necessary to convert tacit field knowledge into formal knowledge via the fundamental principles of traditional academic disciplines—universality, logicality, and objectivity. This conversion to formal knowledge means conforming to the analytical framework of method concepts accumulated in the traditional academic disciplines, and using methodologies shared in the academic domain to which engineers belong, to logically derive conclusions from certain hypotheses. This conversion of field knowledge to formal knowledge is here expressed as "objectivization". A practical academic discipline, however, must respond to issues related to the uniqueness, symbolism, and activity required of field practice. In other words, it is necessary to demonstrate, when using a practical academic discipline, that the method concepts and methodologies used by engineers are meaningful tools for addressing the target problem. The effort to prove the acceptability of the process of converting practical knowledge to formal knowledge is here referred to as the "objectivization of objectivization." The collection of tools an engineer can use for understanding and acting are referred to as a "repertory." A practical approach requires the accumulation of a repertory that engineers can use for the process of objectivization, and the development of practical approaches for the objectivization of objectivization. The process of objectivization requires rigorous logical development, and the guiding principle of evaluation for the objectivization of objectivization is the appropriateness for individual target contexts. Research on tools for the objectivization of objectivization in human security engineering is new and the body of accumulated work is extremely small. This chapter discusses field experimentation, frame analysis, intermediary theories, and examination amid reflection from a practical perspective. Conceptually, the process of objectivizing objectivization could entail infinite objectivization, or infinite regress. However, practically, as engineers actively engage the object, their engagement can itself be changed by the object. Under such circumstances it becomes impossible to strictly differentiate the subject and the object, and the actor and what is acted upon, and researchers require the reflection of engineers continuously questioning the appropriateness of the analysis itself. This manifestation of the principle of activity excludes infinite regress with regard to the objectivization process.

## 2.3 Issues Encountered in Practice by Engineers

### *2.3.1 The Expertise Problem*

Decisions on human security occur amid the diverse interests of taxpayers including local residents, businesses, various public service users, and various individuals and groups. Evaluations by engineers, the provision of information, and audits play important roles in backing the legitimacy of such decision-making. In advancing human security, decision makers must determine whose demands will be satisfied of all the varied stakeholders. There is a need for expert accountability (Gilman 1939) on the decision-making process used in reaching conclusions. Critical elements in this type of expert accountability include expertise in engineering and related fields, and how engineers familiar with the pertinent engineering and related fields can contribute to the expert accountability of government activities.

Engineers have traditionally played an important role in underpinning the legitimacy of decisions made for the benefit of society. However, it is increasingly the case that judgments must be made on natural disaster risks, pollutant risks, nuclear power risks, and other problems for which engineers cannot offer solid expert knowledge (Beck 1986). Differences of opinion on scientific or technical matters can arise among engineers, and the scientific and technical judgments made are often influenced by the values engineers themselves hold. It is impossible, therefore, to present clear decision-making criteria even for the fields in which engineers are expert, and the legitimacy of engineer expertise is being undermined (Schön 1983).

Expert engineering knowledge is the basis on which engineers evaluate the appropriateness of scientific and technical judgments concerning human security. The scope of appropriateness serving as the basis for engineering judgments is referred to here as the “frame.” In their areas of expertise, engineers have theories, models, and other tools serving as repertories for justifying the bases of their judgments and decision-making processes. However, there are frequent cases where the problems presented exceed the engineer’s frame or are complexly entwined. Judgments must be made in such cases however, and this can result in confrontations with researchers and engineers in other fields. Within the engineering frame differences of opinion regarding certain scientific or technical judgments can frequently arise with experts or engineers from other fields. Moreover, there is a considerable frame difference between engineers and ordinary interested parties.

One reason for such differences of opinion is a conflict between rigor and appropriateness in scientific and technical judgments. In professional association settings, engineers encounter scholarly competition in their particular field and are judged on precise data and solid evidence, and must therefore be rigorous in their scientific and technical judgments. In contrast, ordinary interested parties focus on the appropriateness of technical judgments in terms of whether their interests are being served and whether technical judgments adhere to common sense. Engineers, therefore, must decide whether to emphasize rigor in technical judgments or take a practical perspective and emphasize appropriateness in balancing the concerns of interested parties (Schein 1973). Related parties will be characterized by a diversity of values and interests, and each will have a different frame. Discerning a frame appropriate for solving the respective problems requires the balancing of the frames advocated by the different actors. To achieve a workable balance, engineers must relativize their own frame through communication with the various interested parties and experts from other fields (Forester 1982), and then construct a new frame.

### 2.3.2 The Legitimacy Problem

Making decisions having a bearing on human security directly and indirectly impacts the interests of government, users, taxpayers, businesses, organizations, and various other interested parties. Interested parties have diverse values and concerns, and differing levels of human security demands that arise from their own particular perspectives and circumstances. Forming an agreement that satisfies all interested parties is essentially impossible. Whose opinions and desires to recognize as appropriate, therefore, becomes an important issue. In other words it becomes a question of how to bestow decision-making legitimacy.

It is extremely difficult to implement policies that satisfy all of the related actors and diverse interests. The question of legitimacy—which perspective’s opinions and desires will be recognized as appropriate—therefore becomes important. In securing this legitimacy, a key role is played by an entity that understands the particularities of the interested parties and their concerns regarding human security, and then evaluates levels of human security infrastructure preparation from a big-picture view. Advanced expert judgment is also needed to address human security problems. Securing legitimacy for human security decision-making requires engineers who can identify the specifics of the various interested parties and their concerns, and then evaluates the appropriateness of decision-making from an expert perspective.

Suchman raises three problems in securing legitimacy: (1) heterogeneity of audiences (interested parties); (2) rigidity of legitimacy; and (3) generation of opposition (Suchman 1995a). Concerning the first, legitimacy becomes necessary when the related actors have dissimilar interests: if there is an action that satisfies all of the actors there will not be a legitimacy problem. The second problem occurs when the opinions and desires of a certain perspective are judged as appropriate (their legitimacy is recognized). This can lead to the rigidification of the perspective that was granted legitimacy and the subsequent tendency to disregard the opinions and desires of different perspectives. When social decision-making becomes rigidified, the fact that different interests exist will give rise to opposition, the third problem identified by Suchman.

Considerable research has been undertaken on legitimacy in the field of sociology. Maurer (1971), in focusing on evaluations in hierarchical organizations, defined legitimacy as the process by which an organization gains the approval of a similar or higher level system for its actions or decisions. Pfeffer (1981) defined legitimacy, from the perspective of cultural reception, as an expression of the harmonization of social values related to, or inherent in, the actions of an organization, with the action norms being accepted within a social system. Meyer and Scott (1983) locate the roots of organizational legitimacy not in whether the organization is desirable, but in whether it is comprehensible. Building on these diverse definitions, Suchman states that, “Legitimacy is a generalized perception or assumption that the actions of an entity are desirable, proper or, appropriate within some socially constructed system of norms, values, beliefs, and definitions (Suchman 1995b)”. Suchman’s definition includes the perspective of external observers (or the audience) on an actor or an organization’s activities. Legitimacy, in other words, is a concept informed from the group perspective of an audience on the activities of an actor. Therefore, even if some group members have negative views of the actor’s actions, the overall positive view of the audience as a group will grant legitimacy to the actor’s actions.

Suchman describes three types of legitimacy: pragmatic, moral, and cognitive. Pragmatic legitimacy is based on an actor’s actions serving the interests of related parties. Pragmatic legitimacy is bestowed when an actor’s actions serve the interests of related parties or when there is the expectation of benefits for society as a whole. Cost-benefit analysis is used as a method for securing pragmatic legitimacy for human security policies. It is practically impossible, however, to guarantee that all related parties will enjoy benefits from human security policies. Consequently, the concept of pragmatic legitimacy alone is effective only to a certain extent in legitimizing human security policies. Moral legitimacy is based on the moral correctness of actions. Evaluations of moral legitimacy are classified as:

(1) evaluations of results; (2) evaluations of procedures; and (3) evaluations of actors. Evaluations of the results of human security policies assess whether costs to be borne by parties or environments have been fully considered, and whether measures have been taken to mitigate costs by limiting their impact and scope as much as possible. Evaluations of procedures assess whether human security decision-making has been pursued in accordance with a set of fair rules (whether procedures are appropriate), and that transparency of the process is assured. Evaluations of actors examines whether a structure of proper incentives and compensation is in place for the actors as recipients: For example, if an actor has an objective involving a conflict of interest this does not imply a structure of proper incentives and compensation. The propriety of the actions of an actor that has an audience can be judged when the actor has the proper capabilities for implementing the actions and a structure of proper incentives and compensation is in place for the implementation of the actions. Cognitive legitimacy is based on the recognition of social need, rather than on interests or evaluations. The standards for cognitive legitimacy are "comprehensibility" and "taken-for-grantedness" (Koshimizu et al. 2006). Comprehensibility refers to the ability to forecast the results of actions, and to easily perceive the details and results of actions. Taken-for-grantedness refers to the status gained when actions and their results were fully discussed and considered and thus socially accepted as givens.

In decision-making for human security, it is extremely difficult to formulate agreement within an environment of parties with diverse values and conflicting interests. Public Involvement (PI) is currently being advanced as a planning process characterized by significant citizen participation (Yai et al. 2004). For such a planning process to have decision-making legitimacy, the need to achieve pragmatic and moral legitimacy is unquestionable. This alone, however, is insufficient for assuring the legitimacy of human security policies. Ultimately, securing cognitive legitimacy, based on a full consideration of the expected benefits and costs of human security policies, is a matter of great import.

### 2.3.3 The Need for Frame Relativization

The relativization of the engineer's frame is necessary for preventing the expertise of engineers from becoming isolated. Engineers must realize that the frame for their expertise is context-dependent and that this expertise was gained within a certain context. An engineer's frame is often dependent upon their professional associations or other communities of which they are members, so it is possible that engineers themselves do not realize that their frame is limited to the field with which they are associated. It is important for engineers to determine how the residents of the target region view the inherent human security problems, and do so with an awareness of the difference between their own frame and those of professionals and researchers in other fields. With the recognition that the same problems are being perceived from a variety of frames, it then becomes critical for engineers to clarify the position of (relativize) their own frame among the others.

The effort to relativize the engineer's frame opens a channel for communication with other professionals and with local residents (human security beneficiaries). This is important, in part, because of the appreciable number of cases where local residents have experiential knowledge that can be of significant value in making social decisions. Local residents have knowledge specific to local circumstances. The engineer's frame was formed from knowledge gained under certain limited circumstances and there is no guarantee that it is suited to the local conditions at hand. Engineers must consider on their own frame and be open to the opinions of local residents. Attention has been called to the isolated, or closed, nature of Japanese universities, research institutes, and other academic and professional communities in relation to this point (Kobayashi 2004).

Human security policies gain legitimacy by identifying the demands and concerns (frames) of interested parties and establishing a frame that is acceptable to the greatest number of people. Walls of incompatibility can form between actions with differing cognitive legitimacies, giving rise to inter-field friction between differing frames. Two conditions are required to resolve conflicts between frames (Renn 1995). The first is clarification of the scope of responsibility for each expert field (the frame for professionals in each expert field). This is critical. Taking the risk that a certain structure will collapse as a result of a natural disaster as an example; estimating the risk of collapse from an engineering perspective is an important frame for an engineer. However, for an expert in legal matters an important frame would be whether it is possible to pursue legal responsibility, given certain scopes of professional responsibility and possibilities for avoiding risk. It should be clarified whether the engineer's judgment reflected the engineer's frame. The second condition required for the resolution of conflicts is that communities must disclose the type of groups making actual policy and program judgments and the sorts of information and evidence upon which decisions are being made.

### *2.3.4 Reflection Amid Practice and Action*

As a technical expert whose status as such is based on technical rationality, Schön proposed an alternative view to that of the traditional professional: the image of the new professional as a reflective practitioner—one who practices reflection in action (Schön 1983). The image of the modern engineer is well established as having basic principles of technical rationality founded on positive science. The technical rationality principle implies that practice is the rational application of scientific techniques.

The problems modern society faces are complex, and engineers must deal with problems that go beyond the boundaries of their specialized areas of expertise. Hence the engineer that is needed today is a professional equipped with the technical and pragmatic rationality to understand the uniqueness of the problems at hand and actively engage them, while maintaining awareness of all the problems to be dealt with. Engineers establish an appropriate frame for the problems faced and apply a repertory based on technical rationality while drawing on the repertories of required external professionals to practically engage the problems at hand. This kind of practical appropriateness is evaluated and corrected through interactions with the complex problems faced. Engineers learn through this "conversation with situation", accumulate field knowledge and streamline action. Schön refers to such practical action as "reflection in action", and to the professionals who practice it as "reflective practitioners."

Civil engineering, as an example, has been evaluated as useful because its technologies have manifested as social infrastructure. Therefore, it is appropriate to say that, in the practical fields of civil engineering, engineers have practiced "reflection in action". On the ground, young engineers have learned much about practice through observing the activities of veteran engineers. This reflects the idea that capable engineers know more than they are able to verbalize. Capable engineers engage in knowing in practice, but most of their efforts in this regard are made tacitly. In practice, engineers use their knowledge and skills, personal experience and insight to make decisions amid real conditions with significant levels of uncertainties and contradictions, and use feedback on their results to judge the appropriateness of their own knowledge. One can say, therefore, that they are a prime example of "reflection in action."

A practical approach begins with an analysis of the unique structure of "reflection in action." A practical approach includes the manipulation of objectivity through a technical rationality model based on traditional engineering. In the practice of engineering, however, there is more than just debate over the rigor of technical rationality. There are in particular, ideas, broadly believed without basis, about the impacts of limits originating with human relationships in which engineers are personally involved and with systemic contexts in the real world. Engineers who have studied human security engineering are expected to enter places where specific problems have occurred or are forecast to occur, and to work with local people to produce solutions. There is a growing demand for engineers to advance more desirable solutions by developing an understanding of the local context of residents and grasping in their entirety the problems at hand. Human security engineering can be defined as applying past technologies in conjunction with the analysis of specific case examples to shed light on the learning process in which engineers generate field knowledge through the "conversation with situation" approach. Human security engineering aims to place the professional image of engineers in a larger social context by: (1) reflecting on the relationship between engineers and stakeholders; placing organizational and systemic limits on the knowledge of engineers; and conducting structural analyses of, and specific implementation processes for, organizational and social learning; (2) improving the planning, implementation and management process for human security policies; (3) improving universities as new reflective structures for nurturing engineers, and as communication processes for public decision-making; (4) giving rise to a professional image of engineers as experts overseeing the realization of public good; and (5) changing the practice frame set of engineers.

## 2.4 A Practical Approach

### *2.4.1 Practical Approach Problems and Issues*

As a practical field of engineering, human security engineering fully considers the diversity of the specific problems it addresses. However, it subsumes within the structure of an academic discipline an attempt to convert tacit field knowledge into formal knowledge amid engagement with the target problems. It is necessary to consider problems that originate in the practical engineering principles of uniqueness, symbolism, and activity, and that researchers involved with human security engineering and engineers who use human security engineering results are inevitably likely to encounter.

The first problem to consider is that the target of the practical approach for developing practical engineering is constrained by the time—the present—and the space in which the target is situated. A practical approach cannot be implemented in isolation from the particular context in which the target problem exists. Doing so runs the risk of it becoming no more than an exercise involving a unique case. A practical approach requires a process of objectivization, where a universal knowledge scheme is built even as the target of the approach is a specific, unique case. It also requires a relativization effort that conforms to the targeted practical case and discerns divergent uniqueness from the scheme of universal knowledge. Moreover, in implementing the results of human security engineering, engineers must make judgments under various real-world systemic, financial, and human limits. This is known as system dependency. Hence, there are more than a few cases where evaluation methods and perspectives are system-dependent and implementation evaluations are valid only under the required systemic framework. Under actual application circumstances, there are problems of systemic subsidiarity where a problem related to a certain system is being impacted by its relationship to a separate system. Here conflict between systemic uniqueness and universality also intervenes. In other words, there is the difficulty of discerning uniqueness through relativization while simultaneously seeking universality.

A further difficulty is the involvement of individuals with different interests and values within the target problem. Engineers disseminate information on threats, dangers, and risks facing society to stakeholders. A sender disseminates information based on his own understanding of it, but a receiver may interpret it differently. In general, it is very difficult to achieve a mutual understanding of positions and perceptions among parties having different interests and values. A major obstacle to the smooth communication between parties is the differences that exist in their cognitive systems. There has been considerable research in the field of psychology showing that people use their own cognitive frame to interpret events and the words of others, and apply their own subjective interpretation (Wakita 2002).This suggests two points: (1) that the meanings of messages are not singular; and (2) that meanings are not necessarily shared. Regarding the first, words can have multiple meanings, even within the cognitive system of an individual, depending on the circumstances or context in which the person is situated. The meaning an individual assigns to the words they attempt to communicate depends on how the individual perceives the circumstances in which they are situated. Regarding the second point, the symbolic meanings of words are structured based on the experiences and knowledge of each individual, and there is no guarantee that another individual with different experiences and knowledge will assign the same meaning to words. Stakeholders will have various perceptions of the target problem and will assign different meanings to it. Hence, it is necessary to analyze the structure of the meaning of a target problem as a symbolic whole to which various perceptions or meanings are assigned. Studies targeting existing public works projects found that the causes of communication failures between government and local residents can be traced to factors such as differences in interests, differences in views, and discrepancies in how circumstances are defined. Kajita (1988) explains differences in viewpoints (relating to public projects) as a phenomenon where the same social problem is perceived and experienced in different ways by different parties. Achieving smooth communication among parties with different cognitive systems requires efforts to achieve common understanding to the greatest degree possible.

A third problem is that engineers involved with human security engineering are not independent from the problems they work on; they uncover issues that need to be addressed from the problems at hand and actively engage them to improve circumstances. Given the principle of activity, practical activity itself has many pitfalls from a fundamental perspective (Yano 1987). To the extent that the practice of human security engineering is a social enterprise entailing certain complications, it cannot remain isolated from real political demands and there is, therefore, no assurance that a practical approach can maintain neutrality. Moreover, if engineers overlook the relatedness of their personal historical or cultural traits and neglect consideration of particular cultural views or values, they can become non-neutral to a practical approach. The relationship ethos is the assessment of the appropriateness of the frame established for the region that is the target of the practical approach, and the careful consideration by engineers of the appropriateness of their own position in contributing knowledge and techniques. A practical approach inevitably entails an evaluation of practical actions, and, in most cases, engineers are left to evaluate their own work. They may lack objectivity because of systemic limits and the perceptual and analytical limits of the engineers themselves. To overcome this difficulty, engineers who participate in a practical approach must remain detached when inspecting their own work: they must objectivize practice and objectivize the very action of objectivizing practice. During practice, engineers must endeavor to guarantee the appropriateness of the technologies applied. In a practical approach, however, they must also explain in as objective a manner as possible the appropriateness, in all respects, of the practical action itself in relation to the problem at hand, i.e. the objectivization of objectivization.

Researchers involved with human security engineering and engineers attempting to apply it must take a dialectical stance in making their way through personal and active engagement with objects and, conversely, simultaneous feedback on themselves from the objects. Schön defines this type of dialectic action as "reflective action" (Schön 1983). Human security engineering requires the accumulation of an objectivization repertory using a traditional technical rationality model and the development of a practical methodology for achieving the objectivization of objectivization. The body of research on practical approaches in the field of engineering is poor, nevertheless Schön, having accumulated cases of practical studies and clinical fields, has proposed a practical approach characterized by: (1) frame analysis; (2) field experimentation; (3) intermediary theories; and (4) reflection in action.

### *2.4.2 A Practical Approach: Frame Analysis*

Practical engineers must maintain a constant focus on specific problems (object of focus); they must thus consider the unique qualities of the target problems in establishing the problem frame. Engineers attempt to set frames for individual problems based on past experience, similar cases, and their own scientific and technological knowledge. The quality of the frames set depends on the systematization of the techniques and knowledge applicable by the engineer, and the engineer's overall experience. Engineers must examine their own repertories (the collection of tools used for understanding and acting on a problem) for usable knowledge and experience, or employ external knowledge and techniques to construct repertories for solving the target problems. That such construction of repertories occupies an important area of practice goes without saying. Technical rationality models in engineering fields, the natural sciences, social sciences, and other related fields play an important role in constructing repertories. This mobilizes the engineer's ability to both identify the target problem, based on cases of which the engineer is aware, and conceive the repertory required. This practice involves the repeated reflection process of: (1) consideration of past case studies and available repertories; (2) frame analysis based on the identification of new perspectives and problems; and (3) repertory construction and testing of hypotheses through field experiments.

An engineer's skills depend on the breadth and variety of repertories that the engineer brings. When an engineer encounters unfamiliar conditions, frame analysis becomes necessary to expand the scope of the repertory to be used. Frame analysis means clearly describing both the scope of the repertory to be applied in solving the target problems and the target of the analysis, and should include:

1. A list of the tools (repertory) to be used in solving the target problem,
2. A model describing the problem conditions,

3. A comprehensive theory for describing the symbolic structure of the problem,
4. A role frame for the engineers who will participate in solving the problem.

Engineers can thus acknowledge the tacit frame upon which they depend. Using frame analysis results as a foundation, it is possible to understand, through dialogue with clients and stakeholders, the plurality of the target problem perspectives. There may also be cases where practice consists of multiple role frames, enabling "reflection in action" from a tacit frame perspective. In such cases, it is important to note that engineers tend to rely on established theoretical and technical categories and may attempt to apply existing case frames. Particularly notable is that an engineer's attempt to maintain an existing frame that either they or an organization have established means that the engineer is not conducting a self-examination. Stated differently, this leads to the consecration of previous frames as tacit knowledge. If this happens engineers should be motivated to improve their frames by breaking down their self-imposed constraints (based on existing frames) and revising their role frames within the individual contexts of the problems faced. Hence frame analysis should consider:

1. The importance of not relying on established theoretical and technical categories and instead using the reflections of actors to build new theories for unique cases,
2. The necessity of not separating methods and purposes, and considering the perception of both sides as a framework for the problem conditions.

It is instructive to examine here a previous case study[1] conducted by the authors on the relationship between social capital and water supply systems in Indonesia, commencing in 2009. Indonesia has continued to experience high economic growth, and public water supply systems (PDAMs) overseen by local governments are being rapidly adopted. PDAMs have contributed significantly to the improvement of hygiene conditions for the people they serve. A concurrent community-participation system, called "HIPPAM," has also played a major role in supplying water. This system operates primarily in regional areas and consists of self-managed water supply units operating on a traditional trust-based relationship with community residents. In promoting the adoption of PDAMs, engineers ran a major risk when establishing the simple frame of bringing about the transition from the traditional water supply system to a public water supply system as quickly as possible. It was the risk of discussing the choice of water supply systems without considering local socioeconomic factors, and daily community conditions. The authors conducted a local survey during their research and established a new frame focused on identifying key social capital conditions for maintaining a community-participation water supply system to secure the minimum level of water supply required for human security.

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[1] This research was conducted in connection with Kyoto University's Global COE Program, "Human Security Engineering in Asian Megacities." For more details, please refer to the website: http://hse.gcoe.kyoto-u.ac.jp/.

### 2.4.3 A Practical Approach: Field Experimentation

From a traditional academic view, experiments are considered tools for testing scientific or technological hypotheses, and are managed in such a way that different people conducting the same experiment in the same way would obtain the same results. Researchers must maintain distance from their research subjects, so that their own interests and preferences do not interfere, and the objectivity of the experiment is preserved. Some experiments, however, are performed by engineers as practical activities, including ground probes and preliminary experiments, experiments that test methods or hypotheses, social experiments, and preliminary field experiments to lay the groundwork for construction work or policy implementation. The purpose of field experiments differs from that of scientific experiments managed for the purpose of testing scientific or theoretical hypothesis models. Field experiments are conducted so that engineers can reduce the uncertainty they face, and thereby make better decisions or arrive at better judgments. Hence, the purpose of experiments for engineers is to find an approach that will produce a better solution for a problem they are confronting rather than to test a scientific theory or technological thesis.

Engineering field experiments depend on the type and content of information required and on the degree of uncertainty involved. Consequently, the success of an experiment is not judged on how detailed it was or how rigorous its results were, or by academic novelty, but by how accurately it reflected the problem conditions, and the degree to which it improved the decision-making environment where the engineer was situated. The result of an experiment is the change it engenders in conditions. Therefore, the field experimentation process, rather than being designed through scientific procedures, must be designed to answer two questions: (1) Can the information required for making decisions and rendering judgments be obtained? and, (2) Will new meaning be given to conditions, and the essence of doubts clarified? Considering these questions, practical field experiments are not based on Popper's (1963) concept of refutability—the ability to test whether a scientific hypothesis is true or false. Consequently, testing the appropriateness of an experiment—whether the engineer was able to rationalize their decision-making through the field experiment—becomes key.

Field experiments are not limited to experiments undertaken in a laboratory or on the ground. Schön points out that when engineers make notes or draw sketches they are conducting experiments in a virtual world of their own making. Even when it is impractical to conduct experiments in the real world, engineers undertake necessary thought experiments to make better judgments and decisions. To this end, practice takes on two meanings. In one sense, it means to apply thought experiment results in problem solving. In the other, it means to improve thought experiment capabilities by trying to influence the target of the engineer's problem-solving efforts. This practice requires that engineers are capable of reflecting on the influence they have tried to have on the target of their problem-solving efforts and how the target behaves independently of their influence. Through such reflection capabilities engineers can actively work to influence the target with the results of their thought experiment, yet are also ready to cease their activities as necessary and to develop different thought experiment approaches.

It is useful here to refer again to the Indonesian research conducted by the authors. The authors revised their original frame that was based on their past experiences, similar cases, and their knowledge of science and technology. This was done through local knowledge of conditions in the area, but that alone was insufficient. To obtain the information necessary for making decisions and rendering judgments, the authors visited the project site and conducted a survey and interviews and thus gathered valuable information on why it was proving difficult to persuade people to adopt public water supply systems with relatively advanced technology. This information made the uncertainty engineers were confronting in establishing a frame part of the conditions to be addressed. The result was that the revised frame established by the authors was not necessarily appropriate, and a different effort was put in place to objectively identify the project target through enabling better decision-making conditions.

### *2.4.4 A Practical Approach: Intermediary Theories*

Engineers must match target problems with the repertories required to solve them. Sometimes an engineer's own repertory is inadequate to properly address the problems faced. To understand new conditions that seem incompatible with their own past experience and knowledge system, engineers need theories for reconstructing the new conditions. They must therefore build repertories linking their existing repertories and experience to knowledge systems outside of their own: this requires theories ("intermediary theories") and methods. Engineers use intermediary theories to explain practical actions. Typical intermediary theories consist of:

1. Methods for discovering thematic patterns within a unique phenomenon; not universal rules or laws,
2. Methods for translating thematic patterns into forms suitable for discrete contexts,
3. Methods for obtaining an appropriate level of rigor; not scientific rigor.

Intermediary theories are methods by which an engineer can test prior cases and episodes, acknowledge a frame, and construct a new repertory. Human security engineering requires the accumulation of information on previous practical cases to mitigate the threats, risks, and dangers that intervene in local regions, and to simultaneously use case study research to improve the way engineers view problems and to develop methods for constructing repertories.

When a problem is particularly complex or spans fields of expertise different to their own, engineers must create partnerships with other engineers and professionals with differing frames and repertories. Engineers must be sensitive to precision gaps between their own repertories and those newly acquired from other fields. Areas of practical knowledge in engineering extend significantly beyond individual engineering fields—often to the social sciences or humanities. Cases requiring repertories that stretch beyond the engineering domain can require repertories as great or greater than engineering expertise, and it would be foolish to apply superficial understanding or be overconfident in an unfamiliar field. When an engineer extends past their own field of expertise they must seriously commit themselves to the effort, and master the methodological concepts and methodologies to achieve the same level of understanding as experts in the particular field.

Schön considers that the cooperation between a practical engineer and academic researcher is characterized by a mutually permeable border and is based on reflection amid reciprocity. A partnership of the researcher as engineer and the engineer as researcher becomes necessary and, as Schön points out, requires the researcher to self-reflect and to then support the engineer in further developing their reflection abilities. Two points, therefore, have been presented—the researcher's reflection on their own activities and the facilitation of the engineer's reflection. The model wherein industry, government, and academia cooperate has long been advocated, but there are few examples of such cooperation in the fields of engineering. Taking intermediary theories as a starting point, a practicing partnership begins with the researcher, who is a professional in making knowledge explicit, bridging a gap in which the researcher as engineer will initiate action to convert the engineer's tacit knowledge into formal knowledge.

In the Indonesian case, it was essential to go beyond the extended engineering field repertories to those based on humanities and social science knowledge in areas such as economics, sociology, and political science. Connections to engineers well-versed in local knowledge were more important than links to academic repertories. It is critical to increase the knowledge shared by researchers and engineers through dialogue with members of the target community and with long-term researchers in the area, and to establish a frame that offers the possibility of eliciting more appropriate decision-making.

### *2.4.5 A Practical Approach: The Process of "Reflection in Action"*

When acting, engineers must, through the "conversation with situation" process, reflect on the appropriateness of the frame they originally established, the effectiveness of their newly constructed repertory, and the appropriateness of field experiments. They must continuously ask themselves the following questions:

1. Is the established frame appropriate for solving problems?
2. Is it appropriate to use the existing repertory to solve problems?
3. Is the examination process, consisting of the intellectual process and field experiments, logically consistent?

4. Is the structure of the meaning (symbolic meaning) of the target problem being correctly perceived?
5. Is it possible to continue work along the current course?

Engineers change problem frames through the observations they make in reflecting. When they change the problem framework, they often do not know the types of solutions available and lack confidence in the possibility of solving new problems. Changing a problem frame, however, makes it possible to confirm progress in understanding problems or conditions, and to construct new repertories. The construction of a new repertory gives rise to new and unexpected effects, and attention is focused on evaluating the appropriateness of the new repertory rather than on whether it is possible to discover new meanings and value in these effects. Changing the problem frame and introducing a new repertory leads to changes in the target problem or conditions. Engineers address such changes by further appropriately changing the problem frame, made possible by a reflective conversation with the problem conditions.

In analyzing the water supply system in Indonesia the authors conducted a local survey and held four international seminars. They used the accumulated research results to conduct a repeated and reflective conversation regarding the evident problem conditions. By continually searching for a more appropriate frame, and by presenting in the midst of their intellectual process research results on a practical approach, they have literally practiced the process of "objectivization of objectivization."

### 2.4.6 Practical Approach Evaluation

Practice has features of uniqueness, symbolism, and activity. When compared with positive science discipline standards it is subject to doubt on its appropriateness or legitimacy in terms of universality, logicality, and objectivity. Positioning practice in engineering as a method for producing field knowledge raises the issue of how to evaluate the reliability of the practical knowledge gained. Fenstermacher (1995) strictly distinguishes context-dependent practical knowledge and formal knowledge that is generalizable and not dependent on context. Furthermore, given that establishing bases for (and justifying) assertions is unavoidable for the establishment of practical knowledge, Fenstermacher objects to the claim that practical knowledge can be justified without using positive scientific methodologies that produce formal knowledge. In contrast, Richardson (1994) separates knowledge gained from practical pursuit and knowledge gained from formal research. She points out that practice by engineers is for the purpose of changing practice or for developing understanding for that purpose, and not for producing a thesis that conforms to general rules. She defends the practical pursuit of knowledge by contending that new points of interest are uncovered through the description of practical knowledge (characterized by uniqueness), and that this actually encourages the formal pursuit of knowledge.

This debate includes a strict dichotomy of practical knowledge and formal knowledge and ignores the perspective where practice (1) incorporates the formal research feature of producing repertories conforming to standards of rigor based on technical rationality, and (2) seeks problem solutions through a dialectical methodology pursued through reflection on practical action, based on standards of appropriateness, within a "conversation with situation". Addressing this, Anderson and Herr (1999) take the position that practice should not be evaluated by the same strict standards used to evaluate positive scientific research, and that new standards are needed to prevent practice taking a wrong direction. Five standards tentatively proposed by Anderson and Herr are:

1. Outcome validity: To what extent does the practical action that is the focus of the practical approach solve the target problem?
2. Process validity: To what extent are the data gathering and analysis, and other repertory elements, used in practice, and are their application methods valid?
3. Democratic validity: To what extent have the various perspectives of parties with a stake in the problem been considered? Alternatively, to what extent has cooperation with stakeholders been realized?
4. Catalytic validity: In bringing about actual change, to what extent have participants and other stakeholders been motivated to support that change?
5. Dialogic validity: To what extent did reflective dialogue take place among research participants?

The Anderson-Herr standards are distinctive because they extend beyond repertory validity and evaluation of results, to evaluate aspects of democracy and the process for forming cooperative relationships. There are critics of efforts to develop evaluation standards applicable to practice in general, and it is important to continue with a detailed discussion of standards for evaluating practice.

## 2.5 A Schematic of the Various Elements of Human Security Engineering

### *2.5.1 Government/Citizen Partnership*

Human security engineering addresses problems of interest to governments, businesses, and households in addition to non-profit organizations, non-governmental organizations, citizens groups, and other organizations. The roles that a new public (in the form of citizen participation and volunteer organizations) can play in the establishment of regional human security are by no means small. Volunteer organizations are less amenable to systematic controls than companies. Consequently, for a partnership with government to function, there must be proper governance. Government is premised on the assumption of its own ongoing existence, hence government bears ultimate responsibility. When there is a partnership between government and citizens, government—as the party ultimately responsible—has a duty to maintain a sound consignor/consignee relationship with the volunteer organization. It is thus important to conclude an agreement, apportion risk, and establish systematic frameworks (such as accountability in decision-making and policy discussions) that allow the volunteer organization to function properly.

The traditional concept of accountability was based on the assumption of a bilateral relationship between a consignor and consignee. Public accountability extends beyond the traditional bilateral relationship. In an indirect democratic system, the legislative institution is expected to achieve political accountability by exercising political control over a governmental institution. The governmental institution has a duty of accountability to the legislative institution. However, governments are now asked to be directly accountable to citizens. Furthermore, when a volunteer organization performs public services under government consignment, the volunteer organization has a duty of accountability to the government; and the government has a duty of accountability to citizens regarding the existence and results produced by the consignor/consignee relationship with the volunteer organization. The basic structure of accountability in the consignor/consignee relationship consists of three parts: (1) definition structure (how did the parties arrive at an agreement on the consigner/consignee details?); (2) legitimacy structure (by what standards does the consignee validate its own actions?); and (3) control structure (under what governance does the consignor/consignee relationship function?)

Public accountability is a means by which government gains public confidence. It functions to promote the legitimacy of decision-making by government, produces conditions that government and citizens can share and agree upon, and is important for preventing meaningless conflicts. Citizens are the ultimate bearers of costs for project failure and dissolution. It is incumbent upon government, therefore, to gain as much citizen agreement as possible on the validity of the government/citizen partnership.

It is impossible for government to conclude partnerships with each of the numerous volunteer organizations that exist; hence it undertakes exclusive partnership agreements with certain volunteer organizations. What volunteer organizations it is acceptable to partner with and whether partnership results are acceptable are important questions. The answers to these questions require the assurance of legitimacy, as defined in Sect. 2.3.2.

### *2.5.2 Role of the Engineer as a Professional*

Volunteer organizations are frequently not experts in the production of public services. Within parties with various interests and values—which may include local residents, businesses, other public service users, other taxpayers, and organizations—engineers, as professionals, play important roles in providing advice and information, and performing inspection functions that help to secure the legitimacy of volunteer organization actions. It is possible, however, that engineers may differ among themselves on scientific or technical judgments. Furthermore, engineers must ensure that their scientific and technical judgments are not influenced by their personal values. There is a risk, therefore, that a relationship between a volunteer organization and an engineer could become confrontational.

Engineers use their expertise to evaluate the validity of scientific and technical judgments. The limit of validity serving as the basis for these judgments is referred to as the "validity boundary." However, the opinions of volunteer organizations, engineers, and citizens on validity boundaries for scientific and technical judgments are often in conflict. For most volunteer organizations and interested parties in general, it is not the rigor but the appropriateness of technical judgments—whether they are useful for accomplishing the organization's mission and adhere to common sense—that is the primary concern. In addition, related parties with diverse values and interests have their own individual validity boundaries, and engineers, to find the appropriate validity boundary, must iron out differences among the various validity boundaries advocated. To accomplish this, individual engineers must first endeavor to relativize their own validity boundaries by communicating with the various interested parties and professionals from other fields.

An engineer must understand the context-dependency of the validity boundary for their own expertise, and acknowledge that that knowledge was gained within certain contexts and given certain variables. Such validity boundaries have often been internalized by the professional or other organizations to which the engineer belongs and it is therefore possible that the engineer has accepted them unintentionally. Local residents who are service users have experiential knowledge or first-hand knowledge of local circumstances that is indispensable for making social decisions. When an engineer's validity boundary has been formed based on knowledge gained within a limited context, there is no guarantee that it matches the validity criteria suitable for the project site. Engineers must reflect on their own validity boundaries and listen to the voices of people on the ground.

### *2.5.3 The Co-evolution of Technology and Society: The Local Learning Approach*

There are no universal prescriptions available to solve the problems human security engineering seeks to address. Government, private-sector companies, and individuals must cooperate with each other and continuously seek to elucidate the problems at hand and solve them. To this end, it is necessary to establish a mechanism in which the various stakeholders living in the target area acquire knowledge and work with each other toward solutions. There are three approaches through which governance for such learning could be established: (1) citizen participation approach; (2) stakeholder approach; and (3) entitlement approach. Under the citizen participation approach, government could provide local learning opportunities to citizens—for example, through a social experiment—while in the stakeholder approach, stakeholders could be induced through education to take certain actions. Both approaches are limited by a passive learning process.

The entitlement approach, in contrast, would allow local residents to be involved with the production of public services or the drafting of policies. The creation of an active learning process for local residents requires that volunteer organizations and local residents be endowed with some of the resources and decision-making discretion needed for the planning and production of public services. Volunteer organizations and involved local residents must also be required to report on (be accountable for) the specifics and results of their activities. Co-production (Sundeen 1985) is one entitlement approach proposed by Sundeen and others. There are three co-production stages—joint creation, co-provision, and co-financing. In the first two, local resident participation does not rise above a passive level. However, in the co-financing stage, local residents are asked to contribute a portion of their own resources or property. This naturally results in a significant increase in the awareness of participating local residents as stakeholders. Emphasizing co-production as an entitlement approach is extremely important for the development of human security engineering.

## 2.6 Conclusion

Engineering is a field of practical science closely related to the real world, but it has long been bifurcated between formal knowledge and techniques based on technical rationality, privately held opinions, and other types of field-based tacit knowledge. It is not focused on real world practice where engineering results are produced as the object of practice. Practice, because it is characterized by uniqueness, symbolism, and activity, abounds in fundamental problems stemming from the inability to adequately evaluate its appropriateness based on the positive scientific standards of universality, logicality, and objectivity. Consequently, the following features are often observable:

1. The engineer's intent has not been correctly interpreted and it is, therefore, difficult to say that "reflection in action" is sufficient.
2. The engineer is wrapped up in his/her self-image as a technical master and there are, consequently, insufficient opportunities for reflection in actual practice conditions.
3. A reflective engineer has not described "reflection in action" as formal knowledge.

This chapter has emphasized (1) the primary importance of furthering research on examination amid reflection, and (2) addressing the dilemma of rigor versus appropriateness through the epistemology of practice in rectifying this situation. Engineering is a prime example of an academic discipline that has developed from technological practice. However, it is only recently that the importance of practicing engineering was recognized and the volume of accumulated research is still relatively small. Acknowledging this, human security engineering focuses on accumulating field knowledge and developing practical problem-solving methods from a local perspective.

This chapter has raised several issues on the future development of the practical engineering aspect of human security engineering. Going forward is essential to expand and build up human security engineering repertories. Repertories can be developed by integrating elements of technologies from different engineering fields. In developing repertories, it is vital to consider the rationality of purpose and technical rationality, and the Anderson-Herr validity standards can be used in evaluation. It is important to build a collection of frame analysis, field experimentation, intermediary theory, "reflection in action", and other practical approaches. Practical development must consider the uniqueness, symbolism, and physical implementation of practical approaches, and it is essential to formalize the field knowledge gained from case studies and experience. The evaluation of practical approaches requires unique perspectives—such as those that emphasize standards for outcome validity, democratic validity, catalytic validity, and dialogic validity. The Anderson-Herr standards have been referenced as examples of evaluation standards for practical approaches, but they require conceptual deepening. This is the third issue to address for the future development of human security engineering. There are risks associated with introducing single dimension evaluation standards, and further consideration must be given to practical evaluation methods.

## References

Anderson G, Herr K (1999) The new paradigm wars: is there room for rigorous practitioner knowledge in school and universities? Educ Res 28:12–40

Beck U (1986) Risikogesellschaft. Auf dem Weg in eine andere Moderne. Suhrkamp, Frankfurt am Main. Japanese translation: Azuma R, Ito M (1998) Kiken Shakai. Hosei University Press, Tokyo

Descartes R (1637) Discours de la Methode. Editions Gallimard, Paris. Japanese translation: Tanikawa T (1997) Hoho josetsu. Iwanami Bunko, Tokyo

Fenstermacher GD (1995) The knower and the known: the nature of knowledge in research and teaching. Rev Res Educ 20(1):3–56

Forester J (1982) Planning in the face of power. J Am Plan Assoc 48:67–80

Gilman S (1939) Accounting concepts of profit. The Rolland Press, New York

Kajita T (1988) Tekunokurashi to shakai undo – Taikoteki sohosei no shakaigaku (Technocracy and social movements – the sociology of oppositional complementarity). University of Tokyo Press, Tokyo

Kobayashi T (2004) Dare ga kagaku gijutsu ni tsuite kangaeru no ka - Konsensasu kaigi to iu jikken (Who is it that thinks about science and technology – the consensus meeting experiment). The University of Nagoya Press, Tokai

Koshimizu K, Hatori T, Kobayashi K (2006) Akauntabiriti no kozo to kino: Kenkyu tenbo (The structure and function of accountability: research survey, Japan society of civil engineers collected papers D). Doboku Gakkai Ronbunshu D 62(3):304–323

Maurer JG (1971) Readings in organizational theory: open system approaches. Random House, New York

Meyer JW, Scott WR (1983) Centralization and the legitimacy problems of local government. In: Meyer JW, Scott WR (eds) Organizational environments, ritual and rationality. Sage, Beverly Hills, pp 199–215

Nakamura Y (1981) Tetsugaku no genzai (philosophy now). Iwanami Shoten Publishers, Tokyo

Pfeffer J (1981) Management as symbolic action: the creation and maintenance of organizational paradigms. In: Cummings LL, Staw BM (eds) Research in organizational behavior, vol 13. JAI Press, Greenwich, pp 1–52

Polanyi M (1958) Personal knowledge: towards a post-critical philosophy. Routledge, London. Japanese translation: Nagao J (1985) Kojiteki Chishiki – Datsu Hihan Tetsugaku wo Mezashite. Harvest-sha

Popper KR (1963) Conjectures and refutations: the growth of scientific knowledge. Routledge, London. Japanese translation: Fujimoto T (1980) Suisoku to hanbaku: Kagakuteki chishiki no hatten. Hosei University Press, Tokyo

Renn O (1995) Style of using scientific enterprise: a comparative framework. Sci Publ Pol 22(3):147–156

Richardson V (1994) Conducting research on practice. Educ Res 23(5):5–10

Schein E (1973) Professional education. McGraw-Hill, New York

Schön DA (1983) The reflective practitioner: how professionals think in action. Basic Books, New York. Japanese translation: Yanagisawa S, Miwa K (2007) Seisatsuteki jissen to wa nani ka – Purofeshonaru no koi to shiko. Otorishobo, Tokyo

Suchman MC (1995a) Managing legitimacy: strategic and institutional approaches. Acad Manage Rev 20(3):571–610

Suchman MC (1995b) Managing legitimacy: strategic and institutional approaches. Acad Manage Rev 20(3):574

Sundeen RA (1985) Coproduction and communities: implications for local administration. Admin Soc 16:387–402

Wakita K (2002) Komyunikeshon katei ni hasseisuru “Jokyo no teigi no zure” (Discrepancies in condition definitions that arise in the communication process). Toshi Mondai (The Tokyo Institute for Municipal Research) 93(10):57–68

Yai T, Maekawa H (Supervising editor) (2004) Snumbered himin-sankagata doro keikaku purosesu kenkyukai (Citizen-Participatory Road Planning Process Research Group) (ed) Shimin-sanka no Michidzukuri Paburikku Inborubumento (PI) Handobukku, (Citizen-participatory road construction public involvement (PI) handbook). Gyosei, Tokyo

Yano T (ed) (1987) Chiiki kenkyu (Regional research), vol IV, Koza seijigaku (Lecture political science). Sanrei Shobo, Kyoto

# Chapter 3
# Construction and Development of Social Infrastructure

**Hiroyasu Ohtsu**

**Abstract** This chapter proposes that when constructing hard infrastructure it is necessary to develop an urban management concept that takes a broad perspective, extending beyond megacities to include the development of rural areas and a consideration of the links between rural areas and megacities. This chapter includes representative examples that explain approaches for solving problems endemic to megacities, and problems related to links between megacities and rural areas. For problems endemic to megacities: land subsidence caused by excessive groundwater extraction in both Bangkok, Thailand and Osaka, Japan, and a comparison of the measures adopted to mitigate the progress of land subsidence in both cities, are discussed in detail. For problems related to links between megacities and rural areas: landslides in Thailand are examined and the effectiveness of an established early warning system is discussed.

**Keywords** Early warning system • Natural disaster • Risk mitigation • River basin

## 3.1 Model of the Links Between Megacities and Rural Areas

The construction and development of social infrastructure, specifically hard infrastructure, requires both the pursuit of economic interests and the building of theories integrating interdisciplinary learning on strategically managing cities.

The construction of hard infrastructure in large cities has traditionally been influenced by economic concerns. In Japan, a concentrated period of hard infrastructure construction during the relatively short period of high economic growth beginning in the 1960s gave rise to various social problems. Examples included

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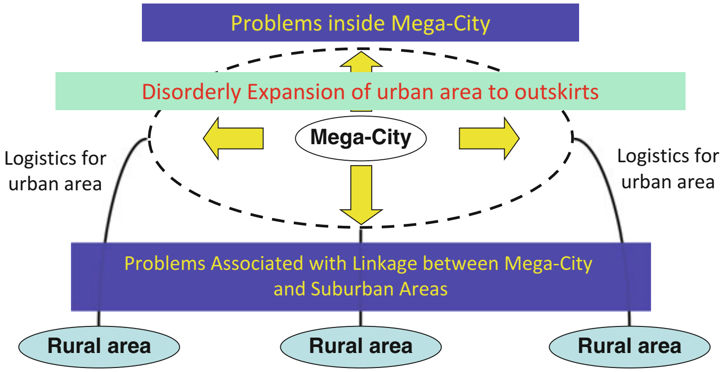

**Fig. 3.1** Model showing the links between megacities and rural areas

overcrowding of cities, environmental degradation, and expansion of the gap between urban and rural areas. In other parts of Asia, the development of economies amid economic globalization beginning in the 1990s has given rise to fears that rapid urbanization and the construction of megacities will engender the same social problems seen in Japan. Those problems warrant discussion in two areas, using the megacity/rural area linking model depicted in Fig. 3.1. These are, (1) problems endemic to megacities, and (2) problems related to the linking of megacities and rural areas.[1]

Problems afflicting megacities tend to spread in a disorderly fashion to surrounding areas as part of the process by which wealth and population concentrate. The development of megacities depends upon rural areas for supplies of not only food and energy but also people. In constructing hard infrastructure, therefore, it is necessary to develop an urban management concept that takes a broad perspective extending beyond megacities to include the development of rural areas and takes consideration of the links between rural areas and megacities.

Consideration should be taken of such urban management concepts during the hard infrastructure construction taking place in Asian countries in recent years. It is becoming critical to address climate change when developing concepts for the management of a particular urban area. Figure 3.2 provides a schematic of the factors underlying climate change related disasters in river basins. The disaster types shown in the figure are associated with problems endemic to megacities, and the problems related to the links between megacities and rural areas depicted in Fig. 3.1 are, (1) land subsidence, floods, coastal erosion, and (2) landslides, river erosion.

Figure 3.2 illustrates that an increase in the frequency of localized torrential rain storms, as a result of climate change, will lead to landslides in upstream mountainous areas, river erosion from an increased flow volume in the middle reaches of

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[1] A megacity is often defined as a city of over ten million people. (e.g. United Nations); however, in this book the term megacity includes cities with economic, cultural and political importance in each country.

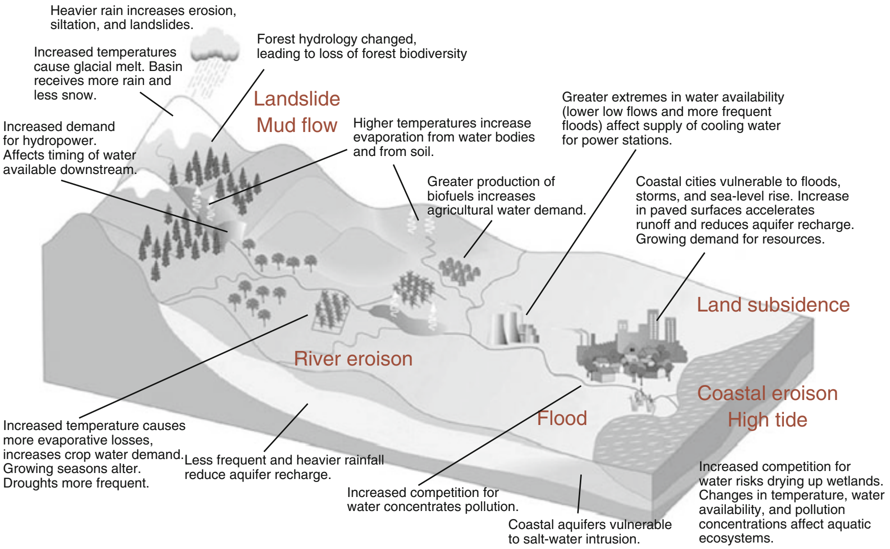


**Fig. 3.2** Schematic of conditions under which climate change-related disasters occur in river basins (Sources: WDR team based on World Bank, forthcoming d; Bates and others, 2008)

rivers, and more frequent damage from floods and other causes in downstream urban areas. It must also be noted that in most Asian megacities, excessive pumping of groundwater has resulted in land subsidence and is a factor of increased flooding risks. This is a classic example of man-made disasters exacerbating damage from natural disasters.

Moreover, Fig. 3.2 shows that a rise in sea level, a further result of climate change, will increase the damage caused by high tides, coastal erosion, and other such developments. Indeed, coastal erosion in Southeast Asia is being accelerated by the cutting of coastal mangrove forests. Like the land subsidence caused by the excessive pumping of groundwater, this development can be seen as another example of a man-made disaster aggravating damage from a natural disaster.

This chapter uses representative examples to explain approaches for solving problems endemic to megacities and problems related to links between megacities and rural areas.

## 3.2 Problems Endemic to Megacities

### *3.2.1 Land Subsidence Due to Mega-City Development*

Most major Asian urban areas have been built on top of alternating sandy gravel and soft clay strata that long ago formed the aquifers of river mouths. Those aquifers are now used as water resources critical to the development of the urban areas that sit above them. In the megacity development of recent years, groundwater has been

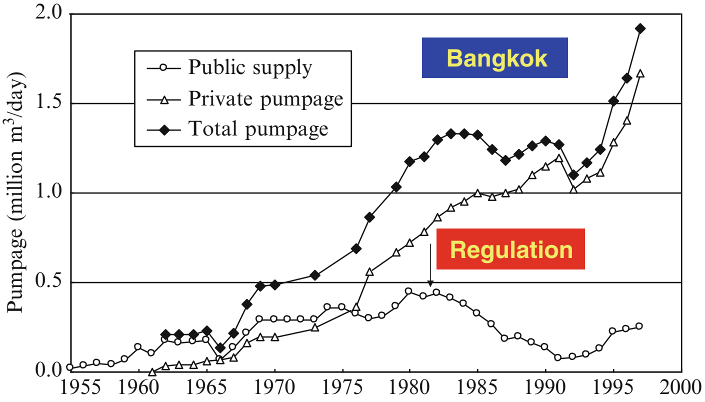


**Fig. 3.3** Volume of groundwater pumped in the Bangkok Metropolitan area, Thailand, 1955–2000

used as a cheap alternative to the construction of waterworks. As a result, land subsidence caused by the excessive pumping of groundwater emerged as a considerable social problem in most major Asian urban areas in the latter half of the twentieth century. Land subsidence as a result of the pumping of groundwater has been reported in major cities in Japan, and in the coastal areas of China, Taiwan, the Philippines, Vietnam, Thailand, Indonesia, and Bangladesh.

Curbing the excessive pumping of groundwater requires the imposition of regulatory or economic measures aimed at its control.

In the 1960s, the Japanese city of Osaka established regulations limiting the drawing of water for industrial purposes and put regulatory measures aimed at, for example, promoting the recycling of industrial water in place. These steps reduced the pumping of groundwater and inhibited further land subsidence.

In the Thai capital, Bangkok, a research group led by the Asian Institute of Technology (AIT) revealed in the early 1980s that land subsidence was being caused by the excessive pumping of groundwater, leading to the imposition of groundwater pumping regulations in 1981. However, as Fig. 3.3 shows, while the pumping of groundwater by the public-sector institutions that were the target of these regulations began a downward trend, pumping by private-sector institutions actually began to increase rapidly. At that time the construction of housing and industrial parks was shifting from central Bangkok to surrounding areas as a result of economic development. This expansion relied on the use of groundwater in both residential and industrial areas because it was inexpensive compared with the cost of constructing water systems. This use of groundwater caused the area afflicted by land subsidence to expand beyond central Bangkok. By the late 1990s, private-sector interests accounted for nearly all groundwater pumping (Phienwej et al. 2005).

The volume of groundwater pumped in Bangkok later declined because of economic measures—a groundwater charge introduced in stages beginning in 1985 and a groundwater preservation charge—imposed on private-sector institutions.

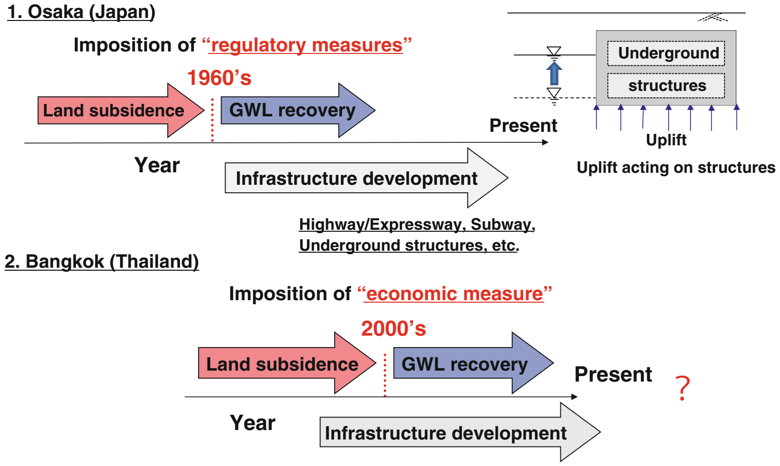


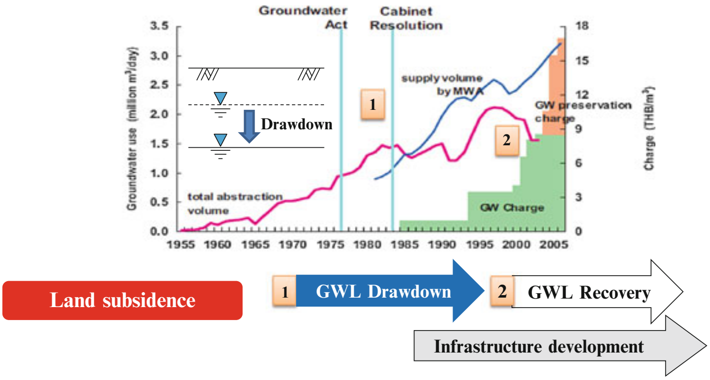
**Fig. 3.4** Comparison of the damage caused by excessive groundwater pumping in Osaka, Japan and Bangkok, Thailand (*GWL*: ground water level)

The examples of Osaka and Bangkok show that regulatory and economic measures, despite their differences, succeeded in achieving reductions in groundwater pumping. In both cases, however, measures were taken only after the onset of land subsidence caused by excessive groundwater pumping.

Figure 3.4 shows that in Osaka damage up to the point when a decrease in groundwater pumping was achieved was limited to land subsidence. The construction of major hard infrastructure projects after groundwater pumping restrictions were implemented helped limit the expansion of land subsidence from metropolitan areas to the surrounding regions. From an urban management perspective, the impacts of not implementing groundwater pumping regulations until problems began to emerge are considered minor in this instance.

Initially, damage occurred to hard infrastructure because of land subsidence. In general, land subsidence caused by the pumping of groundwater is referred to in engineering terms as irregular subsidence, because subsidence occurs differently depending on location and inclination of the ground surface. Irregular subsidence can cause the walls of structures to crack, as shown in Fig. 3.4, and can lead to other problems such as the inability to open or close doors. In the overlap period of early 2000, experienced in Bangkok, damage occurred even to newly constructed hard infrastructure.

An example of structural damage on the lower section of an elevated highway is shown in photograph two in Fig. 3.5 (Phienwej et al. 2006). As the can be seen the pillars have not subsided, because they are being supported by their foundations, while the surrounding area has. This phenomenon, known in geotechnical engineering terms as "negative skin friction", reduces the load-bearing capacity of pillar foundations, causes stability problems for the upper sections of elevated highways, and results in irregular subsidence in roads directly below. Negative skin friction,



(1) Damages on Housing/Building (2) Damages on elevated highway

(3) Increase of flooding risk (4) Coastal erosion/Salt water intrusion

**Fig. 3.5** Example of damage caused by excessive pumping of groundwater in Bangkok, Thailand (*MWA*: The Metropolitan Waterworks Authority, *GW*: ground water, *THB*: Thai Baht, *GWL*: ground water level). (1) Damage on housing/building. (2) Damage on elevated highway. (3) Increase of flooding risk. (4) Coastal erosion/salt water intrusion

therefore, gives rise to long-term stability concerns for pillar foundations and necessitates long-term maintenance and repair expenditure, including overlay work to address irregular subsidence impacts on roads under elevated highways.

Further examples can be seen in the heightened risks of flooding, coastal erosion and saltwater intrusion, illustrated in Fig. 3.5. Bangkok is positioned in a low-lying area and, based on previous flood experience, has established height specifications for the levees constructed as flood protection. Because of land subsidence, however, the city is now subject to greater flooding risk than in the past. To the south of Bangkok, the Gulf of Thailand coastline has moved inland as a result of land subsidence, coastal erosion is accelerating, and it is feared that there will be increasing damage from sea level rises caused by climate change. In addition, saltwater intrusion is occurring between the coastline and southern part of Bangkok city because of reduced pore-water pressure and this is resulting in a degradation of the urban groundwater environment.

The use of groundwater began as the pursuit of economic efficiency by private-sector institutions. As a result, there is now the question of who will bear the burden

**Table 3.1** Damage from groundwater pumping and who bears the cost

| | | | Type of damage | Losses |
|---|---|---|---|---|
| Past | ↓ | GWL Drawdown | Housing/building damage | Individual |
| | | | Elevated highway damage | Society |
| | | | Increased flooding risk | |
| | | | Coastal erosion | |
| Present | | | Salt water intrusion | |
| | | GWL Recovery | Uplift on UG structures | |
| Future | | | Infrastructure foundation damage | |

*UG* underground, *GWL* ground water level

of the resultant damage. Table 3.1 summarizes the damage that has resulted to date and shows where the burden has fallen. Initial damage to structures was borne by individuals and businesses. Beyond that point, however, damage—caused by individuals and businesses—has been borne by society, and the costs stretch over the long term.

The examples provided by Osaka and Bangkok lead to the following discussion from an urban management perspective.

Cities involve interactions between various public bodies, private institutions, and individual actors. From a development perspective, governments can implement land-use regulations, taxation schemes, and various other measures. However, because most development projects are undertaken by private-sector institutions, it is necessary to balance the interests of actors. This balance of interests can be effectively accomplished through good governance,[2] and overseeing good governance is the duty of the urban manager. To objectively balance interests among actors, urban managers must employ technical knowledge. Addressing the problem of excessive groundwater pumping requires a geotechnical engineering technical examination and, to provide an objective assessment of how a situation will develop, a simulation based on quantitative analysis is necessary. Although wells present different challenges, it is possible to examine aquifer recharge and pumping volume relationships using quantitative analysis based simulations (Ohtsu et al. 2006).

In the example of Osaka, the establishment of regulations on the pumping of groundwater was supplemented with measures such as promoting the recycling of industrial water. These measures were undertaken in consideration of private-sector user needs, and helped reduce the pumping of groundwater. At the time the measures were implemented, however, quantitative analysis based simulation technology had not yet been developed, so the measures implemented reflected only the views of geotechnical engineering experts.

In contrast, the Bangkok example illustrates a failure to achieve agreement among actors, because of a lack of private-sector groundwater pumping measures working in tandem with the public-sector groundwater pumping regulations.

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[2] "Good governance" implies that public authorities work for the public good and properly manage public resources. A variety of indicators are proposed (see the glossary).

Moreover, urban managers were unable to adequately employ technical knowledge in their attempts to form an agreement on groundwater pumping. The lack of experts with a geotechnical engineering knowledge base is cited as one cause of the failure. Additionally, the emergence of different damage types during the overlap shown in Fig. 3.5, can be seen as arising from a shortage of technical knowledge. Quantitative analysis based simulation technology was available in developing countries at the time problems stemming from land subsidence arose in Bangkok, however, cities were developing so rapidly that the validity of the simulation results was at risk. Under bad governance conditions, the balancing of interests across the various public-sector, private-sector, and individual actors requires time. Even under good governance conditions, decision-making is frequently slow in developing countries.

### *3.2.2 Rapid Urban Development and Flood Prevention*

The disastrous flooding of Bangkok in 2011 is a prime example of the level of damage that can occur (Ohtsu 2012).

In Japan and other Asian countries, the increasing frequency of localized torrential rainstorms (considered a product of climate change) has resulted in a growing number of damaging floods. East and Southeast Asia have historically experienced heavy rainfall and frequent flooding; however it is feared that the urban development accompanying economic growth will result in greater damage from flooding.

The Chao Phraya River basin courses through central Thailand and the river enters the sea at Bangkok. The basin is characterized by the gently sloping riverbed of the Chao Phraya River and generally low elevation: the elevation from Ayutthaya, 100 km to the north of the Gulf of Thailand, to Bangkok is less than 3 m. This low elevation means that flooding is a recurrent phenomenon in the Chao Phraya River basin.

The reasons for the extensive flood damage experienced in Bangkok in 2011 are summarized in Fig. 3.6.

Following the significant damage caused by the major floods of 1978, 1980 and 1983, a decision was made to build a dyke to protect the Bangkok Metropolitan Region. Pumps were installed within the dyke as an additional flood control measure (see Fig. 3.7.) Most of this “King’s Dyke,” has now been made into a roadway.

These flood control measures were designed to protect central Bangkok by redirecting floodwaters coming from the north in either an easterly or a westerly direction. When they were designed in the 1980s, the city of Bangkok consisted only of what is now central Bangkok and hence the defenses were deemed effective. The area outside the dyke was considered a retarding basin for the flooding Chao Phraya River. However, with the economic developments following the 1980s, the construction of homes and industrial parks expanded beyond the dyke and gave rise to a disaster damage gap both inside and outside the dyke.

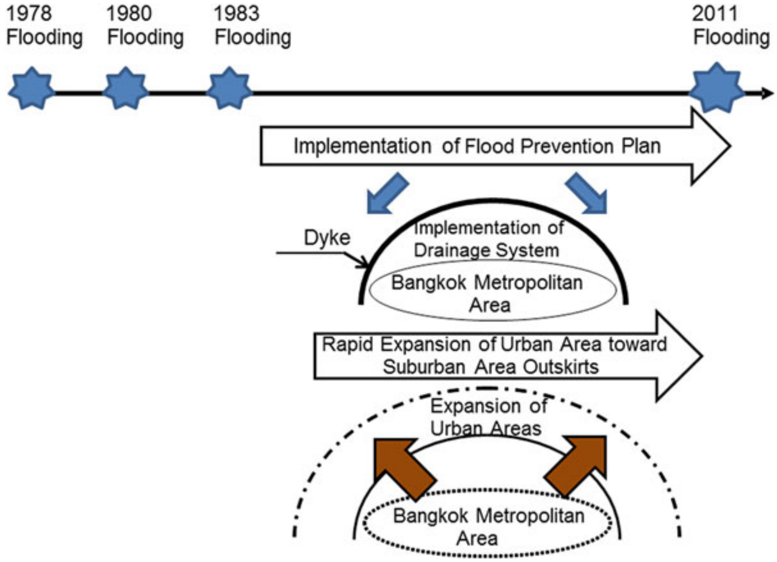


**Fig. 3.6** Factors exacerbating the damage caused by the 2011 Bangkok flood

The 2011 massive flood damage began with record-breaking rainfall being dumped on northern Thailand by multiple typhoons beginning in June of that year. The rainfall resulted in major flooding in central Thailand that extended throughout most of the Chao Phraya River basin (extending from Nakhon Sawan Province in the north to the Gulf of Thailand in the south). Massive flood damage spread throughout the Ayutthaya and Pathum Thani Provinces, and the Bangkok Metropolitan Region (see Fig. 3.8).

In the Ayutthaya and Pathum Thani Provinces, lying to the north of the city, the Rojana Industrial Park and the Nava Nakorn Industrial Estate (among other industrial facilities) were inundated and the manufacturing plants of many Japanese companies were damaged. Don Mueang International Airport (formerly known as Bangkok International Airport), located in the north of the Bangkok Metropolitan Region, experienced flooding of its runways and parking facilities and was forced to temporarily suspend operations (Fig. 3.9). Areas surrounding Phaholyothin Station, the northernmost station on the Bangkok subway which began operations in July 2004, still had floodwaters of 50 cm in November 2011 (Fig. 3.10). The subway itself, however, had been built with proper flood-control measures protecting the stations, ventilation and air-conditioning shafts, and other facilities. Water was kept out of the subway system, despite record flooding, and nearly normal operations were maintained, preserving a critical mode of transportation for citizens.

In preparation for the 2011 flood, canals and water conduits were closed and sandbags (referred to locally as “Big Bags”) were placed around the periphery of the King’s Dyke. These measures, however, created conditions that resulted in the extended flooding of the Pathum Thani Province and the northern section of the

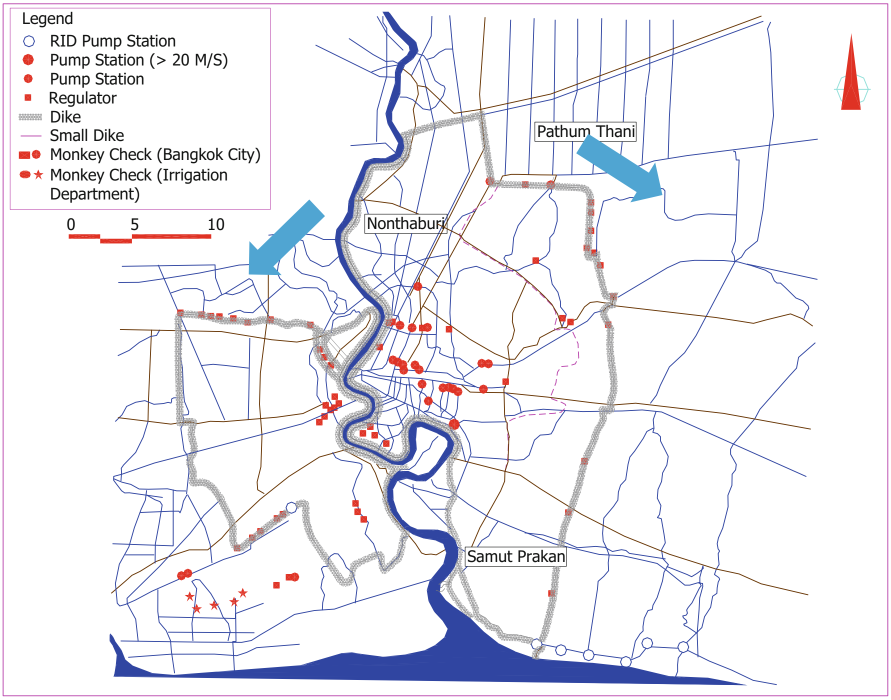


**Fig. 3.7** Bangkok's flood prevention measures (since 1983) (Phienwej et al. 2005)

Bangkok Metropolitan Region. In Japan, for example, floods normally subside within a day or two. However, the Chao Phraya River basin has a very low elevation, and floodwaters remain in place unless pumps are used to drain the affected areas. Areas outside those protected by the Big Bags, therefore, were plagued by the foul odor of stagnating floodwater, while those within protected areas remained dry and people were able to go about their normal daily lives. This situation symbolized the difficulty of bridging the perception gap between, on the one hand, communities and individuals forced to endure difficult conditions over a long period of time outside central Bangkok and, on the other, the government that worked desperately to protect central Bangkok, the political and economic center of the nation.

The problems encountered in Bangkok stemmed from (1) the flood protection master plan depicted in Fig. 3.7 being formulated based on the damage incurred during the 1983 flood, and (2) the lack of a simulation model predicting the population growth of metropolitan Bangkok. Moreover, individual and community needs for hard infrastructure and disaster mitigation had clearly grown in the intervening period since earlier flooding incidents.

In formulating urban disaster mitigation master plans, it is necessary to consider the opinions of urban planning, engineering, economic, and other experts, and make appropriate revisions as warranted by the city's development. It is the duty of urban managers and engineers to balance the interests of public-sector, private-sector, and individual actors.

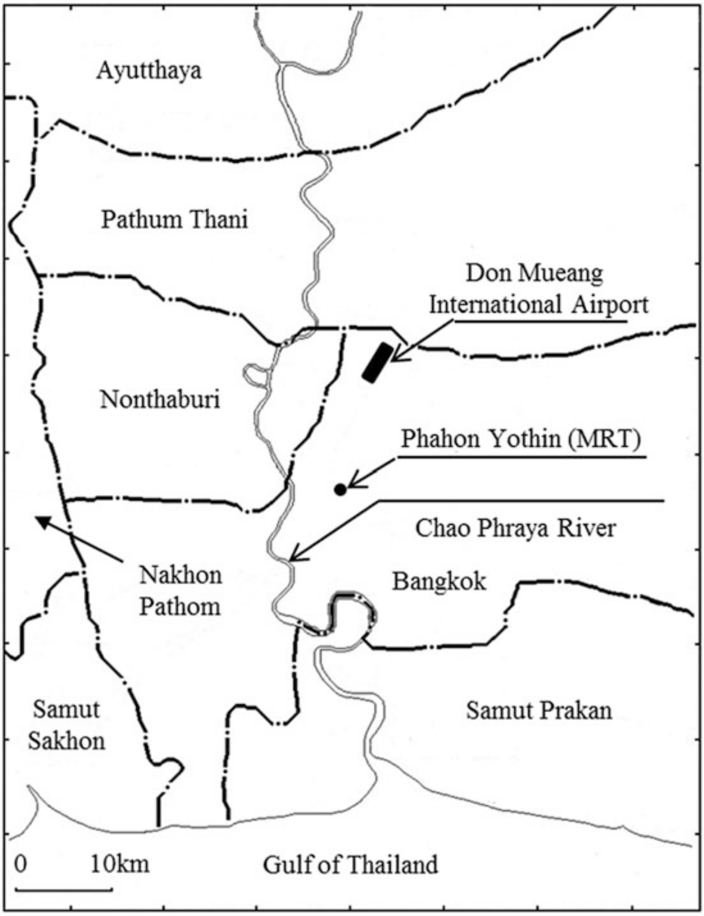


**Fig. 3.8** Bangkok area map

### *3.2.3 Problems Related to the Linking of Megacities and Rural Areas*

In recent years, localized torrential rainstorms, as a result of climate change, have caused more landslides in Asian upstream mountainous regions (Fig. 3.11).

For example, in Thailand, statistics (although these contain some inaccuracies) indicate that landslides were a rarity before 2000 (Fig. 3.12); indeed, it was claimed that Thailand was landslide-free. However, since 2001 the same statistics show a marked increase in landslide frequency. Among the reported causes of this increase are (1) the impacts of a climate change induced rise in the frequency of localized torrential rainstorms on collapsing natural slopes, and (2) the collapse of cut slopes

**Fig. 3.9** Flooding at Don Mueang International Airport, Bangkok, 2011

**Fig. 3.10** Flooding around the Bangkok subway Phaholyothin station, 2011

**Fig. 3.11** Landslide, debris flow, and flood damage in Asia. (**a**) 1988 Ban Katoon, Thailand—catastrophic landslide and debris flow. (**b**) 2010 Taiwan—highway 3 landslide. (**c**) 2010 Vietnam flood

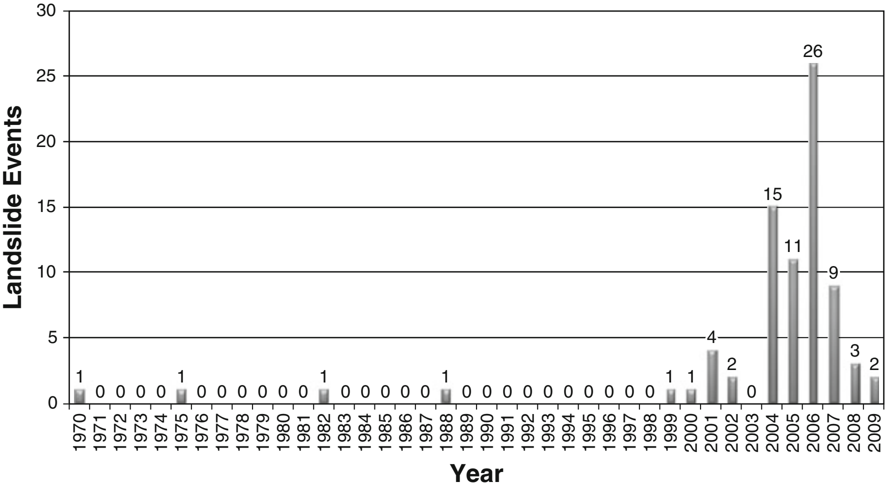


**Fig. 3.12** Instances of landslide damage in Thailand (Soralump 2010)

excavated to create space, mainly for rubber plantations, vegetable farming, or other agricultural purposes, or for road or housing construction (Soralump 2010).

Local government and road management authorities, among others responsible for measures aimed at addressing landslides, conducted few, if any, landslide risk surveys in 2000 and indeed subsequently. These parties, given a combination of an enormous number of slopes under their responsibility and a limited budget, are unable to implement measures that would stabilize slopes and reduce the risk of landslides—a situation that is most acute for local governments in mountainous areas.

Under such circumstances, it is thought that local government, road management authorities and other authorities should implement measures such as:

1. Preparation of landslide hazard maps showing areas vulnerable to landslides and containing indicators of landslide risks for each.
2. Establishment of land usage restrictions addressing agricultural land development, road construction, housing development, and other purposes.
3. Establishment of citizen evacuation, road traffic restrictions, and other landslide early-warning systems.

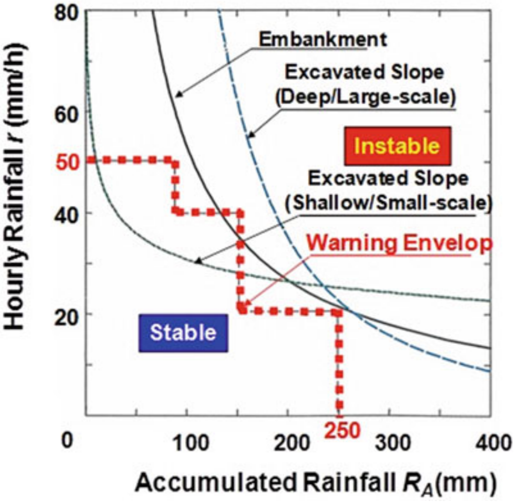
As an initial step, it is essential that local government, road management authorities and other authorities enlist the cooperation of engineers to analyze the conditions that have resulted in landslides in recent years, and produce landslide hazard maps. It is possible to prepare landslide hazard maps for broad expanses of land by using aerial photographs and remote sensing technology.

Once landslide hazard maps have been prepared, the next critical step is to identify those areas where landslide risk is high and establish restrictions on agricultural land development, road construction, housing development, and other purposes. Communicating information on land usage restrictions in high-risk areas is also vital, along with balancing the interests of the various public-sector, private-sector, community and individual actors in urban settings. The imposition of land-use restrictions in mountainous areas, where usable land is limited, will be particularly difficult because of the direct impacts on community incomes. Local government, road management authorities and other authorities can play a key role by explaining to communities and citizens the losses they would bear as a result of a landslide.

The third measure is to establish landslide early-warning systems. The purpose of these systems will not be to reduce the frequency of landslides themselves, but to reduce the human toll from landslides by effecting citizen evacuations, road traffic restrictions, and other measures. For local governments overseeing mountainous areas where limited budgets make it impossible to reduce landslides through engineering or other measures, this is an effective damage limitation approach.

In Japan, road authorities and railroad operators have adopted landslide early-warning systems, the underlying basic concepts of which are illustrated in Fig. 3.13. Using data from previous disasters, rainfall accumulating on a flat surface is plotted (from the time a rainstorm begins until it stops) and hourly rainfall is measured, and a warning envelope is set to define rainfall conditions under which slopes can be

**Fig. 3.13** An example of landslide early warning system proposed by a Japanese research institute



judged stable or instable. When it becomes evident that additional rainfall could push beyond the warning envelop, speed limits can be reduced or traffic restrictions imposed, and in the more extreme cases evacuation warnings issued, to reduce the losses of life and property from landslides.

In Japan, rainfall is measured by a system of measurement points established by the Japan Meteorological Agency. These measurement points are separated by approximately 10 km and measure rainfall every 10 min, and sufficient data has been accumulated to establish landslide early-warning systems. However, in Thailand and other developing Asian countries rainfall measurement sites are limited in number and tend to measure accumulated rainfall only. There are not, therefore, sufficient accumulations of data to establish landslide early-warning systems. Moreover, because localized torrential rainstorms can continue for several hours, daily rainfall measurements may not be appropriate as rainfall indicators for the establishment of landslide early-warning systems. Increasing the number of measurement points and equipping measurement points with systems capable of collecting hourly data, rather than daily, merits urgent attention to address this.

Nevertheless, in building a landslide early-warning system, it is important to clearly demark the roles of the central and local governments. Limited local government budgets mean that even if a decision is made to build a warning system, the rainfall measurement system may not be adequate. Hence, landslide early-warning systems that employ rainfall measurements based on central government satellite information and Doppler radar data are currently being planned. The implementation of such systems, however, will bring into question whether it is acceptable for a central government to use this information to issue evacuation or road traffic orders. This question will also arise in relation to flood response evacuations.

It can be said that the principle disaster response actors are shifting from central governments to local governments, or to communities and individuals. It is essential, therefore, to build flood and rainfall measurement systems at the local level and, more importantly again, to determine how to communicate observation results in real time to many communities and individuals. There is also the connected question of how to develop the required skills in local governments.

## 3.3 Model for Developing New Urban Managers

This chapter showed that the excessive pumping of groundwater was effectively controlled by regulatory measures in Osaka, Japan and by economic measures in the case of Bangkok in Thailand. It is notable in Japan however, that controls were implemented during a period of high economic growth, that the government could use subsidies to promote the recycling of industrial water, and that a solution was achieved in part because of an existing trust-base between government and private-sector actors.

Developing countries have yet to achieve similar levels of trust between government and private-sector actors. Economic development and higher living standards have resulted in differences at national levels, and the levels of hard infrastructure and disaster prevention and response demands at the community and individual level are also rising, making for complicated conditions in developing countries as a whole.

The excessive pumping of groundwater is no longer a problem for either Osaka or Bangkok, however groundwater pumping continues apace with economic development in other Asian megacities.

Vietnam, for example, has achieved remarkable economic development in recent years and in two of its largest cities, Hanoi and Ho Chi Minh City, groundwater pumping continues to increase amid the ongoing construction of hard infrastructure. The volume of groundwater currently being pumped to fulfill its population and economic needs has not yet exceeded the recharge capacity, so land subsidence has not occurred in either city. Nevertheless, the continuation of current development conditions could give rise to risks of the same land subsidence and associated increased flood risks, and maintenance and repair issues for newly constructed hard infrastructure, experienced in Bangkok (Giao 2004). These risks are reflected in the three-city damage model shown in Fig. 3.14.

In responding to these issues, urban managers are responsible for preparing urban development master plans, effectively using quantitative simulation technology to revise plans in response to urban development, and balancing the interests of various public-sector, private-sector and individual actors.

In addressing problems related to the linking of megacities and rural areas, the role of the principle actor is shifting from central governments, which have traditionally handled such problems, to local governments, or to communities and individuals.

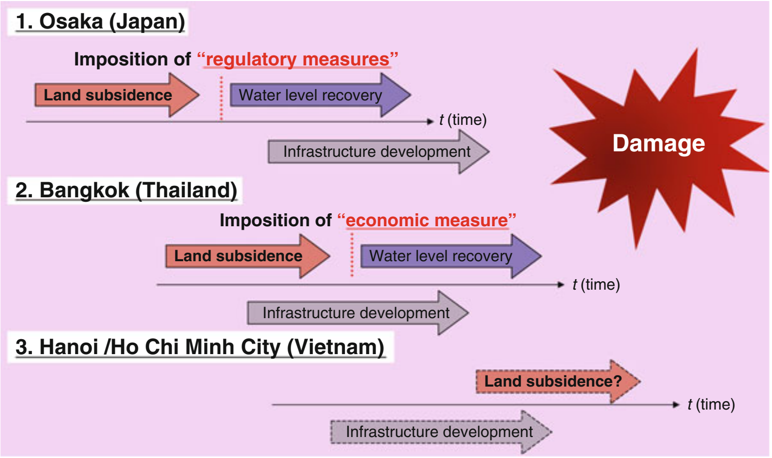


**Fig. 3.14** Three-city comparison of damage from groundwater pumping

The comprehensive management of entire river basins, as illustrated in Fig. 3.2, may be effective for addressing these problems. Figure 3.2 illustrates that there is a complex interaction between the various strata of actors along the length of the river basin. If appropriate land-use agreements (covering agricultural land development, road construction and housing development) are not formed between local governments, and communities and individuals in upstream mountainous areas experiencing increased rainfall from climate change, the risk of landslides will rise. Furthermore, disorderly land usage will result in greater run-off from rainstorms, greater river erosion from increased flows in the middle reaches of river basins, and more frequent flooding and other disasters in downstream urban areas. These problems cannot be solved without cooperation across the stratified actors—local governments, communities, individuals, and the central government. Problems that can emerge without such cooperation also include greater risks of flooding, inducement of coastal erosion, and increased risks of damage from high tides, which are seen as an artifact of climate change.

Breaking the chain of damage in the river basin model requires the construction of infrastructure such as river and coastal dykes. However, another key factor is the development of urban and local government managers who will shepherd the formation of comprehensive agreements among the stratified actors. These managers will have expertise in various mechanics and hydraulic modeling fields, and in a broad array of urban simulation, hazard map preparation, and other simulation technologies. They will be able to combine that expertise with socioeconomic expertise to deliver the services demanded by communities and individuals.

## References

Giao PH (2004) Some considerations on problems and solutions of Hanoi land subsidence – part II: risk and control. In: Proceedings of the 3rd Southeast Asian workshop on rock engineering, Kyoto University and Hanoi University of Geology and Mining in Hanoi, Vietnam, pp 181–186

Ohtsu H (2012) Bankoku Chikatetsu Ekibu ni okeru Kozui Taisaku (Flood prevention measures at Bangkok subway stations). Jiban Kogakkai-shi 60(3):30–33

Ohtsu H, Phienwej N, Takahashi K, Izumi H (2006) Bankoku ni okeru chikasuiyosuiryo no Fukakujitsusei wo koryoshita jiban chinka suitei. Doboku Gakkai Ronbunshuu F (Prediction of land subsidence considering the variation of ground water extraction in Bangkok). JSCE J Constr Eng Manage 62(1):25–40

Phienwej N, Ohtsu H, Supawiwat N, Takahashi K (2005) Bankoku niokeru chikasuiyosui ni tomonau jiban chinka (Land subsidence caused by groundwater pumpage in Bangkok). Soil Mech Found Eng 53(2):16–18

Phienwej N, Giao PH, Nutalaya P (2006) Land subsidence in Bangkok, Thailand. Eng Geol 82:187–201

Soralump S (2010) Rainfall-triggered landslide: from research to mitigation practice in Thailand. Geotech Eng J SEAGS AGSSEA 41(1), ISSN 0046–5828

# Chapter 4
# Co-Evolution of Health Risk Management and Urban Environmental Infrastructure

**Hiroaki Tanaka**

**Abstract** This chapter provides an overview of the ways that environmental problems contributing to health risks in Asian megacities relate to health problems for people. In addition, the development of water supply and sewerage systems and other environmental infrastructure critical for solving such problems and potential future issues are discussed.

Sections 4.1–4.4 explain the complicated nature and scale of environmental health problems in Asia, particularly for its megacities. Risk factors, predominantly with respect to environmental health, are considered based on the Global Burden of Disease report.

Sections 4.5–4.8 discuss the roles environmental infrastructure—water supply and sewerage systems in particular—have played in supporting environmental health in Asian megacities, based on Japanese experiences. Issues that have emerged in connection with the common division of environmental infrastructure into sectors such as water supply systems and sewerage systems are addressed. Solving the environmental health problems facing Asian megacities will require solutions that also consider energy-related issues.

**Keywords** Co-benefit solution • Environmental health risk • Environmental infrastructures • Global burden of disease • Twenty-first century-type urban water cycle system

This chapter provides an overview of the ways that environmental problems contributing to health risks in Asian megacities relate to health problems for people. The development of water and sewerage systems and other environmental infrastructure and potential future issues are also discussed. Rapid industrialization, population growth, delays in establishing pollution-control measures, and problems

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such as poverty all contribute to a degradation of environmental conditions in Asia. Rapid industrialization and growth in urban populations, in particular, have given rise to serious health risks tied to environmental risk factors. Examples include unsafe drinking water, inadequate sanitation facilities, inadequate waste disposal, air pollution, insufficient management of flies, mosquitoes, and other insect disease carriers, and exposure to existing or new forms of pollutants. Existing or new environmental health risks are appearing in many Asian megacities, particularly in those countries considered emerging or developing.

It is estimated that 6.6 million people die each year in Asia as a direct or indirect result of environmental problems: this is equivalent to one quarter of Asia's total annual mortality. Nevertheless, environmental problems giving rise to environmental health risks are either ignored or underappreciated in developing countries; they display both a limited desire to, and ability in, solving environmental health problems despite their severity. Asia is acutely vulnerable to annual onslaughts of influenza and other diseases, and natural disasters such as typhoons, earthquakes, tsunamis, droughts, and floods. Natural disasters (including disease) have occurred with growing frequency over the past 10 years and are expected to exacerbate future environmental health problems.

Sections 4.1, 4.2, 4.3, and 4.4 explain the complicated nature and scale of environmental health problems in Asia, particularly for its megacities.

Sections 4.5, 4.6, 4.7, and 4.8 discuss the roles environmental infrastructure—water supply and sewerage systems in particular—have played in supporting environmental health in Asian megacities using Japan, the country with the most advanced systems, as an example. Issues that have emerged in connection with the common division of environmental infrastructure into sectors such as water supply systems, sewerage systems, and waste management systems are addressed. Solving the environmental health problems facing Asian megacities will require solutions that also consider energy-related issues. Illustrations of such solutions and the need for complex responses that include disaster preparedness, urban infrastructure, urban governance, and environmental management issues are provided in the latter half of this chapter.

## 4.1 Causes of Global Diseases and Deaths

Disease is one of the threats to human health. The World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO 1946).

Disease—or, more accurately ill-health—is a state that includes problems of physical, mental and social well-being. Over its history, humanity has occasionally experienced declines in population from infectious and other diseases. In the past 100 years, however, mankind has discovered large numbers of pathogenic micro-organisms that cause disease in humans or animals, and has studied how to guard against these and treat the diseases they produce. Nevertheless, many people in developing countries still suffer from infectious diseases such as plague, cholera, typhoid fever, and malaria. Acquired immunodeficiency syndrome (AIDS) is an example of a disease that has emerged relatively recently. A serious threat to humanity, AIDS is a viral disease that disables the immune system and prevents the body from defending itself from infection. The WHO estimates that ten million people throughout the world have been infected with AIDS since its initial discovery in the United States in 1981. There is no existing cure for AIDS, but significant investments are being undertaken to discover one.

It is useful to investigate statistics on and causes of disease and mortality throughout the world, and to discuss where to invest limited resources to reduce illness and death. The WHO, in an effort to provide basic information on disease burdens and risk factors at national and international levels, developed the Global Burden of Disease (GBD) project in cooperation with the World Bank and other parties. The GBD comprehensively analyzes and evaluates the mortality and loss of health that results from disease, injury, and risk factors.

The GBD uses Disability-Adjusted Life Years (DALYs) to measure disease burden. DALYs are calculated by adding the “years of life lost” due to premature death and the “years lived with disability” (or years of healthy life lost to a health condition). DALYs offer the combined benefit of measuring both years of life lost to premature mortality and years of health lost to a disease- or accident-related disability. DALYs and other disease burden indices are not perfect measures, but they are significant as indices for grasping the overall health condition of a country’s people and for setting public health priorities.

The WHO analyzes various factors related to public health and environmental hygiene and it estimates that 44 % of global mortalities and 34 % of DALYs are attributable to 24 risk factors, and that the top ten risk factors account for 33 % of global mortality (WHO 2009). Twenty-three percent of global mortality is caused in part by environmental risk factors. Chronic obstructive pulmonary disease (COPD), for example, was a factor in 3.2 million of the 58.8 million global deaths in 2004 and 42 % of those COPD-related deaths resulted directly from environmental risk factors (WHO/UNEP 2008). Every year over four million children die, and environmental risk factors are considered a major reason why infant mortality percentages in developing countries are 12 times those of developed countries (WHO 2009).

## 4.2 Health Problems Related to Urban Environments

The concentration of human activity in cities often gives rise to environmental hygiene problems, so it is imperative to have city governance strategies for continuous protection of the environment. In 1992, the United Nations (UN) held a global conference on environmental and development problems in Rio de Janeiro, Brazil. An action plan on sustainable development was adopted at this conference. Referred to as “Agenda 21”, this plan sets out directions for urban development and methods of relating to the environment for purposes of human survival. Since its adoption, Agenda 21 has played an important role in addressing matters concerning human involvement in urban environmental and health problems. High population concentrations in urban spaces consume natural resources and cause environmental problems. Urban environmental conditions that affect human health include:

1. Air Pollution—Particulates and chemical substances released from factories, automobiles, and other sources, and greenhouse gas emissions.
2. Water Quality—Releases of pathogenic, infectious, and toxic substances in sewage and massive volumes of household and factory wastewater.
3. Traffic—Air pollutants, noise, and vibration from automobiles, motorbikes, and other forms of transportation used where public transportation is inefficient.
4. Waste—The volume of waste buried in landfills, recycled, or incinerated.
5. Energy Consumption—Energy efficiency and consumption of renewable energy.

### *4.2.1 Environmental Factors Related to DALYs*

Figure 4.1 shows WHO DALY data on risk factors as percentages of global disease burden (WHO 2006). Risk factors are organized by descending size of environmental risk fraction (percentage); non-environmental risk fractions are also shown. The WHO's definition of "environment" includes all activities related to physical, chemical, or biological factors external to people, but does not include natural environmental factors that cannot be improved. For example, environmental pollution, ultraviolet radiation, noise, work-related risks, and living environments are included, while nonessential goods, the consumption of food, and the loss of employment are not (WHO 2006). Figure 4.1 shows percentages of health risk elements in DALYs, and the size of environmental and non-environmental fractions for each health risk. The WHO estimates that environmental factors contribute to 24 % of the disease burden and 23 % of the mortality worldwide. Of particular note are infections of the lower respiratory tract, being the second largest DALY contributor, and diarrhea, being the largest environmental factor contributor.

Much of the world's population only has access to unsafe water and inadequate sanitation facilities. Being subject to unsanitary conditions exposes people to waterborne diseases via the water used for drinking, cooking, bathing, and recreation, and from contaminated fish and shellfish, and other sources. As a result, diarrhea that is caused by unsafe water and the lack of sanitation facilities is the highest environmental risk factor as shown in Fig. 4.1. Indeed, 90 % of diarrhea-related mortalities are caused by environmental factors. Infections of the lower respiratory tract are a major health risk factor in DALYs, and the second greatest environmental risk factor.

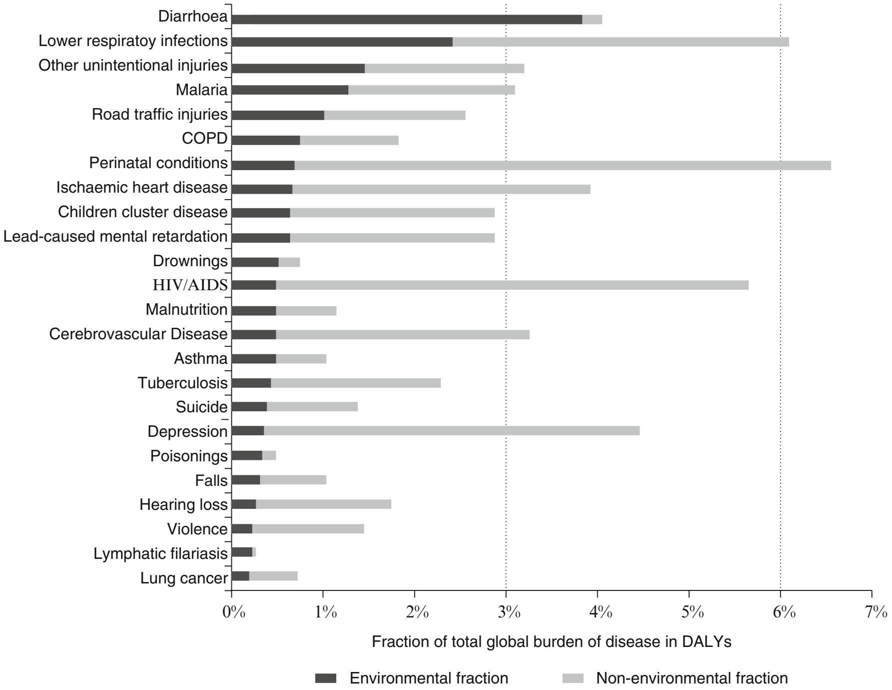

**Fig. 4.1** Health risk factor contributions to DALYs, and their environmental and non-environmental percentages (WHO 2006)

The WHO summarized the major health risk factors arising from urban environmental factors and arranged them by their contributions to DALYs (Fig. 4.2) (WHO 2009). This shows that unsafe water and inadequate sanitation and hygiene account for 4.2 % of the 1.53 billion global DALYs, followed by the major urban environmental health risk factors of indoor air pollution from solid fuels (2.7 %), urban outdoor air pollution (0.6 %), lead exposure (0.6 %), and climate change (0.4 %).

### 4.2.2 *Water and Hygiene*

Water occupies a position of particular importance among natural resources. The WHO has indicated that unsafe water and inadequate sanitation are the greatest of environmental and health risk factors based on its analysis of global mortality causes (WHO/UNEP 2008). Unsafe water and inadequate sanitation are the reasons behind increasing cholera, typhoid fever, and other waterborne diseases risks. Predictions are that contaminated water supplies will worsen given the increases in water demand, improperly treated sewage, industrial wastewater, saltwater intrusion, and other problems resulting from the world's growing population.

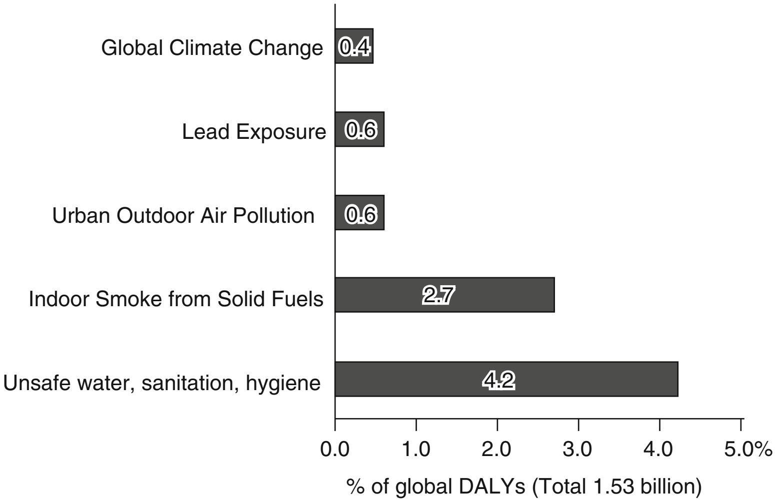

**Fig. 4.2** DALY contributions by key urban environmental health risk factors (WHO 2009)

Access to water is fundamental for ensuring societal sustainability and human security. Hence, overcoming problems associated with water shortages and providing water infrastructure with sufficient capacity are both essential. Water supply and sewerage systems, or substitute approaches for providing these services, are critical for improving environmental health.

Globally, one billion people obtained access to safe drinking water from 1990 to 2010; nonetheless, it is estimated that 3 % of the world's population continues to live without safe drinking water (WHO/UNICEF 2012). The number of people throughout the world with access to safe drinking water had reached an all-time high in 2010, however many countries still operate with inadequate safe drinking water supplies. Indeed, in some African and Oceanic countries there are regions where safe drinking water is available to less than half of the population. In Asia, efforts to secure safe drinking water supplies are making progress, but there are still regions where access remains inadequate (WHO/UNICEF 2012) (Fig. 4.3).

Efforts to supply safe water and address wastewater problems in Asia are complicated by rapid population growth and accelerating urbanization. In the past 100 years, the use of fresh water has increased more rapidly in Asia than anywhere else in the world (Asian Development Bank 2007). The consequent small volume of fresh water available per person, in conjunction with wide-spread pollution and inappropriate management practices, has created conditions whereby it is impossible to obtain safe water.

Figure 4.3 shows changes in drinking water and sanitation facilities on a worldwide basis, in developing countries, and in regions of Asia for 1990–2010 (WHO/UNICEF 2012). Drinking water and sanitation facilities can take different forms depending on the region and stage of development. Table 4.1 shows drinking

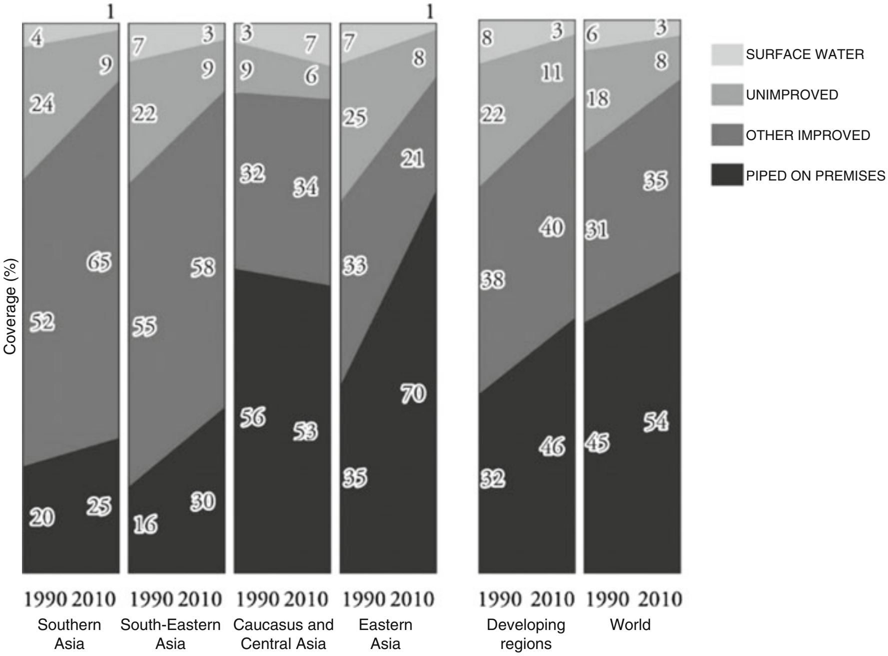

**Fig. 4.3** Population percentage per drinking water supply systems in 1990 and 2010 (WHO/UNICEF 2012)

**Table 4.1** Drinking water and sanitation facility classifications (WHO/UNICEF 2012)

| | Drinking water | Sanitation facilities |
|---|---|---|
| Improved | Piped water into dwelling, yard or plot, Public tap or standpipe; Tubewell or borehole; Protected spring; Protected dug well; Rainwater collection | Flush or pour-flush to: piped sewer system, septic tank, or pit latrine; Ventilated improved pit (VIP) latrine; Pit latrine with slab; Composting toilet |
| Unimproved | Unprotected dug well; Unprotected spring; Cart with small tank or drum; Tanker truck; Surface water (river, dam, lake, pond, stream, canal, irrigation channel); Bottled water | Flush or pour-flush to elsewhere (not to piped sewer system, septic tank or pit latrine); Pit latrine without slab, or open pit; Bucket; Hanging toilet or hanging latrine; Shared or public facilities of any type; Open defecation |

water and sanitation facilities categorized by the WHO/UNICEF (United Nations Children's Fund) (WHO/UNICEF 2012) as either appropriate or inappropriate. It provides percentages for users of drinking water that is piped on premises, provided through other improved water supply facilities, provided through inadequately improved water supply facilities, or comes from surface water. The percentage of the global population with access to a water supply system or improved

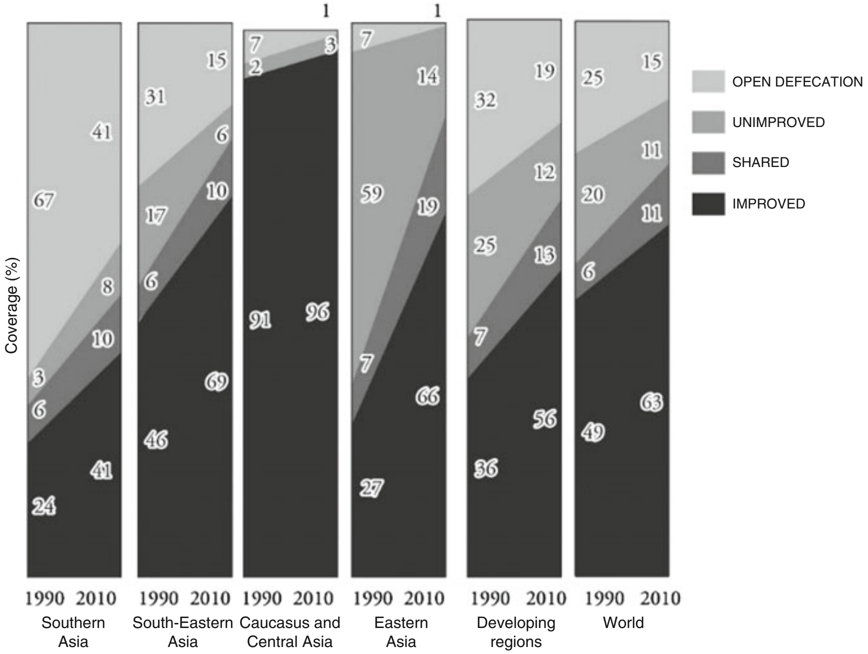

**Fig. 4.4** Population percentages per sanitation facilities in 1990 and 2010 (WHO/UNICEF 2012)

drinking water facilities rose from 74 % in 1990 to 89 % in 2010. On the Asian continent, the Caucasus and Central Asia regions had existing high water supply system penetration by 1990. However, Eastern, South-Eastern, and Southern Asia saw a doubling of water supply system penetration from 1990 to 2010. If figures for "other improved" systems are included, approximately 90 % of the populations in these areas had access to drinking water by 2010.

A further major concern for many countries is the lack of adequate sanitation facilities; the presence or absence of which is directly related to the control of diarrhea, trachoma, parasitic diseases, and the spread of other water-related illnesses. In 2010, the percentage of the world's population with access to sanitation facilities was higher than ever before. Nevertheless, there were still regions in Africa, Oceania, and Southern Asia where access to sanitation facilities was available to less than half of the population. In Asia as a whole, there are only a limited number of countries with at least 90 % access to appropriate sanitation facilities.

Figure 4.4 shows a breakdown of populations using improved, shared, unimproved or no sanitation facilities. The percentage of those with access to improved or shared sanitation facilities increased from 55 % in 1990 to 74 % in 2010. Looking at figures for Asia, approximately 90 % of those living in the Caucasus and Central Asia had access to improved sanitation facilities in 1990. In Eastern and South-Eastern Asia, access to improved sanitation facilities increased to two out of every three people in 2010 (approximately 66 %), while in Southern Asia access was approximately 40 %.

Here, “sanitation facilities” are defined as treatment facilities with the ability to treat and dispose of human waste, rather than facilities to prevent water pollution. Responding to water pollution, therefore, happens at a later stage. Water pollution is a serious problem and occurs mainly when untreated sewage, industrial wastewater, nitrates from livestock effluent or chemical fertilizers, saltwater intruding via river estuaries or groundwater pumping contaminate precious water resources. In Asia and elsewhere river pollution from sanitary waste is worsening as a result of growing urban populations and inappropriate sanitary waste treatment facilities (United Nations Environment Programme Global Environment Monitoring System (GEMS)/Water Programme 2008).

### *4.2.3 Air Pollution*

Air pollution is an important global environmental health concern. The world’s urban population is expanding yearly and with this comes an increase in automobile numbers and the pollutants emitted from these and other sources. Examples of the health impacts of air pollution include respiratory illness, diseases related to heavy metals, and allergies; with children and the impoverished being in the high-risk group. The use of gasoline, other fuels, and the imprudent emissions of automobile exhausts have led to a gradual exacerbation of air pollution. Examples of air pollutants include nitrogen oxide, sulfur oxide, ozone, suspended solids, polycyclic aromatic hydrocarbons, metals, and volatile organic compounds. It is accepted that such pollutants threaten human health. Fine particulates, in particular, cause cardiopulmonary and various other acute and chronic diseases and are estimated to be responsible for 8 % of lung cancer deaths, 5 % of cardiopulmonary disease deaths, and 3 % of respiratory infections throughout the world (WHO 2009).

### *4.2.4 Chemical Substances*

Since the middle of the twentieth century, chemicals have played a leading role in global economic development. To date, nearly 40 million chemicals have been developed. Fifteen million are presently being used commercially, and of that number 1,000 are produced in quantities of at least one ton per year. Chemical accidents and environmental pollution can occur as a result of inappropriate chemical production or consumption processes. Table 4.2 presents information on some previous chemical accidents and the resultant damage. Many regulations are now in place to effectively manage chemicals; despite such controls however, hazards remain. Chemicals such as agricultural chemicals, pharmaceuticals and personal care products, and endocrine disruptors pose potential threats as water-related health risks and could affect ecosystems.

**Table 4.2** Examples of chemical accidents and their health impacts

| Year | Location | Accident | Damage |
|---|---|---|---|
| 1984 | Bhopal, India | Methyl isocyanate leak | 3,800 fatalities, 500,000 people exposed to gas |
| 1984 | Mexico City, Mexico | Liquefied petroleum gas terminal explosion | 500 fatalities, 6,400 injured |
| 1995 | Tokyo, Japan | Intentional gas release | 12 fatalities, 1,000 people affected |
| 2004 | Neyshabur, Iran | Chemical explosion on train | Several hundred fatalities |
| 2005 | Songhua River, China | Release of 1,000 tons of pollutants into the Songhua River following a factory explosion | Five fatalities, several hundred people affected by extended loss of water services |
| 2005 | Bohol, The Philippines | Negligent inclusion of insecticide in a candy manufacturing process | 29 fatalities, 104 hospitalized |
| 2007 | Angola | Inclusion of sodium bromide in salt for human consumption | 460 people (mainly children) sickened |
| 2008 | Senegal | Release of lead from uncontrolled reuse of batteries | Large number of lead poisoning victims |

The WHO (2009) maintains that lead, which is extensively used, is widely dispersed in the air (as particulate matter) and in soil and water. There are concerns that it can cause mental retardation and behavioral and developmental handicaps in fetuses and children, and high blood pressure in adults. There are particular concerns relating to the exposure of children to lead in developing countries, in part because of the ongoing practice of adding lead to fuel.

### *4.2.5 Global Warming*

Climate change, giving rise to changes in average temperatures and precipitation patterns, is becoming an unavoidable reality as a result of rising emissions of carbon dioxide, methane, nitrous oxide, and other global warming gases from human activities. It is expected that climate change will have impacts on human health.

The WHO anticipates that threats to human health will increase in line with changes in the environment. There are fears that precipitation variability, rising temperatures, and other climate extremes occurring with greater frequency will give rise to health problems such as diarrheal diseases, malaria, selected unintentional injuries, and protein-energy malnutrition (WHO 2006). The WHO (2009) states that high temperatures and extreme weather, vector-borne diseases, foodborne or waterborne infectious diseases, photochemical air pollutants, conflict over depleted natural resources, and other impacts of global warming have already caused deaths from diarrheal diseases to rise by 3 %, deaths from malaria by 3 %, and deaths from dengue fever by 3.8 %.

**Table 4.3** Examples of the health impacts from the improper disposal of hazardous waste

| Year | Location | Problem Substance | Result |
|---|---|---|---|
| 1919 | Toyama Prefecture, Japan | Cadmium | Itai–itai disease |
| 1935–1971 | Hamburg, Germany | Liquid and solid chemical pollutants | Dioxin detected in landfill |
| 1988 | Rajasthan, India | Silver chemical dye | Pollutants discovered nearby at 15,000 times the safety threshold |
| 1989 | Madras India | Cyanide | Large number of buffalo killed |

### 4.2.6 The Waste Problem

The improper processing of waste impacts both on human health and the environment. Waste processing often takes such forms as unsanitary dumping or burial, discharges into bodies of water, and open burning, and better alternatives must be employed. The improper disposal of hazardous waste, consisting mainly of agricultural chemicals, and household, mining, medical, and industrial waste, results in soil and groundwater contamination. Table 4.3 gives examples of the health impacts that have resulted from the improper disposal of hazardous waste.

### 4.2.7 Developing Countries Where Environmental Factors are Particularly Serious

The top five environmental factors for global DALYs and mortality were discussed in Sect. 4.2.1 in terms of their relative impacts. The WHO (2009) has further analyzed the factor differences between low-income (developing and other) countries and high-income countries.

The top five environmental factors account for greater DALY percentages in low-income countries than in high-income countries. Specifically, indoor smoke from solid fuels composes 2.9 % of DALYs for low-income countries and less than 0.0 % of DALYs for high-income countries. Unsafe water, sanitation, and hygiene correspond to 4.6 % in low-income countries and 0.3 % in high-income countries; urban outdoor air pollution, 0.6 and 0.8 %; global climate change, 0.4 % and less than 0.0 %; and lead exposure, 0.6 and 0.1 %. The combination of these risk factors account for a total of 8.6 % of DALYs in low-income countries and 1.2 % in high income countries, showing that the impacts of environmental factors on DALYs are several times higher for low-income countries than for high-income countries. In terms of impact on mortality, the figures for low-income and high-income countries respectively, are: indoor smoke from solid fuels, 3.9 % and less than 0.0 %; unsafe water, sanitation, and hygiene 3.8 and 0.1 %; urban outdoor air pollution, 1.9 and 2.5 %; global climate change 0.3 % and less than 0.0 %; and lead exposure 0.3 and 0.0 %. As is the case for DALYs, the overall impacts of the top five environmental factors on mortality are several times higher in low-income countries (9.6 %) than in high income countries (2.6 %).

The WHO/GBD data on these stark differences clearly show that, except in the case of urban outdoor air pollution, significant differences in living environments (water, sewage, and other environmental infrastructure) and medical care standards are contributing to serious environmental health problems in low-income countries (WHO 2009).

## 4.3 Worsening Protection-of-Species Conditions

As environmental problems worsen, many forms of life on earth are facing the threat of extinction. Species are already becoming extinct and, as the environment's physical and biological conditions change, there are concerns that the rate of extinctions will increase (Fig. 4.5). It has been scientifically proven that the probabilities of extinction are higher now than in the past. The principal causes, working either alone or in combination, are thought to be:

- Rapid increase in habitat loss
- Commercial hunting of wildlife
- Invasion by harmful non-native species
- Environmental pollution
- Spreading disease
- Climate change

Looking at environmental pollution: specifically, the precipitous decline of the bald eagle population in the middle of the twentieth century was a major warning of the dangers associated with the widespread use of bio-accumulating chemical products, such as DDT. Similarly, it has become clear that the feminization of fish, now a problem in the United Kingdom and other countries, is caused by industrial cleaning agents as well as estrogen, contraceptive drugs, and other

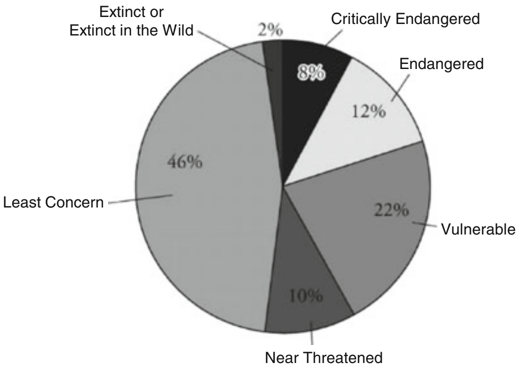

**Fig. 4.5** Breakdown of all species (47,677) included on the International Union for Conservation of Nature's (IUCN) red list by extinction threat (Convention on Biological Diversity 2010)

substances found in human waste. Furthermore, it is feared that bisphenol A (contained in manufactured products), pharmaceuticals used in daily life, antibacterial agents, and other substances acting as endocrine disruptors will reduce species survival rates (Jobling et al. 1998).

Sudden change in natural habitats is one of the most important factors in the current discussions on species extinction, and an increase in extinctions will ultimately lead to a decline in the number of species. One reason for sudden changes in natural habitats is human interference when searching for the natural resources needed for ongoing industrialization and urbanization. Other causes include agriculture, mining, logging, and trawl fishing.

## 4.4 Toward Health Risk Management

As this chapter stresses, rapid economic and population growths in Asian megacities have resulted in serious water, air, and other environmental problems. Hence, when undertaking surveys of the various environmental problems found in many Asian megacities, it is necessary to identify and assess the highest priority ecosystem environmental risks. Human health and living environments should also be investigated and appropriate risk management measures proposed and developed, and ultimately action must be taken to solve environmental problems (Fig. 4.6).

An initial step is to identify first-hand the environmental problems that exist in the target area. Monitoring the water, air, soil, sediment, and other environmental instruments in Asian megacities helps identify various pollutants. Conducting epidemiological studies of the health and mortality of people directly impacted by environmental factors may also make it possible to identify human health problems stemming from environmental causes.

Limited resources make it necessary to prioritize the problems when considering causes and solutions. When determining priorities, it should be possible to evaluate

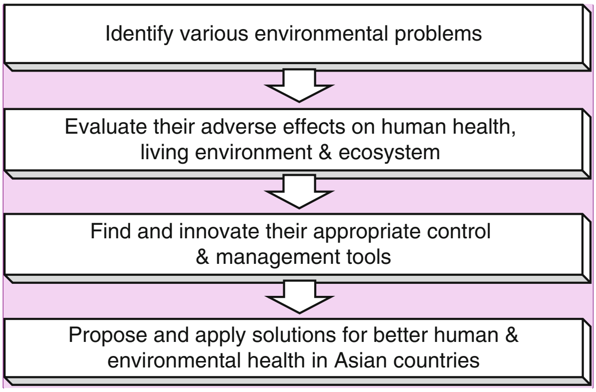

**Fig. 4.6** Problem-solving approach in the field of health risks

and quantify the human health risks posed by the identified environmental pollution. Alternatively, it may be possible to consider risk factors and priorities based on DALYs and other statistical data.

When searching for risk causes and seeking to reduce risks, it is necessary to control and manage risk factors. When producing food products and drinking water, the approach for analyzing process hazards and continuously managing and achieving safety regarding critical control points—parts of a process where hazards can be most efficiently managed—is referred to as Hazard Analysis and Critical Control Point, or HACCP. In employing a HACCP approach it is necessary to, for example, identify critical control points for reducing risks before the point of release into the environment, hence reducing risk sources and reducing risks at the usage stage, and to manage risks through the multi-barrier approach. The multi-barrier management approach secures redundancy and reliability to reduce public health risks. For example, to protect water supply systems from contamination sources, various measures and approaches are used at multiple stages (from water intake to purification, supply, and use) to eliminate or reduce the contamination of drinking water. Various management technologies are available for reducing risk, and decisions as to which to use should be made based on considerations of factors including reliability of the risk reduction technology, cost, sustainability and technical transferability of the measures used, and future substitutability. The selection of technologies appropriate for particular geographic locations and development stages is one of the most important matters to address in emerging or developing countries that differ in terms of social, economic, educational, and cultural backgrounds.

### Column 2: The Great East Japan Earthquake and Subsequent Sewage Treatment Problems

The Great East Japan Earthquake of March 11, 2011, caused serious damage to sewage treatment facilities along a wide stretch of the coastline of eastern Japan (Fig. 4.7). Despite the scale of the magnitude 9.0 earthquake, damage to sewer pipes and sewage treatment facilities by the earthquake itself was relatively light. It was the tsunami generated by the earthquake that wrought major damage on coastal sewage treatment plants, destroying mainly pumps, but also structures, machinery, and electrical facilities. Japan's Ministry of Land, Infrastructure, Transport and Tourism reported 48 sewage treatment facilities to be no longer operating. Residents had to evacuate areas designated as off limits because of damage to sewage treatment facilities, and sewage treatment facilities located within the 30 km (radius) evacuation zone around the damaged Fukushima Daiichi Nuclear Power Station were abandoned. Sewage works experts from central and local governments and other relevant Japanese specialists are still (late 2013) working to restore damaged facilities, but repair works will take several years.

(continued)

**Column 2** (continued)

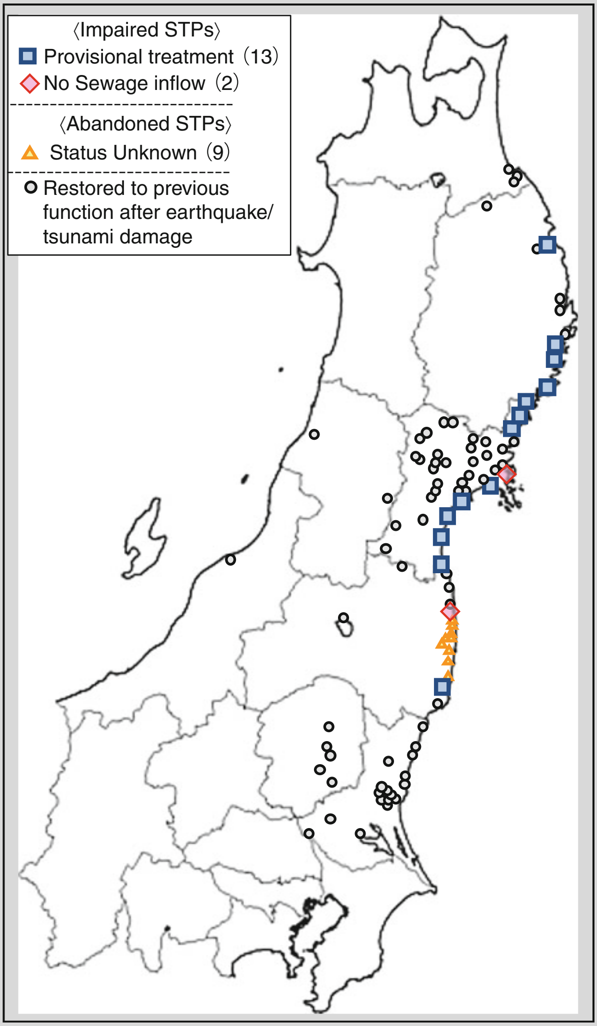

**Fig. 4.7** Sewage treatment facility damage following the Great East Japan Earthquake (as of January 10, 2012) (Courtesy of the Japanese Ministry of Land Infrastructure, Management). *STPs* Sewage Treatment Plants

Moreover, repairs will take considerable time in some cases where, although there was no structural damage, the tsunami caused water damage to machinery and electrical facilities. In the immediate aftermath of the disaster, the failure of the power grid and damage to on-site electricity

(continued)

**Column 2** (continued)

generating facilities left many sewage treatment facilities with inadequate power and no choice but to suspend operations. The aeration and sludge dewatering equipment used for activated sludge treatment and incinerators require large amounts of electricity and were unable to function normally. Sewage treatment facilities where sewage inflows continued were forced, as emergency measures, to simply precipitate sewage in settling tanks and then chlorinate it to protect public health before discharging it.

In central Sendai and other urban areas further inland, infrastructure suffered relatively minor earthquake damage and almost no direct tsunami damage, so water supplies were quickly restored after the disaster. Water use, therefore, suddenly rebounded in disaster-stricken areas, giving rise to large volumes of sewage that, because of damaged pipes and inoperable pumping stations, overflowed onto streets or at sewage treatment facilities. Similarly, the repair of pipes and restoration of pumping stations brought large inflows of sewage to sewage treatment facilities that were still off-line, forcing them to restart pumps with only emergency repairs. Unable to do anything more, treatment facilities processed sewage by first sending it through settling tanks and then chlorinating it without adequate biological treatment, before discharging it into the ocean. In the wake of the Great East Japan Earthquake, it is clear that a disaster can result in a developed country such as Japan experiencing public health and environmental health problems similar to those of developing countries, and that there is a lack of technologies for coping with limited electricity and resources.

## 4.5 Environmental Infrastructure Supporting Asian Megacities

In 2007, 11 of the world's 21 megacities with populations of at least ten million were located in Asia. Megacities are the centers of advanced manufacturing in Asia, and it is estimated that their populations will rise from 37 % of the total Asian population in 2000, to 53 %, in 2030. Southeast Asia, in particular, is expected to experience a megacity population increase of 170 % (Asian Development Bank 2007) (Fig. 4.8). In conjunction with rapid industrialization, Asian megacities are seeing their populations and economies grow swiftly, and their current infrastructure is no longer adequate for responding to urban needs. This includes environmental infrastructure related to water, sewage, and waste, in addition to resource use and, hence, the environment will ultimately be affected. Other impacts will include habitat destruction, traffic increase, water shortages, insufficient water supplies, and waste treatment, global warming and climate change difficulties. Given the above, supporting environmental infrastructure for the future development of Asian megacities becomes more important.

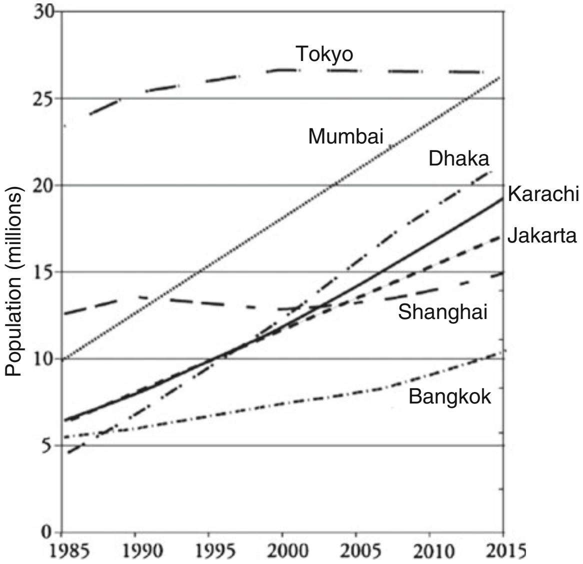

**Fig. 4.8** Asian megacity population trends 1985–2015 (Asian Development 2007)

## 4.6 Urban Water Infrastructure: Separating Water Supply and Sewerage Systems

Water supply and sewerage systems are indispensable for the urban areas in which more than half of the human population lives. The requirements for water supplies and sewerage systems appropriate for particular urban areas have become particularly acute in emerging and developing countries.

### *4.6.1 Water Infrastructure for Meeting Growing Water Demand*

Globally, cities face water supply issues. Rapidly rising urban populations are beginning to burden existing water supplies and sewerage systems. Moreover, water use has undergone drastic changes, with rising standards of living driving up demand for water, not just for drinking, but also for showers, baths, washing machines and other household appliances. At present, the urban populations of developed countries have stable water supplies from centralized water supply systems. However, this stability is an illusion that water supplies are stable, and the numbers of areas where water shortages are a concern (and indeed are expected to worsen) are projected to spread. The need to plan for water crises that will result from future climate change and other causes is becoming critical and has changed the priority of concerns for cities.

**Table 4.4** Alternative sewerage systems (Fujiu et al. 2006)

| Types | Overview |
|---|---|
| Condominial sewerage (shallower sewer) | Consolidates wastewater underground from multiple homes (i.e. under residential properties or sidewalks) before connecting to a public sewerage system. Goal is to reduce costs |
| Simplified sewerage | Consolidates wastewater from several homes using pipes buried at shallow depths and low gradients, and using simplified manholes. Goal is to reduce costs |
| Small bore sewer system | Collects wastewater from homes conveying it first to a septic (interceptor) tank to precipitate out solids. Liquid then moves by gravity flow from a high point on the tank into pipes buried at shallow depths and low gradients. Goal is to reduce costs |
| Interceptor sewer | Makes effective use of existing wastewater facilities (e.g., septic tanks, wastewater infiltration basins, gutters). For example, uses existing septic tanks to process human waste, but directs miscellaneous wastewater to a central treatment facility via gutters, ditches and intercepting sewers. Goal is to reduces costs and achieve a functioning system as quickly as possible |

In 2010, the volume of water supplied on a global basis was $4.2 \times 10^{12}$ $m^3$, versus water demand of $4.5 \times 10^{12}$ $m^3$ (2030 Water Resource Group 2009). By 2030, global water demand is forecast to be $6.9 \times 10^{12}$ $m^3$ per year as a result of the higher food demands from a larger global population. The critical point here is that urban water demand is expected to increase by 54 % by 2030 (2030 Water Resource Group 2009).

Water, like food and energy, is essential for urban populations to go about their daily lives. Growing populations will require the production of massive amounts of food, and food production, in turn, will require large amounts of energy and water. Energy production (excluding power from renewable sources like wind and sunlight) will require large amounts of water to, for example, cool and meet other electric power plant needs. Asian megacities and cities in general, therefore, will come to rely on even greater amounts of water than they already do, and will require water infrastructure networks to meet that expanded need.

### 4.6.2 *Human Waste in Cities*

Most Asian megacities already face serious problems related to human waste. These problems have worsened as growing urban populations and changing consumption patterns have resulted in rapidly growing volumes of waste: waste that is now more complex in character and composition than in the past.

Urban sanitation facilities that keep pace with population growth are indispensable for public health. In cities where sanitation facilities are lacking, the likelihood of death and disease is relatively high, with children among the most vulnerable members of the population. These sanitation problems can be addressed with traditional sewerage systems, condominial sewerage or other alternative systems to control sewage discharge and improve environments (Table 4.4).

Human waste was previously used for maintaining soil fertility and grain production volumes; hence farms in pre-industrial Japan used both human waste and fertilizer from human waste in the cultivation of crops. Fermentation of human waste over a long period kills most pathogenic microbes and produces a resource that is rich in nitrogen and phosphorus that can be used on agricultural land without contaminating surface water.

With industrialization came the development of chemical fertilizers that provided an inexpensive, convenient alternative for nourishing fields. The use of human waste, therefore, declined and it was now considered something that needed to be disposed of. In Japanese cities at that time, human waste was not discharged untreated into surface water. Each household stored its own waste until it was collected, on a regular schedule, and then dumped at sea or taken to a treatment plant for processing. In contrast, at the beginning of the urbanization of European and American cities, human waste was dumped untreated into drainage channels giving rise to urban hygiene problems.

The need to control odors, flies and other harmful insects associated with the storage of human waste by households gave rise to a strong demand for flush toilets. Sewerage systems, therefore, were built to handle waste and improve public health, and septic tanks were installed for individual households to accommodate flush toilets. Septic tanks, however, lacked the processing ability to handle miscellaneous wastewater or gray water (which does not include human waste); hence, this was discharged separately and contributed to water pollution. In 2001 the installation of new septic tanks was prohibited and wastewater treatment facilities for jointly handling human waste and miscellaneous wastewater became, along with the sewerage system, necessary for the operation of plumbing systems with flush toilets.

### *4.6.3 Water Pollution from Gaps in the Construction of Water Supply and Sewerage Systems*

The water that cities require can now be supplied in great quantity and at a uniformly drinkable quality because of the construction of water supply systems. Prior to the installation of such systems, there was access only to the limited volumes of water provided by sources like wells or springs, and people had to physically carry the water to where it was needed. With water supply systems, as much water as is needed is available at the turn of a faucet (water tap).

To meet burgeoning water demand in rapidly urbanizing and industrializing areas, and to address the problem of water source contamination from rising volumes of wastewater, it became necessary to draw large volumes of water from rivers and lakes located far from city water intake points. However, rivers were unreliable, limited water sources, so many dams were built to create reservoirs.

In Japan, the supply of high-quality water vastly improved hygiene conditions, but also fostered a huge increase in water use, giving rise to a concomitant increase in urban wastewater volumes. Sewerage systems were originally limited to cities with foreign enclaves such as Yokohama and Kobe, and to the large cities of Tokyo, Osaka, Nagoya, and Kyoto. Most Japanese cities had no sewerage system into which wastewater could be drained and collected; hence it was discharged into city channels. This led to various problems including the accumulation of pollutants, the emergence of foul odors, flies and other harmful insects, and unsightly urban environments. Solving these problems required the construction of sewerage systems on a par with the water supply systems already in place.

### *4.6.4 Sewerage System Construction*

In cities the majority of space is covered, for example, by buildings or roads, so systems built to handle sewage that includes storm runoff are particularly important. Public health problems due to diarrhea and other illnesses are serious concerns in cities that have experienced rapid population growth. The safe collection and on-site processing of human waste, however, is extremely difficult in densely populated areas. Moreover, the removal of human waste, and household and commercial wastewater, is necessary even with proper on-site processing. Furthermore, with urban ground surfaces being impervious to water, rainstorms can result in rapidly rising runoff.

Therefore, in cities and suburbs where the population density is high and large volumes of wastewater are generated, it is necessary to construct sewerage systems for taking in wastewater and sending it to a central treatment facility. In Japanese cities, the laying of sewer pipes and the connection of individual households and businesses to the system required substantial time and financial investments. As urbanization advanced, sewerage systems played an important role in removing increased volumes of runoff from rainstorms.

Investments in Japan’s sewerage systems began in earnest in the 1960s, when pollution had become a major problem, and, to date, have exceeded 80 trillion yen (over $825 billion US dollars). Seventy percent of this investment has been on pipes and pumping stations for transporting sewage to treatment facilities. In the large cities, where sewerage system construction began in Japan, the systems installed were mostly combined systems for removing both storm runoff and sanitary sewage. However, when these systems are overwhelmed by the extra flows from rainstorms, the excess is discharged directly into rivers or oceans and this includes a mixture of storm runoff and sanitary sewage. Therefore, beginning in the 1970s, cities installing new sewerage systems opted for those that handled storm runoff and sanitary sewage separately when possible. Separate systems are preferable to combined systems from the perspective of water quality. Nevertheless, in developed urban areas where roads are narrow, installing systems for handling sewage and storm runoff separately is complex in terms of both structure and installation, and separate systems naturally involve the laying of more pipe. Furthermore, in narrow urban spaces with existing underground water and gas pipes, the cost for installing sewer pipes can be considerable because of the need to place them below existing infrastructure.

### *4.6.5 The Efficiency of Centralized Sewage Treatment Systems, and Issues Related to Centralization*

While the removal of sewage from cities reduced urban water pollution, it created the parallel need to treat sewage to prevent the pollution of downstream rivers and oceans. In 1923, Tokyo became the first city in Japan to install a sewage treatment facility employing trickling filter technology, and from the late 1920s, Nagoya, Kyoto, and other cities adopted systems using the activated sludge process modeled on similar systems in Europe and the United States. The adoption of sewage treatment systems at this time promoted the use of sewer pipes to collect human waste.

Following the World War II, Japan experienced a period of high economic growth and the resultant migration of people to cities—similar to current experiences in emerging Asian countries—led to a significant degree of water pollution. In response, Japan established sewerage system construction plans covering entire watersheds to protect water quality on a broad scale. This ‘Comprehensive Basin-wide Planning of Sewerage Systems’ plan logically set sewerage facility capacities, discharge water quality, and discharge points to satisfy environmental standards for public waters. These water quality standards included Biological Oxygen Demand (BOD), as an indicator of organic matter concentration in rivers, and, later, Chemical Oxygen Demand (COD) as an indicator of organic matter concentration in inner bays. Standards for nitrogen and phosphorous were set for lake, marshes, and enclosed marine areas. The building of sewage treatment facilities, therefore, was based on plans to reduce the discharge of these substances. In watersheds containing multiple municipalities and where pollution of public waters was a concern, it was considered efficient and economical to build sewage treatment facilities for entire river basins, rather than on a municipality-by-municipality basis. This watershed-scale perspective meant that prefectures took responsibility for collecting sewage from the multiple municipalities in their jurisdictions and efforts were focused on building watershed-level sewerage systems. This approach made it possible to collect sewage from across a wide area and to establish discharge points with consideration for the public’s use of water resources. Nevertheless, the construction of such wide-area sewerage systems entails substantial time and problems emerge such as differences in when particular areas can begin to use the system.

The advancing construction of sewerage systems that included the collection of wastewater—in particular, miscellaneous wastewater—that had previously polluted urban rivers had greatly reduced this problem. However, there was a concurrent reduction in the flows of rivers acting as sources for the intake of the water needed to supply cities. With the installation of sewerage systems, the sewage that cities had previously discharged into rivers was now being collected through sewer pipes and eventually discharged by sewage treatment facilities into waters further downstream, bypassing previous discharge points and reducing flows in the bypassed sections of urban rivers. Sewage treatment facilities had made great strides in reducing pollutants in treated sewage to meet BOD, COD, nitrogen, phosphorous, and other environmental standards. Bringing the discussion to the present day, the biological treatment approach that currently serves as the primary sewage treatment method is unable to adequately remove unregulated chemical substances, viruses and pathogens that remain in discharged treated sewage. These discharges are concentrated at the discharge points established for wide-area sewerage systems and water quality improvement, like the reduction in river flows, has now appeared to have reached a limit.

### *4.6.6 The Change in Human Waste Treatment and the Water Pollution Brought About by the Use of Flush Toilets*

The environmental quality of many of Japan's rivers has changed dramatically with modern industrialization and urbanization. Water from artificially dammed rivers is sent to cities, purified, supplied to urban homes through water supply systems, and used for drinking and various other purposes. Water used by cities is then discharged back into rivers together with storm runoff. To stop water pollution, regulations on industrial wastewater were established and sewerage systems and joint wastewater treatment facilities were installed. This greatly advanced the handling of human waste from the need for physical removal to the use of flush toilets, and measures for dealing with miscellaneous wastewater also progressed, vastly improving BOD levels in Japan's rivers over a period of 40 years.

The change in the treatment of human waste, however, has given rise to various new environmental problems. Human waste includes nitrogen and phosphorus in addition to BOD. The miscellaneous wastewater from households contains more BOD than it does human waste and, because BOD can be effectively removed through biological treatment, this was effectively addressed by the installation of sewerage systems and joint wastewater treatment (simultaneously resolving issues related to the adoption of flush toilets and the processing of miscellaneous wastewater). However, nitrogen, phosphorus, pathogens, hormones, pharmaceuticals, and other pollutants are found to a greater extent in human waste than in miscellaneous wastewater, and there is now the question of whether human waste treatment facilities are more efficient at removing these pollutants than either sewerage systems or biological treatment in joint wastewater treatment facilities.

The adoption of flush toilets means that concentrations of pollutants in waters receiving discharges can increase because sewage treatment facilities or household septic tanks are incapable of sufficiently removing the large amount of pollutants found in human waste. These include pollutants such as nitrogen, phosphorus, pathogens, hormones, and pharmaceuticals found mainly in human waste. The discharge of these pollutants into the environment results in the eutrophication of the waters receiving discharges. Such pollutant discharges can impact aquatic life in various ways, including hygienic safety impacts for recreation, and effects on fish and shellfish. The feminization of fish living downstream of sewage treatment facilities, from exposure to low concentrations of oral contraceptives and other endocrine disruptors, is one significant example of such impacts (Jobling et al. 1998; Kumar et al. 2011). Unregulated pharmaceuticals, detergents, insecticides, and other chemical products are included in household wastewater (Azuma et al. 2012; Ghosh et al. 2010a, b). Growing concerns over the contamination of both drinking water resources and aquatic environments that are critical as habitats for a wide variety of aquatic life make it even more important to improve water quality. It is not sufficient to convert biological treatments to more advanced methods capable of removing nitrogen and phosphorus. Physical chemistry approaches including membrane and oxidation treatment must be incorporated (Kim et al. 2009a, b). The use of more sophisticated treatment approaches, however, will entail the consumption of more energy.

## 4.7 The Evolution of Environmental Infrastructure Towards Integrated Urban Metabolism of Water, Energy, and Other Resources

### *4.7.1 The Need for a Comprehensive Perspective*

The transition of water supply and sewerage systems in Japanese cities exemplifies step-by-step problem solving. It reveals a history of solving urban water demand and hygiene problems by building water supply systems and then collecting and disposing of urban human waste. To meet the burgeoning water demand engendered by urbanization, dam construction and other approaches were taken to develop water resources. Sewer pipes were subsequently laid to remove the massive volumes of wastewater generated within cities. When water pollution became a problem, the process became one of reducing the targeted pollutants through the use of sewerage systems, septic tanks, and other technologies. Overall, water and sewerage systems, human waste, river management, and environmental management problems were each addressed separately without the benefit of a comprehensive perspective.

Japanese cities have already constructed water and sewerage systems comprising enormous water networks. These networks, having been completed, must be maintained and require constant renewal and investment.

The water and sewerage systems that have been built to date are sources of great urban convenience, delivering plentiful, inexpensive water to users who do not need to consider what happens to the wastewater they produce. This water infrastructure contributes enormously to the convenience of urban life, but the urban water cycle is different to the natural water cycle. Urban dwellers need not think about the source of the water used, the destination of water once it has been used, or the impacts of user behavior on the water cycle.

To date, emerging new contaminations are removed either in the purification of water for use, or in the treatment of wastewater in what is referred to as an "end-of-pipe" approach. For the future, however, is it reasonable to address contaminants or risks one by one? Is there not a need to take a more comprehensive perspective in addressing urban water-cycle problems?

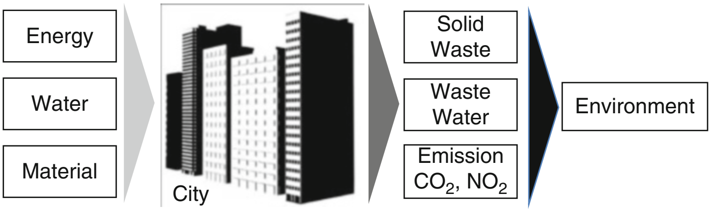

**Fig. 4.9** Pass-through (linear) urban metabolism

## 4.7.2 The Importance of Integrated Water Resource and Energy Management in Cities

To understand the process by which cities take in and metabolize the water, energy, and other resources they need—urban metabolism—the flow of water, energy, and other resources in cities must be analyzed. The pass-through or linear flow system shown in Fig. 4.9 entails massive resource inputs, massive emissions or discharges of contaminants, and additional massive resource inputs to reduce pollution. People live in high densities in cities and economic and social activities are pursued with great vigor. The water, energy, and other resources to support populations and their activities are provided as required. In response, industrial production, energy production, transportation, and other urban activities generate enormous volumes of solid and liquid waste that are discharged into the environment. Japan's water and sewerage systems expend 1–2 % of the country's total electric power consumption on ensuring water access and on minimizing environmental impacts (Ueyama et al. 2010). However, where water resources are limited this figure is greater; on the west coast of the United States, for example, it is 18 % (Kenway et al. 2009).

It is essential that water and sewerage systems appropriately address the future energy problems that will arise from global warming. In Asian megacities that have yet to extend their water and sewerage systems, it is necessary to promote understanding of how water relates to other resources and energy. Understanding the flows of water, energy, and other resources in water and sewerage systems can engender comprehension of the production and use of wastewater, waste, and waste heat, and of ways for reducing the pollution burden on the environment.

## 4.7.3 The Limits of Urban Water Supply System Energy Consumption

In the future, water supplies to the world's cities and for agricultural production will rise, and consideration for human health and the security of ecosystems will take on even greater importance. However, as measures to counter global warming advance, restrictions will be placed on energy resources. The breakdown of energy use by Japan's water supply systems differs from that of its sewerage systems. In Japan's water supply systems, 95 % of energy consumption is accounted for by water intake, conveyance, distribution, and supply, and only 5 % by purification. Nearly all of the energy consumed, therefore, is used to move water (Ihara et al. 2012). Hence, in reducing the water supply system energy consumption, attention should focus on the energy used to move water and, specifically on reducing leakage from pipes. Savings can be effectively achieved by reducing the amount of energy needed to move water so it becomes necessary to consider the use of nearby water sources.

In contrast, the amount of energy used to collect wastewater is relatively small; however, more energy is used to process wastewater and sludge meaning energy savings opportunities. Organic matter and other contaminants included in wastewater contain chemical energy and have value as carbon neutral biomass. Energy used in cities is disposed of in wastewater as waste heat, but this energy can be used, for example, via heat pumps. Urban wastewater offers potential energy where it is produced and is attracting attention for its value as an untapped energy source that could be used for purposes like hydroelectric power generation as the wastewater is conveyed. The potential of wastewater as an energy source (chemical, thermal, and power) is yet to be exploited. The energy needed to remove BOD and, more recently, nitrogen in treating wastewater is increasing. Moreover, the energy value represented by the sludge produced from wastewater treatment is decreasing as biological treatments advance. Experiments aimed at substituting filtration for the removal of solids prior to biological processing are underway. The goals here are to promote the collection of sludge that offers a higher energy value because it has avoided biological treatment, and to decrease the organic matter burden of later biological treatment and, thereby, reduce the amount of energy needed for aeration. The anaerobic ammonium oxidation, or ANAMMOX process, removes nitrogen from ammonia and nitrate, replacing the nitrification and denitrification processes traditionally used, and hence significantly reduces aeration. Approaches that maximize the recovery of carbon neutral bio-solids as energy, while reducing the energy needed for aeration, are considered promising, as are the ANAMMOX process and other innovative nitrogen-removal technologies to reduce the amount of energy used for wastewater treatment. Further progress is needed through, for example, advances in the efficiency of energy inputs and recovery through more efficient sludge digestion, sludge dehydration/thickening technology, drying and incineration technology, and waste-to-energy conversion technology.

Urban water supply systems offer few opportunities for reducing the energy used in their artificial water cycles. Little can be achieved by conserving energy in the purification process alone, without changes in the way water is conveyed or by imposing reductions in amounts used, distances conveyed, and volume supplied. Supplementing the opportunities available for existing water supply and sewerage systems with the use of water reclamation and reuse would open the door to new possibilities for achieving improvements in both urban water quality and energy consumption (Fig. 4.10). In the recycling focused city presented in Fig. 4.10, urban wastewater would be a stable water source, would place supply and demand in close

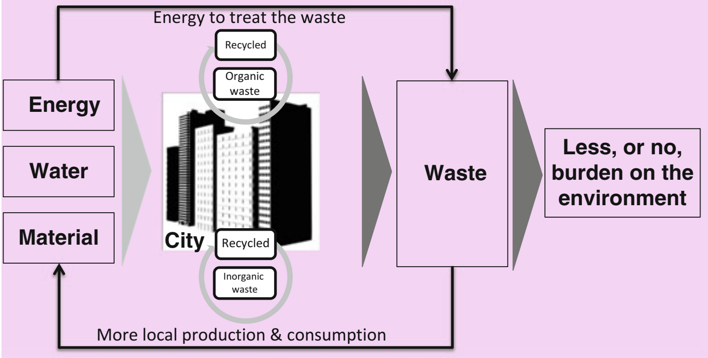

**Fig. 4.10** The metabolism of a recycling-oriented city

proximity to one another, and, as a form of recycling, would reduce the intake of water from, and discharge of wastewater to, natural water cycles including rivers. It thus offers possibilities for securing a water resource, and achieving reductions in both energy consumption and impacts on aquatic environments.

### *4.7.4 Moving from Treatment for Disposal, to the Recovery and Use of Water, Other Resources and Energy*

Collection capability characterizes and is a major asset of sewerage systems, and the extent to which the recovered product can be used is a key issue. There is a need for cities to effectively apply this collection capability to provide and systematically use the water, other resources, and energy that can be recovered from sewerage systems. Sewage treatment facilities can be built in central urban locations to systematically purify water, recover and recycle heat, and recover and use nutrients. Moreover, there are opportunities for upgrading sewerage systems to accept food and kitchen waste (processed separately from sewage to date) and to process it with wastewater in a unified biogas and biomass fuel production system. This system would use fuel cells to recover resources and energy, and would provide energy to cities and industry, and fertilizer to farms. Other possibilities include: supplying biomass—created by farms with fertilizer made with recovered phosphorous—to fuel heating and air conditioning systems; the use of cogeneration technology to promote the recovery of energy; and the recovery of heat from wastewater and treated sewage, and from the incineration of solid waste and sewage sludge. Biogas can be supplied as a fuel for use in automobiles and by gas systems. Water supply systems will have to be changed to reduce the amount of energy used to convey water concerning sources of water intake, intake locations, and the distribution and supply of drinking water.

The reuse of water, in particular, is now an important structural element for both wastewater and water resource management. Securing water resources is critical for meeting rising water demand in Asian megacities. Urban wastewater is available in relatively stable amounts and the ability to reuse it as an intra-city water resource is attractive. The reuse of wastewater would be an effective way to dramatically reduce the aquatic environmental impacts of wastewater discharges into surface water. Additionally, reclaimed wastewater could be used for a wide variety of purposes that do not require potable water (including irrigation and flushing toilets) to preserve supplies of drinking water.

## 4.8 Furthering Human Security Engineering from an Environmental Infrastructure Perspective

### *4.8.1 Solving Both Urban Water Cycle and Energy Problems by Reusing Wastewater*

The use of wastewater in underground sewerage networks would mean that the distances separating water demand and supply would be greatly reduced, yielding significant water conveyance energy savings. It is important to realize that of the water used in cities, very little is used for drinking and cooking; most is used for other domestic purposes, industrial applications, environmental maintenance, gardening, cleaning roads, and various other activities. Hence, different water needs can be met with varied water quality levels. The water supplied by water supply systems is all drinkable, but not all needs to be of such quality. Technologies for ensuring the safety and use of water for particular purposes are vital, and water-related pathogenic and chemical hazards can be risk-managed through the appropriate selection of applications and methods for reclaimed water.

The new water supply and sewerage systems making up urban water cycle systems will have to improve upon the energy consumption of existing systems, and be developed to meet future water demands and conditions for discharge into aquatic environments. Therefore, there is a current focus on the reuse of water within cities. One of the defining characteristics of twenty-first century urban water cycle systems will be the repeated reuse of water in urban areas (Fig. 4.11).

Since the volume of wastewater produced by a city does not change significantly, urban wastewater will probably play an important role in the future construction of urban water cycle systems. Advancing the use of reclaimed wastewater will reduce sewage treatment facility discharges into aquatic environments, preserve water resources, and lighten the impacts of urban wastewater on aquatic environments by reducing the volume of water taken in by water supply systems and restoring flow rates in rivers.

Using reclaimed urban wastewater will reduce the need to convey water, the volume of water requiring purification, and the volume of wastewater requiring treatment, producing related energy savings. However, water reclamation and reuse itself requires energy. Comparing the amount of energy consumed by traditional

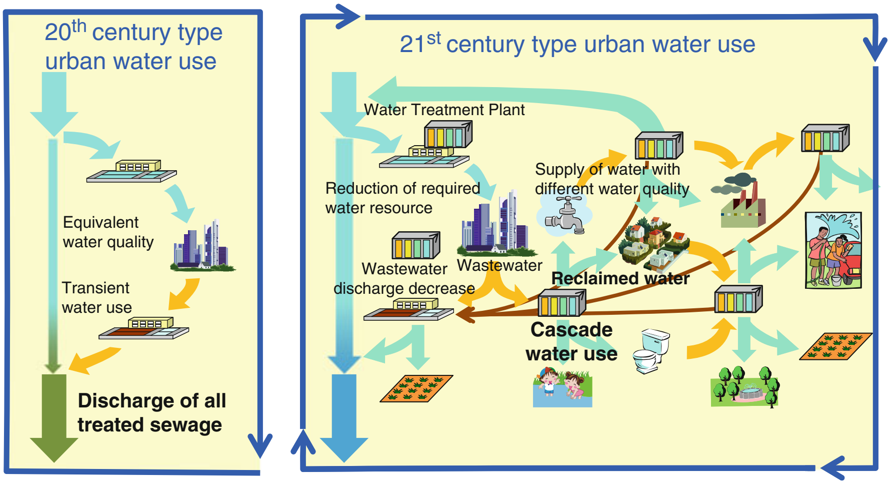

Fig. 4.11 Twenty-first century urban water cycle system (Tanaka 2009)

water supply and sewerage systems with that required for water reclamation and reuse will determine when it is appropriate to use reclaimed wastewater.

The use of reclaimed wastewater in an urban water cycle could have unforeseen impacts on urban ecosystems and human health, and studies should be undertaken to determine what these may include. Reclamation and reuse will reduce discharge volumes from sewage treatment facilities and this could change the quality of the sludge these facilities produce. In particular, it is expected that concentrations of organic material, nitrogen, and phosphorous will rise, and this would be one factor behind a change in the energy consumption of existing waste treatment facilities. Conversely, higher concentrations of organic material and phosphorous might contribute to higher energy and resource recovery efficiencies at sewage treatment facilities. Such efficiencies would emerge if these facilities prove able to make use of biomass, recover phosphorous, and engage in other exciting developments being proposed as new functions that sewage treatment facilities could perform in supporting sustainable societies. In view of the above discussion, the reuse of wastewater might be the key for water use systems that consume less energy.

### *4.8.2 Simultaneous Solutions for Rainwater Use and Runoff Problems*

Given the possibility of flood damage, rainwater should be removed rapidly. It is a hazard more for its volume than its quality, and is a readily accessible water resource that cities can use as drinking water with little processing. Rainwater is used for various purposes—including bathing, drinking, dishwashing, irrigation, and toilet flushing—in many places in the world. In developed countries with existing water infrastructure, however, rainwater is used only for non-drinking purposes such as irrigation, flushing toilets, laundering clothing, emergency purposes, fire prevention, and industrial processing.

Rainwater use is a sustainable technology that can be as simple as gathering rainwater from a roof and directing it into a storage tank for use in watering a garden, or it can be something more complex where rainwater is directed into a large tank for processing for indoor use.

The many benefits of using rainwater include:

- Minimizing the construction of storm-water drainage infrastructure to keep up with growing water demands and to remove rainwater (using rainwater supplements water supplies and reduces infrastructure maintenance expenditure).
- The energy needed to purify water for the water supply system, to process rainwater for disposal, and to operate pumps for both purposes can be saved (greenhouse gas emissions can be reduced).
- Rainwater can serve as an independent, water security guarantee for times of natural disaster.
- Using rainwater can reduce costs over the long term.
- Using rainwater can help to further the public good by providing green spaces, achieving awareness of water for public use, and promoting self-sufficiency.

It is important to use rainwater in accordance with the level of processing it has undergone. Water for irrigation, for example, need not be processed to drinking water standards, thus saving time, money, and energy. However, it is important to assure people that water for indoor use is processed sufficiently to allay health concerns.

The integrated management of urban rainwater is an attractive tool for dealing with runoff, securing resources and energy, and managing urban water quality.

### *4.8.3 Potential Risks of Recycling-Oriented Resource Use and Risk Reduction*

Reclaimed water requires technology for securing the safety and utility of water processed for particular uses, but it entails qualitative hazards—risks to human health and the environment—that can be managed by selecting the ways reclaimed water will be used. The identification, quantification, and evaluation of these risks falls into the area of health risk. Risk reduction technologies that enable the achievement of objectives with acceptable risk-levels will need to be selected. High levels of energy efficiency should be emphasized and the selection of risk reduction technologies should be based on a full consideration of the reliability of risk reduction technologies, costs, on-the-ground continuity and technology transferability, future substitutability, and other factors discussed in Sect. 4.4.

The selection of technologies appropriate for particular locations is critical when working with emerging or developing countries that have significant variations in social, economic, educational, and cultural backgrounds.

### *4.8.4 Co-Benefit Solutions: Urban Environmental, Energy, Disaster Readiness, and Governance Issues*

The limits to the resources that can be invested to solve health and environmental problems are becoming evident. Given these limitations, it has become necessary—in both research and practical settings—to consider co-benefit solutions that address environmental and energy issues, or environmental and disaster preparedness issues, for example, while responding to health risk problems. The field of human security engineering emphasizes step-by-step problem solving on the ground, and the evolution of problem-solving capabilities. It aims to develop human resources capable of exercising composite and comprehensive perspectives in solving environmental, energy, disaster preparedness, urban infrastructure, and urban governance problems, with limited energy, financial, human, and other resources.

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## References

Asian Development Bank (2007) Asian water development outlook 2007: achieving water security for Asia. Asian Development Bank Mandaluyong City 1550, Metro Manila, Philippines

Azuma T, Nakada N, Yamashita N, Tanaka H (2012) Synchronous dynamics of observed and predicted values of anti-influenza drugs in environmental waters during a seasonal influenza outbreak. Environ Sci Technol 46(23):12873–12881

Convention on Biological Diversity (2010) Global biodiversity outlook 3. Convention on Biological Diversity, Montréal

Fujiu K, Minamiyama M, Sugaya T, Hiraide R, Takahashi M, Morita H, Nakajima E, Yamagata H, Nakajima S (2006) Development of low-cost sewerage system for developing countries. Technical notes of the National Institute for Land and Infrastructure Management No. 318

Ghosh GC, Nakada N, Yamashita N, Tanaka H (2010a) Oseltamivir carboxylate—the active metabolite of oseltamivir phosphate (tamiflu): detected in sewage discharge and river water in Japan. Environ Health Perspect 118(1):103–107

Ghosh GC, Nakada N, Yamashita N, Tanaka H (2010b) Occurrence and fate of oseltamivir carboxylate (tamiflu) and amantadine in sewage treatment plants. Chemosphere 81(1):13–17

Ihara M, Ueyama T, Kim IH, Ogoshi M, Nishimura S, Miyamoto A, Tanaka H (2012) Energy consumption in water and wastewater systems and energy saving by wastewater reclamation and reuse. In: Proceedings of 2012 IWA world water congress on water, climate and energy, Busan, South Korea, 16–21 September 2012

Jobling S, Nolan M, Tyler CR, Brighty G, Sumpter JP (1998) Widespread sexual disruption in wild fish. Environ Sci Technol 32:2498–2506

Kenway SJ, Lant P, Priestley A (2009) Influence of urban water choices on energy use—who's responsibility is it? Paper presented at IWA water and energy 2009, Copenhagen, 29–31 October 2009

Kim IH, Yamashita N, Kato Y, Tanaka H (2009a) Discussion on the application of UV/$H_2O_2$, $O_3$ and $O_3$/UV processes as technologies for sewage reuse considering the removal of pharmaceuticals and personal care products. Water Sci Technol 59(5):945–955

Kim IH, Yamashita N, Tanaka H (2009b) Performance of UV and UV/$H_2O_2$ processes for the removal of pharmaceuticals detected in secondary effluent of sewage treatment plant in Japan. J Hazard Mater 166:1134–1140

Kumar V, Nakada N, Yasojima M, Yamashita N, Johnson AC, Tanaka H (2011) The arrival and discharge of conjugated estrogens from a range of different sewage treatment plants in the UK. Chemosphere 82(8):1124–1128

Tanaka H (2009) Niju Isseiki Toshi Taishakei to shite no Gesuido e no Kita, Shin-Toshi (Expectations for sewerage systems as 21st century urban metabolic systems, New Cities) 63(9):16–23

Ueyama T, Kim I, Mizukusa K, Yositani J, Ogoshi M, Tanaka H (2010) The present situation of energy consumption in the field of water supply and sewage in Japan. J EICA 15(2, 3):157–160

United Nations Environment Programme Global Environment Monitoring System (GEMS)/Water Programme (2008) Water quality for ecosystem and human health, 2nd edn. United Nations Environment Programme Global Environment Monitoring System (GEMS)/Water Programme. http://www.unep.org/gemswater/Portals/24154/publications/pdfs/water_quality_human_health.pdf. Accessed 20 February, 2014

WHO (1946) Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19–22 June 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948

WHO (2006) Preventing disease through healthy environments: towards an estimate of the environmental burden of disease. WHO. http://www.who.int/quantifying_ehimpacts/publications/preventingdisease.pdf?ua=1. Accessed 20 February, 2014

WHO (2009) Global health risks: mortality and burden of disease attributable to selected major risks. WHO. http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_Front.pdf. Accessed 20 February 2014

WHO/UNEP (2008) Health environment: managing the linkages for sustainable development. http://whqlibdoc.who.int/publications/2008/9789241563727_eng.pdf. Accessed 26 September 2013

WHO/UNICEF (2012) Joint monitoring programme for water supply and sanitation, 2012. Progress on drinking water and sanitation: 2012 Update. WHO/UNICEF. http://www.wssinfo.org/fileadmin/user_upload/resources/2012_Annual_Report_WHO-UNICEF_JMP_28Mar_e_version.pdf. 20 February 2014

2030 Water Resource Group (2009) Charting Our Water Future, Economic frameworks to inform decision-making. 2030 Water Resource Group. http://www.nestle.com/asset-library/documents/library/events/2009-2030-water-resources-group/charting_our_water_future_final.pdf. Accessed 20 February, 2014

# Chapter 5
# Integrated Disaster Risk Management from the Perspective of Human Security Engineering

**Hirokazu Tatano and Mamoru Yoshida**

**Abstract** There is an urgent need to establish integrated policies against natural disasters on a worldwide basis; however, there are various reasons, which prevent the society from taking decisive action. This chapter introduces the trend of recent natural disasters, and discusses a basic disaster risk management and governance framework from the perspective of human security engineering. It addresses the constituent elements of disaster risk, how human behaviors are related with natural disaster risks, and what types of policy measures are available for disaster risk management. In addition, it introduces the CAUSE model as a framework of disaster risk governance. In reality, there are frequent situations where it is unclear who manages disaster risk, to whom the disaster risk relates to, and what are the disaster risk problems faced by the stakeholders. Various roles of communication, which are placed in the central position of CAUSE model, are clarified and an explanation is provided on how this leads to a proper establishment of disaster risk governance among stakeholders.

**Keywords** CAUSE model • Disaster • Disaster risk governance • Disaster risk management • Risk communication

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## 5.1 Natural Disasters and Human Security

### *5.1.1 Global Natural Disasters Trends*

The United Nations defines a “great natural catastrophe” as having any one of, or a combination of, the following features: (1) inter-regional or international assistance is necessary; (2) fatalities number in the thousands; (3) tens of thousands have lost homes; (4) major economic losses have been incurred; and (5) major insured losses have been incurred. Figure 5.1 provides a breakdown of the great natural catastrophes from 1950–2011. A particularly striking feature is that annual great natural catastrophes numbers show an upward trend in the latter half of the twentieth century. Throughout the 1950s and 1960s, great natural catastrophes occurred at a rate of 2 or 3 years. This figure rises to an average of 4.8 years in the 1970s, 6.4 years in the 1980s, and 9.3 years in the 1990s, quadrupling over a 50-year period. The largest annual number of great natural catastrophes occurred in 1993, when there was only one geophysical event (earthquake, tsunami, volcanic eruption) and one climatological event (extreme temperature, drought, forest fire) but five meteorological events (storm) and eight hydrological events (flood, mass movement). In general, Fig. 5.1 depicts an upward trend in the number of weather-related catastrophes throughout the late twentieth century.

In the twenty-first century, however, Fig. 5.1 depicts an initial downward trend (an annual average of 3.7 in the first decade of the 2000s). In the first 10 years of the twenty-first century, the largest number of great natural catastrophes was recorded

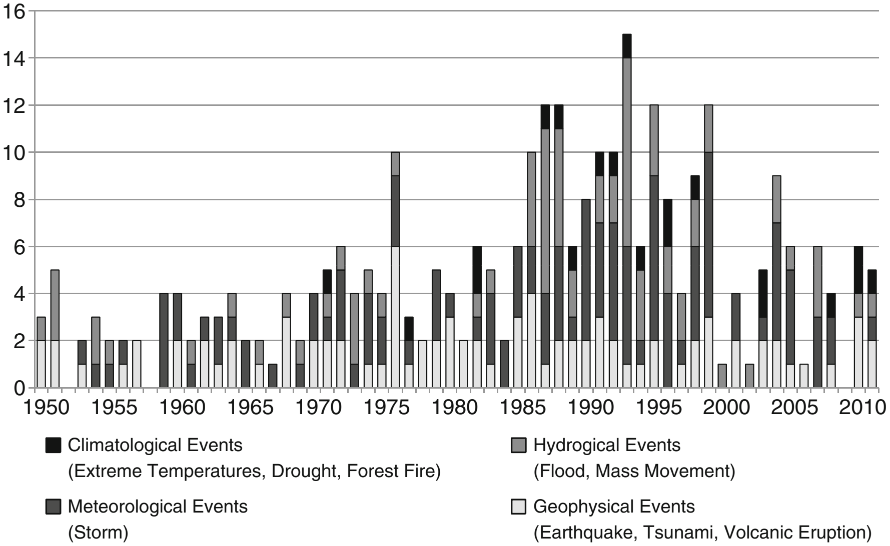

**Fig. 5.1** Natural catastrophes on a worldwide basis 1980–2011: number of events and trend (Munich Re 2012a)

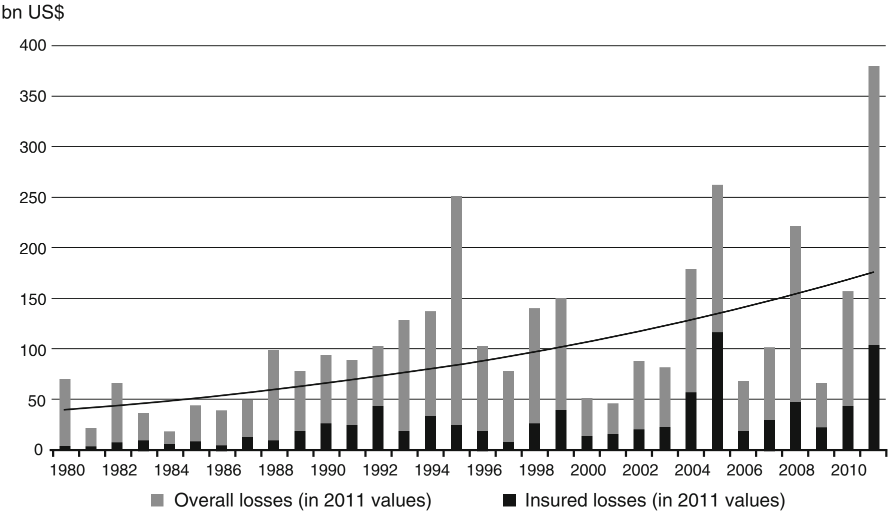

**Fig. 5.2** Worldwide natural catastrophes 1980–2011: overall and insured losses and trend (Munich Re 2012b)

in 2004, when there were two geophysical events, five meteorological events, and two hydrological events. This made 2004 another year where weather-related disasters accounted for a large proportion of the great natural catastrophes occurring in a year with a large number of events.

Damage cost data from great natural catastrophes, and the overall trend, is shown in Fig. 5.2; with both total losses and insured losses being provided in 2011 United States dollars (USD). In contrast with great natural catastrophes figures, data on losses reflect a continuous upward trend. Total losses for the 1990s exceed total losses for the 2000s. Since 2000, annual total losses exceed $100 billion USD on a regular basis: 2004 ($140 billion USD), 2005 ($205 billion USD), 2008 ($155 billion USD), and 2011 ($285 billion USD), or about once every three years. Strikingly, throughout the entire twentieth century this threshold was breached only once, in 1995.

Particularly large insured losses were recorded in 2004, 2005, and 2011. Hurricane Katrina struck in 2005, resulting in insurance payments of an estimated $100 billion USD (¥8 trillion Japanese Yen (JPY)), and 2011 saw major earthquakes in Haiti and New Zealand, and the Great East Japan Earthquake. The latter three disasters resulted in insurance payments totaling an estimated $60 billion USD, $35–40 billion of which was attributable to the Great East Japan Earthquake alone.

Japan saw significant wind and water damage in 2004 as ten typhoons struck in that year. Torrential rains hit Niigata, Fukushima, and Fukui Prefectures in July 2004 causing major damage. Starting on the night of July 12 and continuing through the following day, extremely heavy rains fell in the Chuetsu region of Niigata Prefecture and the Aizu region of Fukushima Prefecture. The city of Tochio and the village of Shitada, both in Niigata, recorded total rainfall in excess of 400 mm during that period. Dikes burst in 11 places along the Ikarashi and Kariya Rivers, in the Shinano River Basin, and the Nakanoshima River as a result of the heavy rainfall. Flood damage occurred across a wide area, mainly in Sanjo City in the Ikarashi River Basin, and the town of Nakanoshima in the Kariya River Basin, but also in the cities of Nagaoka and Mitsuke. Sixteen people were killed, and many structures were either completely (70) or partially (5,354) destroyed. Later that year, typhoons (known locally as Typhoon No. 18 and Typhoon No. 21) in September, and Typhoon No. 23 in October brought destruction to Tokushima, Kagawa, and Miyazaki Prefectures, and other parts of both western and eastern Japan. These typhoons killed 95, left three missing, injured 552, and resulted in total damage of around ¥771 billion JPY ($10 billion USD). In total, Japan suffered flood damage exceeding ¥2 trillion JPY ($26 billion USD) during 2004. Furthermore, Japan suffered a major earthquake in October 2004 in the Chuetsu area of Niigata Prefecture. That catastrophe killed 68, injured 4,805, left thousands of structures completely (3,175) or partially (13,810) destroyed, or with relatively minor damage (105,682), and caused total estimated damages of around ¥3 trillion JPY ($40 billion USD). Elsewhere, in August and September the southern United States was hit by three hurricanes, Charley, Frances, and, the most serious, Ivan, which killed 125 and caused damages of approximately $23 billion USD (¥2 trillion JPY). On December 26, 2004 the Indonesian island of Sumatra was struck by a magnitude 9.1 earthquake. One of the largest earthquakes to have occurred in this century, it gave rise to a tsunami that took approximately 220,000 lives in Sri Lanka, Indonesia, Thailand, and elsewhere along the Indian Ocean coastline. Costs from that catastrophe were estimated at around $10 billion USD (¥800 billion JPY). Insurance payments for all catastrophes occurring in 2004 are estimated to have reached as much as $50 USD billion (¥4 trillion JPY).

Table 5.1 presents a list of the ten catastrophes causing the most fatalities in 1980–2011. Ranking first is the 2011 earthquake in Haiti that sadly took 222,570 lives. The second most deadly catastrophe was the 2004 Indian Ocean tsunami (caused by the Sumatra–Andaman earthquake) that killed 220,000. Cyclone Nargis, which killed 140,000 when it struck Myanmar (Burma) in 2008, ranks third. A cyclone that killed 139,000 in Bangladesh in 1991 ranks fourth. The earthquake in the Indian state of Gujarat in 2005 that killed 88,000 ranks fifth. The 2008 earthquake in Sichuan, China where 84,000 perished, ranks sixth. Notably, the events ranked second through sixth occurred in Asia, and the five most deadly catastrophes all took place in developing countries.

Table 5.1 clearly shows that disasters that occurred in Asian cities with large populations produced large numbers of fatalities. In contrast, all of the top ten catastrophes ranked financially, mainly occurred in the United States, Japan, or China (Table 5.2). This illustrates that catastrophes occurring in areas with concentrations of industry and assets can have considerable financial repercussions.

The extent of insurance cover differs depending on the degree of casualty insurance adoption. Table 5.3 shows the ten most costly catastrophes in terms of insured losses over the period 1980–2011. Of the ten events shown, seven occurred in the United States. The others all occurred in 2011, including the Great East Japan

**Table 5.1** Significant natural catastrophes 1980–2012: ten deadliest worldwide events (Munich Re 2013)

| Period | Event | Affected area | Overall losses | Insured losses | Estimated fatalities |
|---|---|---|---|---|---|
| | | | USD m, original values | | |
| 12.1.2010 | Earthquake | Haiti: Port-au-Prince, Petionville, Jacmel, Carrefour, Leogane, Petit Goave, Gressier | 8,000 | 200 | 222,570 |
| 26.12.2004 | Earthquake, tsunami | Sri Lanka, Indonesia, Thailand, India, Bangladesh, Myanmar (Burma), Maldives, Malaysia | 11,200 | 1,000 | 220,000 |
| 2–5.5.2008 | Cyclone Nargis, storm surge | Myanmar (Burma): Ayeyawaddy, Yangon, Bugalay, Rangun, Irrawaddy, Bago, Karen, Mon, Laputta, Haing Kyi | 4,000 | | 140,000 |
| 29–30.4.1991 | Tropical cyclone, storm surge | Bangladesh: Gulf of Bengal, Cox's Bazar, Chittagong, Bola, Noakhali districts, esp. Kutubdia | 3,000 | 100 | 139,000 |
| 8.10.2005 | Earthquake | Pakistan, India, Afghanistan | 5,200 | 5 | 88,000 |
| 12.5.2008 | Earthquake | China: Sichuan, Mianyang, Beichuan, Wenchuan, Shifang, Chengdu, Guangyuan, Ngawa, Ya'an | 85,000 | 300 | 84,000 |
| July–Aug 2003 | Heat wave, drought | France, Germany, Italy, Portugal, Romania, Spain, United Kingdom | 13,800 | 1,120 | 70,000 |
| July–Sept 2010 | Heat wave | Russian Federation: Moscow region, Kolomna, Mokhovoye | 400 | | 56,000 |
| 20.6.1990 | Earthquake | Iran: Caspian Sea, Gilan province, Manjil, Rudbar; Zanjan, Safid, Qazvin | 7,100 | 100 | 40,000 |
| 26.12.2003 | Earthquake | Iran: Bam | 500 | 19 | 26,200 |

**Table 5.2** Significant natural catastrophes 1980–2012: ten costliest worldwide events (Munich Re 2013)

| Period | Event | Affected area | Overall losses | Insured losses | Estimated fatalities |
|---|---|---|---|---|---|
| | | | USD m, original values | | |
| 11.3.2011 | Earthquake, tsunami | Japan: Honshu, Aomori, Tohoku; Miyagi, Sendai; Fukushima, Mito; Ibaraki; Tochigi, Utsunomiya | 210,000 | 40,000 | 15,840 |
| 25–30.8.2005 | Hurricane Katrina, storm surge | United States: LA, New Orleans, Slidell; MS, Biloxi, Pascagoula, Waveland, Gulfport | 125,000 | 62,200 | 1,322 |
| 17.1.1995 | Earthquake | Japan: Hyogo, Kobe, Osaka, Kyoto | 100,000 | 3,000 | 6,430 |
| 12.5.2008 | Earthquake | China: Sichuan, Mianyang, Beichuan, Wenchuan, Shifang, Chengdu, Guangyuan, Ngawa, Ya'an | 85,000 | 300 | 84,000 |
| 24–31.10.2012 | Hurricane Sandy, storm surge | Bahamas, Cuba, Dominican Republic, Haiti, Jamaica, United States, Puerto Rico, Canada | 65,000 | 30,000 | 210 |
| 17.1.1994 | Earthquake | United States: California, Northridge, Los Angeles, San Fernando Valley, Ventura, Orange | 44,000 | 15,300 | 61 |
| 1.8–15.11.2011 | Floods | Thailand: Phichit, Nakhon Sawan, Phra Nakhon Si Ayuttaya, Pathumthani, Nonthaburi, Bangkok | 43,000 | 16,000 | 813 |
| 6–14.9.2008 | Hurricane Ike | Cuba, Haiti, Dominican Republic, Turks and Caicos Islands, Bahamas, United States | 38,000 | 18,500 | 170 |
| May–Sept 1998 | Floods | China: Jangtsekiang, Songhua Jiang | 30,700 | 1,000 | 4,159 |
| 27.2.2010 | Earthquake, tsunami | Chile: Bió Bió, Concepción, Talcahuano, Coronel, Dichato, Chillán; Del Maule, Talca, Curicó | 30,000 | 8,000 | 520 |

**Table 5.3** Significant natural catastrophes 1980–2012: ten costliest events worldwide by insured losses (Munich Re 2013)

| Period | Event | Affected area | Overall losses | Insured losses | Estimated fatalities |
|---|---|---|---|---|---|
| | | | USD m, original values | | |
| 25–30.8.2005 | Hurricane Katrina, storm surge | United States: LA, New Orleans, Slidell; MS, Biloxi, Pascagoula, Waveland, Gulfport | 125,000 | 62,200 | 1,322 |
| 11.3.2011 | Earthquake, tsunami | Japan: Honshu, Aomori, Tohoku; Miyagi, Sendai; Fukushima, Mito; Ibaraki; Tochigi, Utsunomiya | 210,000 | 40,000 | 15,840 |
| 24–31.10.2012 | Hurricane Sandy, storm surge | Bahamas, Cuba, Dominican Republic, Haiti, Jamaica, Puerto Rico, United States, Canada | 65,000 | 30,000 | 210 |
| 6–14.9.2008 | Hurricane Ike | United States, Cuba, Haiti, Dominican Republic, Turks and Caicos Islands, Bahamas | 38,000 | 18,500 | 170 |
| 23–27.8.1992 | Hurricane Andrew | United States: FL, Homestead; LA; Bahamas | 26,500 | 17,000 | 62 |
| 1.8–15.11.2011 | Floods | Thailand: Phichit, Nakhon Sawan, Phra Nakhon Si Ayuttaya, Pathumthani, Nonthaburi, Bangkok | 43,000 | 16,000 | 813 |
| June–Sept 2012 | Drought, heat wave | United States: Midwest | 20,000 | 15,000–17,000 | 100 |
| 17.1.1994 | Earthquake | United States: California, Northridge, Los Angeles, San Fernando Valley, Ventura, Orange | 44,000 | 15,300 | 61 |
| 7–21.9.2004 | Hurricane Ivan | United States, Caribbean, Venezuela, Colombia, Mexico | 23,000 | 13,800 | 120 |
| 22.2.2011 | Earthquake | New Zealand: South Island, Canterbury, Christchurch, Lyttelton | 16,000 | 13,000 | 185 |

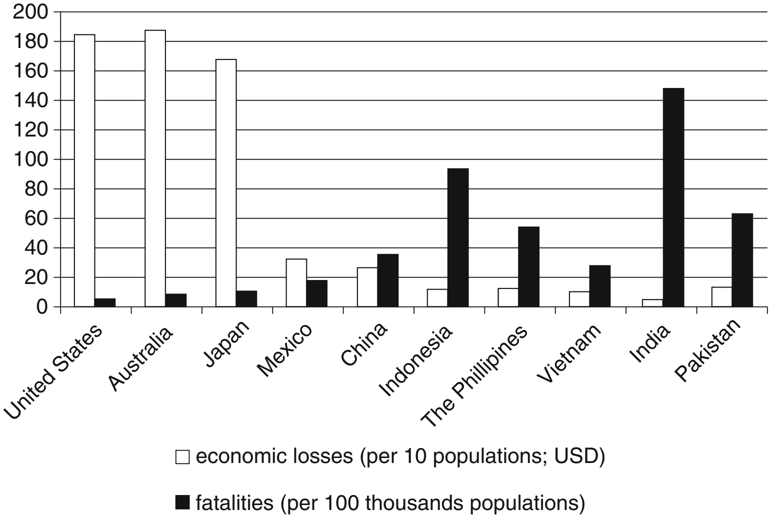

**Fig. 5.3** Relationship between economic losses and fatalities 1960–2010 (Hayashi 2012)

Earthquake, the New Zealand earthquake, and flooding in Thailand. Approximately 80 % of earthquake losses in New Zealand, and one third to a half of disaster losses in the United States, were covered by insurance. In contrast, insurance covered only a sixth of Great East Japan Earthquake losses, and a quarter of the flood losses in Thailand.

Figure 5.3 graphs the data on economic losses and fatalities in the countries with the greatest cumulative numbers of natural catastrophes 1960–2010 (Hayashi 2012). Countries are presented in diminishing order of per capita gross domestic product (GDP). India, Indonesia, and other countries with relatively low per capita GDP have extremely high human losses, compared with countries with higher per capita GDP figures. Countries with relatively high per capita GDP such as the United States and Japan have low human losses and extremely high economic losses.

The question arises as to the significance of these tendencies. To answer this it is useful to examine the mechanism by which disasters occur. Figure 5.4 shows how the mechanism underlying the occurrence of disasters is controlled by various factors. The hazards are the earthquakes, typhoons, torrential rainstorms, and other natural phenomena that give rise to disasters. In most cases, these are out of the direct control of people. However, the emergence of a hazard does not directly result in a disaster. If, for example, a typhoon forms in the tropics and does not pass through a concentrated area of assets and people, it will not result in a disaster regardless of how large the typhoon is. For a disaster to occur there must be not only the natural phenomenon that is a hazard but also a population and/or assets that will be exposed to the hazard and vulnerability of the population and/or assets to the hazard. The condition of a population or assets being threatened by a hazard is

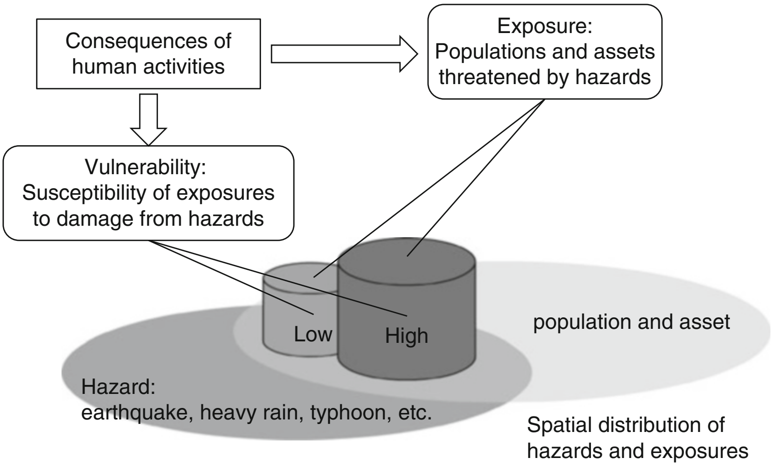

**Fig. 5.4** Disaster risk elements (Hazards, Exposure, Vulnerability)

referred to as "exposure." The susceptibility of individual exposures to damage from a hazard is referred to as "vulnerability." It is generally difficult to control the emergence of hazards hence people go about their daily lives under the threat of hazards. However, the degree to which populations and assets are allocated or concentrated in cities is the result of the economic and social activities of people.

The high per-capita-GDP countries shown in Fig. 5.3—in particular, those that have made the most progress in asset accumulation and, therefore, have high exposure—have suffered high economic losses yet have achieved some degree of success in mitigating human losses. The low per-capita-GDP countries, in contrast, have had relatively low asset exposure and, therefore, have suffered relatively low economic damage. Their human exposure, however, has been high and unfortunately their human losses great.

Humans can affect the degree to which exposures are vulnerable. The emergence of disasters and the degrees of damage associated with them, therefore, are dependent upon human behaviors. Hence, humans must go about their daily lives facing the threats of hazards by exercising appropriate risk management.

## *5.1.2 Features of Disasters in Asia*

Disasters across the globe differ when viewed on a regional basis. Figure 5.5 is based on data from the EM-DAT international disaster database created by the Centre for Research on the Epidemiology of Disasters at the Université Catholique de Louvain in Belgium. It shows how different regions of the world compare to one another in terms of numbers of disasters, disaster fatalities, disaster victims, and economic losses from disasters between 1950−2011. For inclusion a disaster must have met any of the following criteria: (1) ten or more people reported killed; (2) one hundred or more people reported affected; (3) declaration of a state of

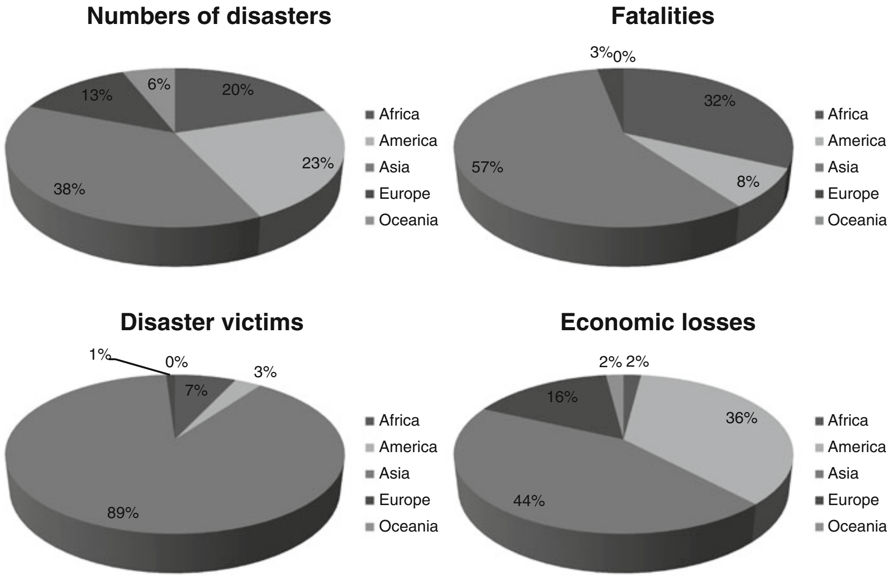

**Fig. 5.5** Regional breakdown of global disaster data (1950–2011)

emergency; and (4) call for international assistance. Figure 5.5 shows that data on numbers of disasters do not distinguish the various regions of the world in any significant way, while the other data do. Just over half of the fatalities and economic losses, for example, occurred in Asia where 89 % of disaster victims were located. Why have the impacts of disasters concentrated in Asia? Moreover, will this continue to be the case in the future?

The graphs presented in Fig. 5.6 show trends in urban and rural population growth by region. The vertical axis of each graph represents population (in millions) while the horizontal axis represents time. As is evident from these graphs, populations (and therefore assets) are projected to continue migrating to cities throughout the world. This trend is particularly strong in Asia, where urban populations in China, India, and Indonesia are forecast to continue growing over the next 30 years. The extent to which disaster risk can be mitigated as development proceeds, therefore, will be critical. Ongoing urban development will expose increasing numbers of people and assets to the threats of disasters. It will become critical, therefore, to reduce the disaster vulnerability of growing populations and asset stocks, so that the concentration of people and assets in urban environments does not result in greater disaster risk.

In Asia, urban dwellers made up 52 % of the total population in 2011. While Asia is not necessarily more urbanized than other regions of the world, six of the world's ten largest cities by population are located there. Table 5.4 shows that all of the world's ten largest cities are exposed to multiple natural disaster threat types.

If the speed of population growth exceeds the rate at which government and the private sector provide the infrastructure and accommodation needed for daily

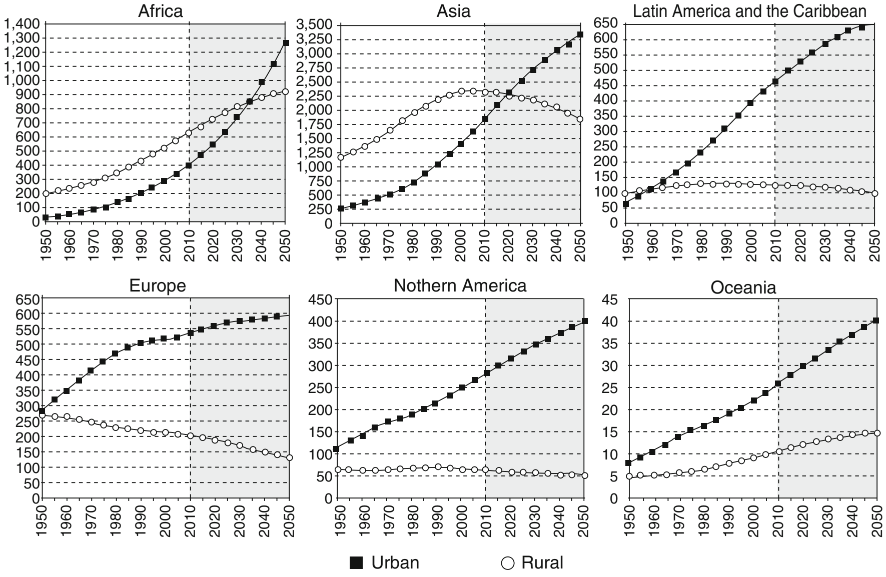

**Fig. 5.6** Urban and rural population by major regions, 1950–2050 (million) (United Nations Department of Economic and Social Affairs/Population Division 2012)

**Table 5.4** World's ten largest cities by population and the natural disaster threats to which they are exposed (Chafe 2007)

| | | Disaster risk | | | | | |
|---|---|---|---|---|---|---|---|
| City | Population (million) | Earthquake | Volcano | Storms | Tornado | Flood | Storm Surge |
| Tokyo | 35.2 | × | | × | × | × | × |
| Mexico City | 19.4 | × | × | × | | | |
| New York | 18.7 | × | | × | | | × |
| São Paulo | 18.3 | | | × | | × | |
| Mumbai | 18.2 | × | | × | | × | × |
| Delhi | 15.0 | × | | × | | × | |
| Shanghai | 14.5 | × | | × | | × | × |
| Kolkata | 14.3 | × | | × | × | × | × |
| Jakarta | 13.2 | × | | | | × | |
| Buenos Aires | 12.6 | | | × | | × | × |

life, slum areas grow at explosive rates. The meaning of the term "slum" varies across the world; however, the UN-Habitat (2003) considers the following to be features of "slums":

- Inadequate access to safe water;
- Inadequate access to sanitation and other infrastructure;
- Poor structural quality of housing;
- Overcrowding;
- Insecure residential status.

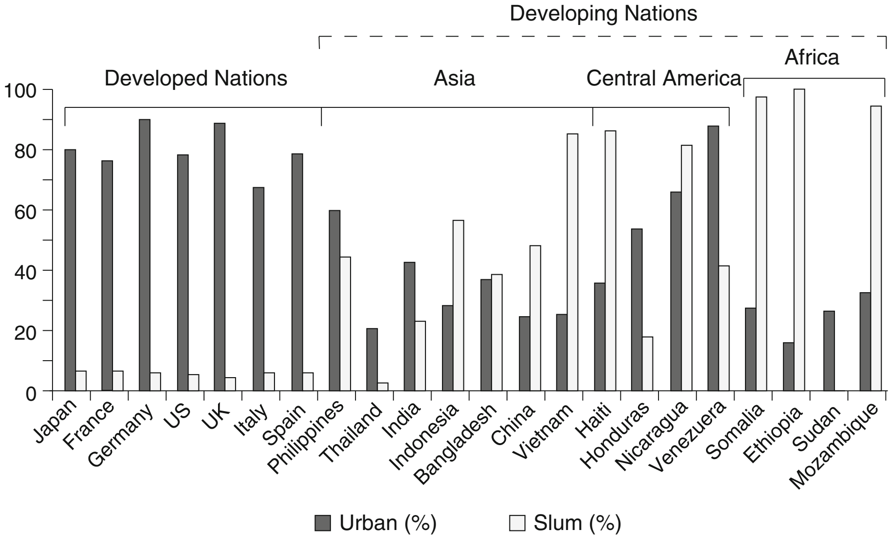

**Fig. 5.7** The urban/slum population ratio in selected countries (Adikari et al. 2010)

Figure 5.7 shows national urban dwelling percentages and the percentage of urban populations made up by slum area inhabitants. While slum populations comprise 6 % or less of urban populations in developed countries, they account for more than half of the urban populations in many developing countries. The percentages of urban slum dwellers in Asian cities are relatively low compared with Central American and African countries, however they account for approximately half of the urban populations of India, the Philippines, and Vietnam.

Figure 5.8 shows the population trend in slum areas as a percentage of urban populations, and Fig. 5.9 shows the population number trend in slum areas in Asian countries. Figure 5.8 implies that the overall percent of those living in slum areas is decreasing in Asian countries. However, most countries show a flat or slightly increasing total slum area population number, except India that exhibits a slightly decreasing trend.

It is essential to establish policies to decrease the total numbers living in slum areas. It is indisputable that people living in slum areas are highly vulnerable to disasters and face various risks on a daily basis.

### *5.1.3 Disaster Risk Management in Mumbai*

The city of Mumbai is the capital city of the Indian state of Maharashtra and is composed of Mumbai City district and Mumbai Suburban district. Both districts are principally governed by the Municipal Corporation of Greater Mumbai (MCGM). Mumbai yields 5 % of India's GDP and 25 % of its tax revenues. The majority of its average annual rainfall of 2,050 mm is concentrated in the monsoon season,

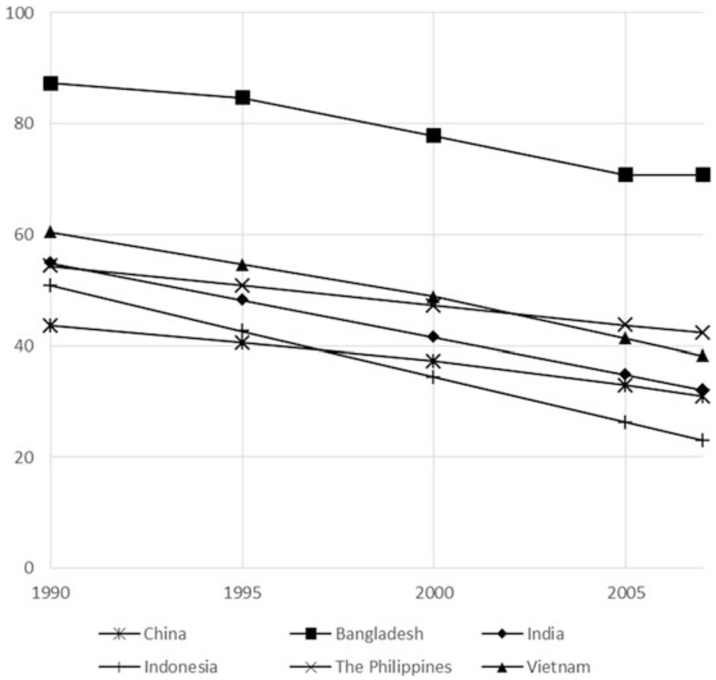

**Fig. 5.8** Slum population trends as percentages of urban populations in Asian Countries, 1990–2007 (UN-Habitat 2010)

June–October (Gupta 2007). A torrential rainstorm that erupted in July 2005 dumped 944 mm of rain in 24 h, causing flooding and landslides that killed 419 people. A further 216 lives were lost to infectious diseases and other disaster-related causes (Government of Maharashtra 2006). Moreover, the storm completely destroyed 100,000 homes and businesses, and submerged 30,000 vehicles. Most of the deaths were in slum areas.

Mumbai has several slums including Dharavi—Asia's largest slum—within its borders. Dharavi covers an area of approximately 2 km$^2$ and is home to more than 600,000 people. Water supplies are limited and public toilets are often in short supply, not only in Dharavi but also in other slums. Bordered on one side by the Mithi River and given the additional problems associated with the sewage system and its management, Dharavi is extremely vulnerable to flooding during the monsoon season.

In the eighteen century, Dharavi was an island. The area was mostly mangrove swamp inhabited by fishermen. This disappeared when the swamps were filled up and the separate islands became one landmass, leading to the creation of Bombay, now Mumbai. This caused the creek to dry up, thus depriving Dharavi of fish, its traditional resource. The newly filled marshes provided space for migrants; eventually resulting in the development of slum. Migrants came from various parts of

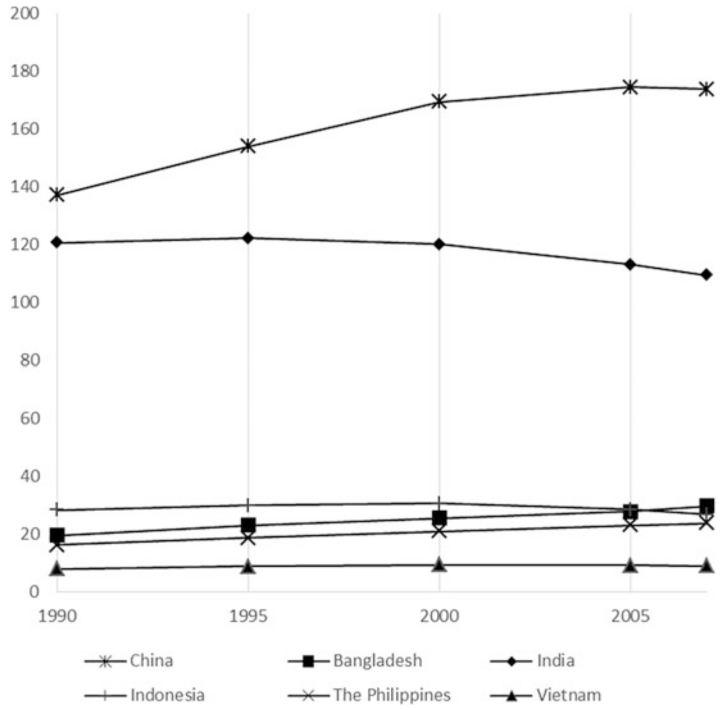

**Fig. 5.9** Total population number trends in slum areas in Asian Countries, 1990–2007 (UN-Habitat 2010)

India, formed their own communities, and began to engage in different types of economic activities. For example, the Gujarat community made ceramic goods with clay from the surrounding area. Dharavi is now home to not only ceramic manufacturing but also garbage recycling, bread baking and sales, apparel processing, leather processing, and other businesses. Annual gross profits generated in the area are said to be as high as $500 million USD (Apte 2011). This slum, therefore, is making a relatively significant contribution to Mumbai's economy and is strongly connected to its industrial output. Figure 5.10 shows the current area of Dharavi, in which slum is formed.

Figure 5.11 below shows an open sewer in Dharavi. The obstruction of its flow by the dumping of garbage increases vulnerability to flood damage. Mumbai city authorities work to mitigate this vulnerability by cleaning open sewers before the monsoon season.

MCGM has a disaster management department that engages in various activities to deal with disaster potentials. Following the flood damage experienced in 2005, the department's functions were greatly expanded. In Mumbai, many homes are situated in close proximity to cliff edges at risk of collapse. Use of these structures is not permitted during the monsoon season and the city government directs people to evacuate or take other action, as necessary. Information on inundation and other

**Fig. 5.10** The area surrounded by the dotted line shows Dharavi (Mumbai, India). The Mithi River can be seen at the top of the photo. ©2010 Europa Technologies; ©2010 Google Image; ©2010 GeoEye

**Fig. 5.11** Open sewer in Dharavi slum, Mumbai, India: Garbage has been dumped and is accumulating in open sewers close to residences. Sludge accumulates in low areas and gives rise to foul odors

flooding-related problems is reported to a control center by telephone or wireless technology and hence acted on. Unfortunately, in the flood of 2005 power outages and other problems interfered with efforts to provide information to help people to evacuate. This situation undeniably exacerbated the damage suffered; however, the degree of human losses was not disproportionate to the scale of the disaster. Weather warning, evacuation, and other systems are inadequate compared with those being used in countries such as Japan, and physical conditions make it difficult to implement evacuations. Slums are extremely short of open space. Buildings and other locations that could be used as evacuation sites have not been designated as such, except for local government offices, meaning that there are no adequate systems are in place for smooth evacuations.

Following the flood damage of 2005, the government of the state of Maharashtra established a fact-finding committee that introduced 20 recommendations (Apte 2011). The most important of these included: (1) improvement of deteriorating rivers and dikes; (2) preservation of lakes and mangroves; (3) improvement of solid waste processing systems; (4) improvement of the environmental management system; (5) repair of the wastewater system; and (6) strengthening of governmental organizations in charge of disaster management.

The disaster risk management problems faced by developing countries, particularly those in Asia, include as primary examples: (1) discrepancies in the speed with which large cities take shape and progress in construction of infrastructure; (2) insufficient water supply, garbage disposal, and wastewater systems; (3) weak disaster preparedness/response systems; and (4) municipal governance problems. These problems reflect the central issues of the four specialized areas of human security engineering: (1) municipal governance; (2) municipal infrastructure management; (3) health risk management; and (4) disaster risk management. Focusing solely on disaster phenomena does not adequately address the emerging issue of disaster risk management in Asian megacities. These problems must be addressed through a comprehensive knowledge of a city's systems and through taking appropriate action on their planning and management of these systems.

## 5.2 Disaster Risk Management in Relation to Human Security

### *5.2.1 The Process by Which Human and Livelihood Vulnerability Takes Shape*

Okada (2004), in proposing a similar model to Fig. 5.12, views cities as organisms and considers urban community life and production activities to be a layered structure. The base of the structure is formed by the natural environment. Overlaid on this are social schemes, culture and convention, followed by infrastructure, followed in turn by land use and the built environment that supports life in communities.

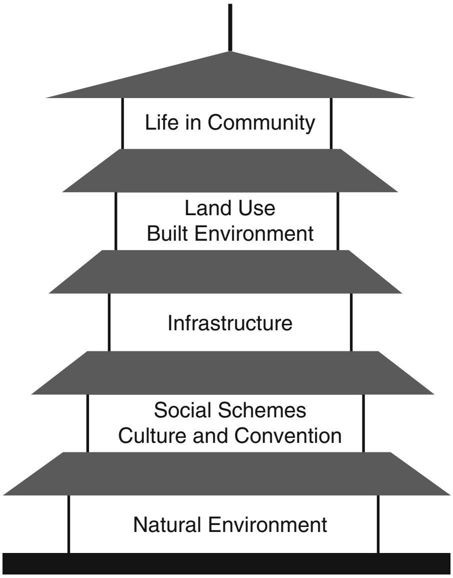

**Fig. 5.12** Cities as organisms (Okada 2004)

The higher the level, the faster the rate of change within this configuration, and the lower the level, the slower the rate of change. Activities at certain levels, therefore, are constrained by conditions at lower levels that thus prove to be decision preconditions for activities at the higher level. Specifically, the lower levels act as a foundation enabling activities at the higher level. Figure 5.12 shows that the natural environment, followed by social schemes, culture and convention, and infrastructure, are all preconditions for selecting locations for companies and households.

This model can be applied in a disaster context. It illustrates that the population and assets (built environment and infrastructure) that would be exposed to a disaster have an interdependent relationship with the more slowly changing social schemes, culture and convention, and natural environment. Two factors lead to the emergence of cities vulnerable to disasters: (1) social schemes, culture and convention—including, for example, racial prejudice and caste systems—as remote factors causing people to live in areas vulnerable to disasters, and (2) slums formed as a result of the inability to provide infrastructure and land quickly enough to match the rapid population growth being driven by sudden inflows of people from rural areas. From this perspective, Fig. 5.8, when applied to the context of disasters, simultaneously explains the formation of vulnerability to disasters.

Further considering this concept, the degree to which populations and assets subject to disaster threats (hazards) can be easily damaged (exposure) has been defined as vulnerability. In the context of Fig. 5.12, community life (life), the built environment, and social infrastructure are factors determining the extent of damage because of a disaster threat (hazard).

Wisner et al. (2003) defined vulnerability as the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of natural hazard. They advocate that the technical term “vulnerability” should be used with respect to people and the area where they live, and that “unsafe” should be used with respect to, for example, structures, specific places where people live, and public structures. This position is advanced because Wisner et al. focus on people. In this book, the term “vulnerability” is used to discuss the susceptibility of assets to damage in addition to in reference to people. It is necessary to avoid underestimating the value of projects that help to improve human conditions and possibilities for restoring livelihoods when evaluating those projects for their ability to mitigate asset damage.

Humans can control vulnerability and exposure in the disaster risks shown in Fig. 5.4. However, in situations with a short-term perspective, during which there will be no major changes in population or assets, exposure is treated as a given and the discussion focuses how the project at hand will affect vulnerability only. This is the perspective of project evaluations that focus on the degree to which expected damage has been mitigated. From the perspective of individual people, however, this view focuses on only one aspect of disaster impacts. The case study below emphasizes the need to be aware that the disaster damage suffered by poor people, while small from an overall perspective may be serious and long lasting from an individual perspective.

### Column 3: How Wealth or Access to Resources Affects Damages from Disasters?

Wisner et al. (2003) referenced an account given by Winchester (1986), Winchester (1992) of the different impacts of a disaster on the wealthy and the poor, summarized here.

Cyclones in the Bay of Bengal periodically move across the coast and strike low-lying ground in Andhra Pradesh (southeast India). They sometimes cause serious losses of lives and properties, and disrupt agriculture for months or even years afterwards. The damage is done by very high winds, often causing a storm-surge, followed by prolonged torrential rain. Winchester actually compared the impacts of cyclone damage on two families—a wealthy one and a poor one—living only 100 m a part.

The wealthy family has six members and lives in a brick house. They own six head of cattle and one hectare of fertile rice paddies. The male head of the household owns a truck and runs a business handling grain. The poor family lives in a thatch-roofed hut, and owns one male draught ox and one ox calf. They have a quarter hectare of poor, non-irrigated farmland, and sharecrop on another quarter hectare of land. The poor family is composed of a husband and wife and two children aged five and two. To feed their family, the husband and wife must spend a part of each year working as agricultural laborers. When the wealthy family heard on their radio that a cyclone was approaching in their direction, they loaded their household goods and tools

(continued)

**Column 3:** (continued)

into the truck and evacuated to a safe area. The storm surge destroyed part of their house and strong winds tore off the roof. Three of their cattle drowned, their land was flooded and their crops destroyed. The poor family's home was completely destroyed, the two-year-old child drowned, the family's land was flooded, the oxen drowned and the crops were destroyed.

After the cyclone, the wealthy family returned and used savings from their farming and grain businesses to rebuild their house within a week. They replaced the cattle they had lost, waited for the flood waters to recede, plowed their field and replanted their crops. The poor family's losses were insignificant in terms of monetary value and quantity, but having no savings they could not afford to rebuild their home, which would cost 5 % of what the wealthy family spent on home reconstruction. Their most pressing need being a place to live, the poor family was forced to reconstruct their home with money borrowed at an extortionately high interest rate from a moneylender in the village. Short of money, the poor family was unable to purchase an ox necessary for farm work, and only just managed to acquire a calf. They needed to rent an ox for farm work, but because demand for draught animals was high and they were late in looking, they were ultimately unable to find an animal to rent. The end result was that the poor family, in addition to the sorrow of losing a child, endured eight months of hunger following the cyclone (Rahmato 1998).

Wisner et al. described this example and suggested a generalized negative association between wealth and damage, and indicated how social systems create the conditions in which hazards have differential impacts on various societies and different groups within society. They pointed out that how access to resources, including information, cash, rights to the means of production, tools and equipment, and the social networks, vary between households and what is the significance of this for potential loss and rate of recovery.

The example illustrates that vulnerability to disasters is not simply a matter of the robustness of the people or property that are exposed. Here, the opportunity to practice an occupation was stolen by a disaster, which disrupted the normal harvest, creating a situation of extended food shortage.

When examining the disaster vulnerability of a particular area to make recommendations for improving the situation, it is important to identify and assess the seriousness of vulnerabilities and critical to determine how the vulnerabilities took shape, what the root causes are, and how they gave rise to hazardous conditions.

Wisner et al. (2003) proposed the Pressure and Release (PAR) model as a way for showing how vulnerability develops.

Figure 5.13 shows how unsafe conditions take shape (the progression of vulnerability). Wisner et al. consider that disaster risk is determined by hazards and

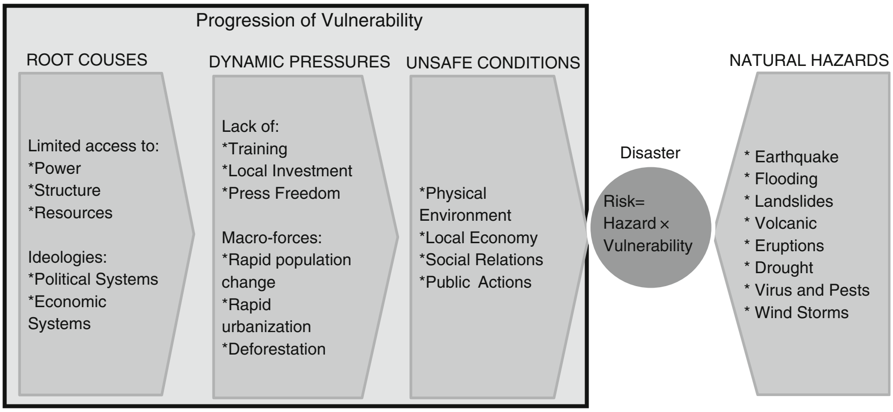

**Fig. 5.13** Pressure and Release (PAR) model (Wisner et al. 2003)

vulnerabilities: it is important to remember here that exposure is a constituent element of vulnerability. Vulnerability develops from limited access to power, structures, and resources, and from ideologies manifested in political and economic systems, as root causes. Dynamic pressures develop from insufficient training, local investment, and press freedom, and from macro forces exerted through, for example, rapid population change, rapid urbanization, and deforestation. Unsafe conditions are created in the physical environment, the local economy, social relations, and public actions. These root causes, dynamic pressures, and unsafe conditions formulate the progression of vulnerability described by Wisner et al.

The model of cities as organisms presented in Fig. 5.12 and the PAR model are very similar. In the city as an organism model, human lives and livelihood vulnerabilities are determined by conditions such as existing social schemes, infrastructure, and the built environment. In the PAR model, vulnerability begins with root causes, where certain factors are limited, and then dynamic pressures on the physical environment, economic and social conditions, and public actions create unsafe conditions. The PAR model, by considering dynamic pressures, stresses the drawing of connections making clear the extent to which social schemes can lead to vulnerability of human lives and livelihoods. In contrast, the city as an organism model draws more general relationships and, therefore, is not well suited for clearly describing causality. Both models, however, include social schemes and hazards to human lives and livelihoods. The PAR model, with its focus on dynamic pressures, makes it possible to describe the progression of (social) vulnerability, whereas the city as an organism model, because of its consideration of infrastructure and the built environment, effectively describes the process by which exposure takes shape.

In both models, the vulnerability of human lives and livelihoods depend on a complex intermingling of social schemes and other elements, and they both emphasize that improving those conditions requires the resolution of fundamental problems. A key point here is that urban governance, other social schemes, and social infrastructure (the productive and daily life infrastructure of cities) greatly determines the vulnerability of human lives and livelihoods to disasters.

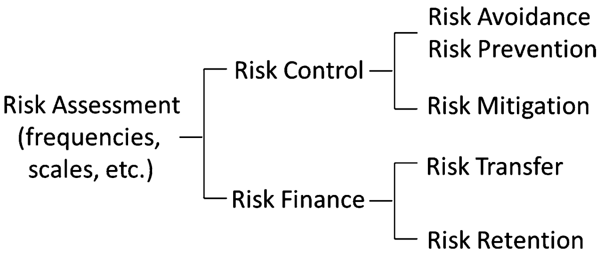

**Fig. 5.14** Disaster risk management measures (Yamaguchi 1998)

### 5.2.2 *Disaster Risk Management Measures*

Of the disaster risk constituent elements (hazard, exposure, vulnerability), two (exposure and vulnerability) are determined by the consequences of human behaviors. The implication of that statement is that exposure and vulnerability can be reduced through human behaviors, and that is at least partially the case.

Disaster risk management measures fall into two categories—risk control and risk financing (Yamaguchi 1998) (Fig. 5.14).

One of the risk control measures is referred to as “avoidance and prevention”. Examples of such measures include individual choices to avoid engaging in activities in an area subject to a high risk of natural disasters, and a government’s decision to regulate land use and prohibit the use of areas to contain exposure and vulnerability.

Another risk control measure that reduces vulnerability is referred to as “mitigation”. The construction of buildings and other structures that are highly resistant to earthquakes, the building of dikes to prevent flood-damage up to a certain level, and the building of additional dikes as second- and third-line defenses against flooding are all measures aimed at mitigating damage.

Risk finance also encompasses two categories. The first, “risk transfer”, is another effective disaster risk management approach. Examples of risk transfer approaches include the traditional use of insurance and alternative approaches such as catastrophe bonds (cat bonds) employing derivatives. Risk transfer methods, in contrast with the risk control methods of avoidance and prevention, and mitigation, are unable to control the scale of damage itself but can control the burden of damage costs. For instance, in Japan, an ordinary household can obtain earthquake insurance that provides coverage up to half that of ordinary casualty insurance. Coverage is determined based on the market value of the house and household goods, or on the amount of money necessary to purchase a new house and household goods (replacement value). Assuming that earthquake insurance has been purchased based on replacement value, up to half of the replacement value of the total loss of a house and its contents due to an earthquake, tsunami, earthquake-related fire or similar disaster would be covered by insurance. Hence, the purchase of such insurance means that, in the wake of a disaster, it is possible to have a portion of the losses suffered reimbursed with money paid by other

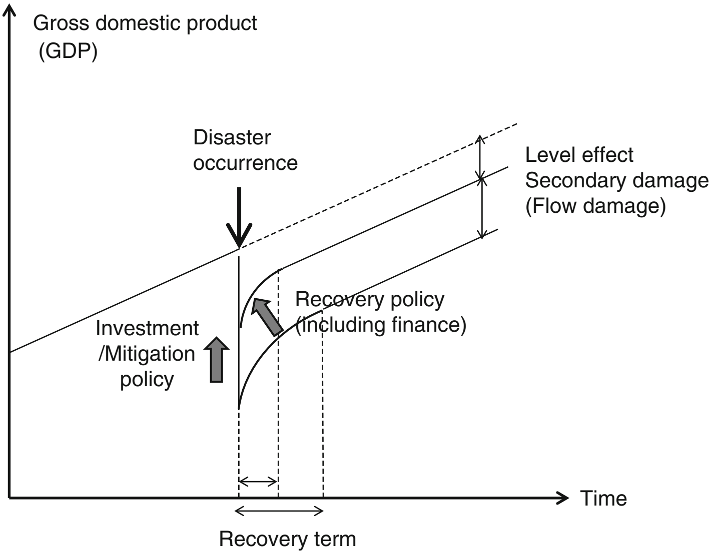

**Fig. 5.15** Disaster recovery and risk management measures

people who have purchased insurance. From a societal perspective, risk transfer does not affect the total amount of losses resulting from a disaster[1] but it does affect how those losses are borne.

It is impossible to completely eliminate risk even if avoidance and prevention, mitigation, and transfer measures are taken. The risk that remains is referred to as "residual uncertainty". Recognizing residual uncertainty and actively bearing risks is one of the measures of risk management, known as "risk retention". Internal reserves and savings are usually included in risk retention measures. Other measures dealing with residual uncertainty, such as disaster-response plans, evacuation plans, training exercises, and similar activities, are also classified in the risk retention category.

Figure 5.2 clearly shows that only a fraction of disaster losses are covered by insurance and most disasters give rise to new financial difficulties related to the reconstruction and recovery processes. The development of systems that will smooth the return to normal daily life following a disaster, therefore, is clearly vital.

Furthermore, as shown in Fig. 5.15, damage mitigation and avoidance measures aimed at reducing or avoiding an economic downturn following a disaster, and risk finance measures for managing the speed of recovery, play mutually complementary roles (Tatano et al. 2004).

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[1] This mainly represents direct damage. The case study in southeast India illustrates that realizing a recovery to baseline living depends on having a post-disaster financial recovery fund. Hence, indirect damage can be reduced via risk transfer that (partially) covers a fund for recovery.

### *5.2.3 Resiliency: Resistance and Ability to Recover*

The British Standards Institution's BS25999 (BCMS: Business Continuity Management System) standard defines resiliency as the ability of an organization to resist the impacts of an incident. The original definition of resiliency is the ability to bounce back. Resiliency, therefore, is interpreted in a narrow sense as the ability to recover and in a broad sense as the ability to resist and recover.

Even in less extreme cases than the example provided of how a cyclone striking the coast of the Bay of Bengal (Column 3: How wealth or access to resources affects damages from disasters?) can have differential impacts on the restoration of daily life, the process of recovery from a disaster is governed by various factors. One factor is the scale of initial damage (Fig. 5.15), and another is the access to resources (primarily financial) during the recovery period. In the example of the Bay of Bengal cyclone, the factor determining the difference in speed with which the wealthy family and poor family could rebuild their lives and livelihoods was the ability to secure finance. Finance is not the only requirement for disaster recovery: the Bay of Bengal cyclone example includes elements such as labor and livestock for restoring damaged farmland, and the securing of farm equipment.

At the time of writing, over two years have passed since the Great East Japan Earthquake struck on March 11, 2011; yet recovery efforts in affected areas have made very little progress for a variety of reasons. Factors strongly impacting the recovery speed included the amount of time needed to develop recovery plans on land use, the disposal of disaster debris, and the relocation of communities. As shown in Fig. 5.15, recovery speed determines the scale of post-disaster damage. The swifter the recovery, the closer the post-disaster growth curve will be to the growth curve that would have been in place without a disaster, and the lighter the post-disaster (flow) damage. In this sense, schemes that enable post-disaster access to resources produce a more balanced distribution of damage and lessen post-disaster damage.

### *5.2.4 Disaster Risk Management Actors*

Disaster risk management involves many actors, working from many perspectives including public employees, residents and community members among others.

The involvement of the various actors can be illustrated by using an earthquake as a disaster example. The majority of deaths from an earthquake are caused by crushing when the shaking of the ground causes buildings to collapse or objects inside buildings to fall onto people. To reduce the number of potential fatalities means either locating in an area with low earthquake risk (avoidance/prevention), or the strengthening of buildings to make them resistant to earthquakes and the securing of furniture and other heavy objects (mitigation). Whether measures like these are actually taken depends on the decisions of individuals like the owners and users of buildings. Information on the distribution of earthquake risk, however, is obtained from public-sector sources. In Japan, this includes Probabilistic Seismic Hazard Maps and governmental organizations that are responsible for advancing earthquake preparation measures, and issuing forecasts of seismic motion and related damage under defined circumstances. Citizens can use this government-provided information, their personal budgets and other considerations to identify better locations in terms of earthquake safety. If they plan to build a house in the chosen location, it will have to meet the seismic standards set by the government to assure a certain level of safety if an earthquake were to strike. Nevertheless, the 2005 discovery that structural calculations had been falsified shows that construction companies and architects cannot be completely relied upon. If the customer who contracted the construction is unable to appropriately evaluate the safety of the building the construction company has built, it becomes necessary to request a third party to perform that evaluation. This entails an additional cost, and the reliability of the evaluation will vary depending on its precision: a highly precise evaluation is expensive. Evaluating seismic safety after a building has been constructed is not a simple process and is the reason why falsification situations arise.[2]

Some existing houses do not meet the seismic standards. Also, seismic standards have been revised over the years, and therefore, older houses do not meet the latest standards and thus are considered more vulnerable than newer houses. In 1995 the Japanese government passed the Act for Promotion of Renovation for Earthquake-Resistant Structures and took steps to improve the seismic performance of existing houses that do not meet the latest seismic standards. Some local governments have provided subsidies for seismic diagnosis and retrofitting of these houses to promote improvement of earthquake resistance of them.

In disaster risk management, it is the party exposed to damage that is the primary decision-maker in controlling or addressing risk. In cases such as the management of water damage risks, government takes direct actions—such as reducing flood risk through river improvement, and managing flood and drought risk through the construction and operation of dams—to decrease risk. In general, however, government, together with various non-governmental institutions, indirectly helps citizens exposed to the risk of damage make appropriate decisions by providing guidance, and regulates the actions of citizens when necessary.

For decision-making in disaster risk management, therefore, it is important to have a framework in which different actors can explicitly or implicitly cooperate in developing and implementing direct control measures or providing indirect guidance. Traditional risk management was developed with the management of risk at particular organizations in mind and therefore did not explicitly consider the involvement of multiple actors. In an area like disaster risk, however, appropriate

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[2] To avoid such situations, it is necessary to severely penalize persons or companies that conduct misleading structural calculations and to strengthening the inspectorate of structural calculations. The Ministry of Land, Infrastructure, Transport and Tourism, Japan developed the relevant legislation after the 2005 architectural forgery in Japan. http://www.mlit.go.jp/kozogiso/index.html, (in Japanese). Accessed 24 September 2013.

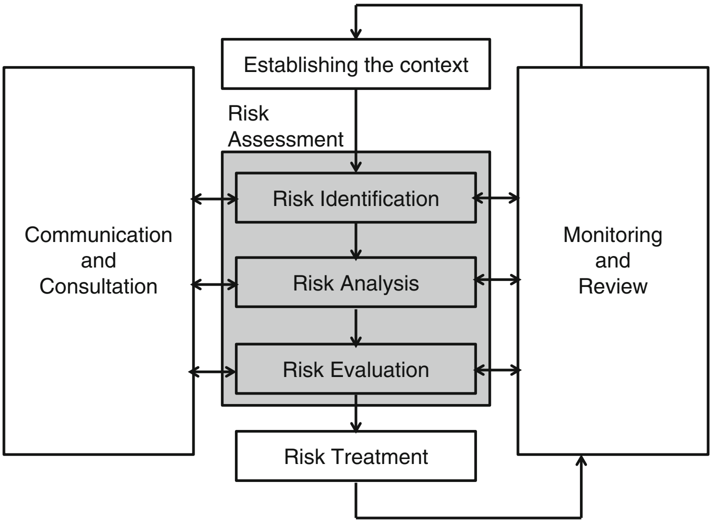

**Fig. 5.16** Risk management process (ISO 31000 2009)

management in an overall sense cannot be achieved based on the decision-making of a single actor. It is necessary to pursue management by setting decision-making scopes for multiple actors and having these actors collaborate through communication and monitoring systems. In disaster risk management, there are various problems unique to particular geographic areas, and many cases in which it is necessary to identify and address the concerns of residents and businesses, and involve stakeholders in planning to ensure that local decision-making is effective. Indeed, this activity, rather than disaster risk management, could be referred to as disaster risk governance.

### *5.2.5 The Disaster Risk Management Process*

Figure 5.16 depicts a standard risk management process. The International Organization for Standardization (ISO) risk management standard ISO 31000 was created in 2009, based on the existing Australian/New Zealand risk management standard (AS/NZS 4360:2004). Japan had its own separate risk management standard—the JIS Q 2001 standard for risk management systems—however, this was abandoned when the JIS Q 31000 risk management standard (based on ISO 31000) was adopted in 2010.

The scheme shown in Fig. 5.16 addresses risk management at a single company or organization. The process entails managing the organization's risks by first engaging in risk assessment—identifying risks, analyzing current conditions, and assessing whether standards have been met—and then addressing risks by developing and implementing plans for achieving conditions under which standards can be met.

It is possible that the activities of the organization could have negative impacts on other stakeholders and that those other stakeholders could press claims for damages against the organization. This supports the idea of expanding the scope of the stakeholder involvement considered for risk management purposes. A key aspect of ISO 31000 is that it clearly incorporates stakeholder communication and consultation, and the monitoring and review functions from the AU/NZ4360 standard on which it is based.

The JIS Q 31000 standard considers that all of an organization's activities include risks and that organizations manage these by identifying and analyzing them, and by judging whether taking corrective actions is desirable for meeting the organization's own risk standards. In carrying out this process, organizations communicate and consult with stakeholders, and monitor and review risk management and risk mitigation policies to ensure that no further actions are necessary to address risks. The JIS Q 31000 standard provides a detailed description of this systematic and rational process.

ISO 31000 also includes "establishing the context", corresponding to the term "set up a situation of organization" in JIS Q 31000. This description is focused on an organization that is subject to risk management. However, the various departments within the organization do not always share common risk management principles or contents. Therefore, risk assessment should be conducted after the contents of risk management, including the targeted risks and the purpose, are clarified.

### *5.2.6 Disaster Risk Governance and Communication Design*

To focus on integrated disaster risk management, it is important to consider the decision making of various stakeholders with different preferences. In the context of disaster risk governance, it is difficult even to clarify in advance the stakeholders to be involved in the risk management process. Moreover, there are issues relating to what the effects are, whom the hazard affects, who can take countermeasures such as "risk avoidance and prevention", "risk mitigation", "risk transfer", and "risk retention", and who are affected by the countermeasures.

Figure 5.17 shows the risk governance process model we propose on a basis of the International Risk Governance Council's risk-governance approach.

This process begins with "Pre-Assessment." Pre-assessment clarifies the various perspectives on a disaster risk, defines the issue to be looked at and forms the baseline for how a disaster risk is assessed and managed. Crucially, it captures and clarifies both (1) the variety of issues that stakeholders and society may associate with a certain disaster risk, and (2) existing indicators, routines and conventions that may help narrow down that is to be addressed as the risk, as well as the manner in

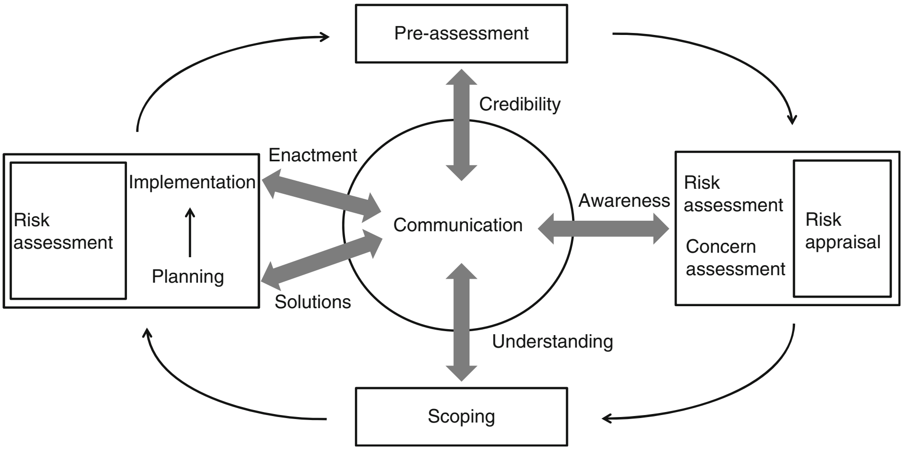

**Fig. 5.17** Disaster risk governance with using CAUSE process

which it should be addressed. In addition, it is often the cases that economic and social context about disaster risk crucially affects the following process, in particular, risk culture.

The next phase is "Risk Appraisal." Risk appraisal develops and synthesizes the knowledge base for the decisions on whether or not a risk should be taken, and if so, how the risk can possibly be reduced or contained. Risk appraisal comprises both (scientific) risk assessment with dynamic simulations or statistical analyses and related assessment with discussions in workshops, questionnaire or interview surveys. Scientists may have specific knowledge on the targeted disaster risk, but residents might have no interest in it due to various other concerns of daily lives. Local governments may have a longer-term perspective for sustainability of cities and communities; on the other hand, residents may have concerns of possibility of disaster happening in their life-time. It should be noted that public concerns are very different from not only scientific knowledge but also governmental concerns.

In the next phase, "Scoping", which does not clearly appear in the IRGC's approach, stakeholders decides a scope of problems they deal with this time. In the context of disasters, there are various problems related with lives, housings, industries, infrastructures and so on. It is difficult to grasp the whole problem at the same time although the problems are interlinked. Deepening an understanding of priority and category of the problems are important task in the phase of scoping. On the basis of results of risk appraisal, the problems to be managed are focused; consequently, the related stakeholders are also squeezed.

After clarifying the related stakeholders and the problems to be tackled, the next phase is "Risk Management". This phase involves design and implementation of the actions and remedies required to avoid, mitigate, transfer or retain the risk. Then, it should be noted who is, or should be, responsible for decisions within the context of the risk management. There exists a big gap between planning and implementation. The stakeholders often differ in concerns and intensions to be involved in the management. It is a key issue how to arrange overall management and keep responsible implementation by each stakeholder.

This circulating process improves the risk situation while gradually changing stakeholders and their scopes.

In addition, Rowan (1995) summarized the purposes of risk communication as the CAUSE process:

- Establish Credibility
- Create Awareness of the risk and its management alternatives
- Enhance Understanding of the risk complexities resolving the issue
- Strive for Satisfaction/agreement on resolving the issue
- Provide strategies for Enactment or moving to action

These purposes are both the classification of risk communication problems and the steps in overcoming risk communication difficulties. Figure 5.17 identifies the purpose of communication in each phase of risk governance using the CAUSE process.

The purpose of communication at the beginning of the CAUSE process is to establish credibility, so that stakeholders build a trusting relationship among each other.

The term “trust” has a variety of definitions; hereafter, “trust” is defined as “expectation of partner’s goodwill and intent” following Yamagishi and Yamagishi 1994. Low level of trust among stakeholders weakens the following process of disaster risk governance.

Traditionally, trust is composed of “expectation of competence” and “expectation of intent”. Recently, it has been accepted that holding similar values is another important factor in forming trust between stakeholders. In the pre-assessment phase, it is important for all stakeholders to gain trust in each other via communication. It is important for risk governance actors to communicate their ability and intention to other stakeholders. If the actors are not local to the area they need to grasp a history of the area and comprehend the issues it faces. Additionally, they may need to reassure other stakeholders that they come to the area to support the resolution of problems. In general, it is very difficult to establish trust between stakeholders. The creation of an ongoing relationship among stakeholders may contribute to establishing trust; however, it is still difficult for outsiders to gain the trust of local stakeholders. Key people, for example those who have engaged in long-term activities in the area, may be able to help outsiders become involved in the risk governance process and to arrange a place where stakeholders frankly discuss the risk and their concerns.

The second phase, “Risk Appraisal”, consists of two processes. The first is to undertake risk assessment including risk identification, risk analysis, and risk evaluation to understand the risk status quo scientifically. The second is to conduct concern assessment to grasp concerns of various stakeholders. The purpose of communication in this phase is to promote awareness of both the risk and its countermeasures and share them among stakeholders.

It is often the cases that concerns are totally different among stakeholders in the context of disaster risk management. For example, when a local government makes a hazard map with a participatory approach, it generally tries to include information from local residents on water depth in the expected flooding area. However, the residents may have queries relating to river flooding or to water system and sewer pipe flooding possibilities those are outside the responsibility of the officer in charge of hazard map preparation. It can be difficult for the officers to access such information because it is handled by a different government section. The officers therefore cannot respond to the residents' request. Moreover, residents may know from experience that a small river is more frequently inundated than a large river. Sometimes flooding can occur inside a levee before the river floods; consequently, the roads on evacuation routes may be underwater before an actual flood is declared. Residents may be concerned that they may not be able to evacuate and would hence be isolated. In this case, a local government needs to consider both the river flooding as well as inundation flooding. Furthermore, when residents are threatened by multiple hazards, for example flood and landslide, the local government has to overlap several hazard maps. The concerns of local residents do not follow the administrative divisions, and they have comprehensive disaster concerns. Therefore, a local government is frequently asked to respond to them outside the scope of bureaucratic compartments. Choi and Tatano (2012) describes a method of conducting a concern assessment that helps categorize residents' concerns into the various consequences and constitute elements of risk. Risk appraisal phase promotes stakeholders to share basic knowledge of the problems they confront.

After risk appraisal phase, the next phase in the process is "Scoping", in which stakeholders scope the issues to be managed; consequently, the types of stakeholders to be involved are also scoped. As mentioned before, the problems may be interlinked. If the interactions among problems are important, stakeholders should deal with the problems as a whole. In addition, if an important stakeholder that is related with a problem is expected not to be involved in the management process, it is an option to leave that problem aside at that time. The essence of communication is promotion of an understanding of priority and category of the problems to be tackled.

The next phase is "Risk Management", which is composed of planning and implementation. As shown in Sect. 5.2.2, risk management alternatives are categorized into risk avoidance/prevention, risk mitigation, risk transfer and risk retention. Proper combination and selection of alternatives are required in the risk management process. In addition, it is necessary at this stage to involve the decision-making stakeholders in finding feasible solutions or recommendations that all stakeholders agree with. In addition, to fill in a gap between planning and implementation, stakeholders keep monitoring and communicating each other for enactment of the established plan to manage the problems. Communication is undertaken here to discover solutions to, or recommendations on improving a current risk situation, and to enact the solutions or the recommendations in the implementation phase.

## 5.3 Toward Integrated Disaster Risk Management Implementation

Some areas are experiencing exceptionally rapid urbanization. Development and disaster are both crucial topics, particularly in Asia, and many innovative disaster risk management concepts have been introduced in Asian cities.

In the Philippines, numerous projects aimed at solving both disaster management and development problems have been implemented. A prime example is a project that began as a flood mitigation plan for Naga city and developed into a project for addressing multiple natural disaster risks in San Carlo city. This project focused on issues such as the creation of a hazard map, development of a damage mitigation plan, land use planning, development of various standards for disaster management, and training of urban specialists. This project is one of nine national demonstration programs being pursued under the Asian Urban Disaster Mitigation Program (AUDMP), with other projects being underway in Bangladesh, Cambodia, India, Indonesia, Laos, Nepal, Sri Lanka, and Thailand (Asian Disaster Preparedness 2012).

As part of the 2012 International Monetary Fund-World Bank Group Annual Meetings, government ministers from around the world met in Sendai, Japan, in October for the Sendai Dialogue—a special event on managing disaster risk co-hosted by the Government of Japan and the World Bank. The event highlighted lessons learnt from the Great East Japan Earthquake and Tsunami and adopted these as guidance for comprehensive disaster risk management in at-risk countries around the world. The Dialogue engaged Ministers, annual meeting delegates and other stakeholders in developing a global consensus to advance the mainstreaming of disaster risk management as a development priority. The special event contributed significantly toward increased cooperation between the World Bank and its partners in reducing vulnerability to natural hazards (World Bank 2012).

Various problems have arisen from the difference in the speed of infrastructure and housing developments and the population concentration into urban areas in prominent developed areas of Asia. Figure 5.3 shows that the number of people living in slum areas is still increasing in some countries. Comprehensive policies need to be implemented in an effort to improve the living environment and to improve infrastructure.

Any current development must consider disaster risk reduction. It is necessary to promote comprehensive measures including information provision related to items such as disaster risk, land use policies and institutional arrangements via disaster insurance. In addition, it is necessary to facilitate an environment where residents can easily take disaster-risk-reduction actions themselves. Local governments now try to inform residents to promote an understanding of risks so that they recognize these and their associated risk measures.

This chapter does not focus on disasters in rural areas; however, disasters in rural areas often result in people losing their livelihoods and can cause mass-movement from the areas hit by disasters. Such people are “disaster refugees”. It is essential to consider this problem in the context of rural development considering disaster risk. Now is the time to take integrated disaster-risk-management policies from the perspective of human security engineering.

## References

Adikari Y, Osti R, Noro T (2010) Flood-related disaster vulnerability: an impending crisis of megacities in Asia. J Flood Risk Manag 3(3):185–191

Apte P (2011) http://www.citymayors.com/development/dharavi.html. Accessed 24 September 2013

Asian Disaster Preparedness Center (2012) http://www.adpc.net/audmp/ audmp.html. Accessed 24 September 2013

Chafe Z (2007) Reducing natural risk disasters in cities. In: 2007 State of the world: our urban future. Worldwatch Institute, Washington, D.C.

Choi J, Tatano H (2012) A study of workshops that develop viable solutions for flood risk reduction through the sharing of concerns: a case study of the Muraida community. Disaster Prevention Research Institute Annuals B, Maibara City, pp 67–74

Chitale Committee (2006) “Final Report” of the fact finding committee on mumbai floods. Government of Maharashtra, Mumbai

Gupta K (2007) Urban flood resilience planning and management and lessons for the future: a case study of Mumbai. Urban Water J 4(3):183–194

Hayashi M (2012) Shizen saigai ni yoru higai to keizai/Shakai-teki yoin to no kanrensei: Todofuken betsu paneru deta wo mochiita jissho bunseki (The Relationship between Damage from Natural Disasters and Economic and Social Factors: Positive Analysis Using Prefecture Level Panel Data). APIR Discussion Paper Series 28

ISO 31000 (2009) Risk management - Principles and guidelines

Munich Re (2012a) Great natural catastrophe worldwide 1950–2011, NatCatSERVICE

Munich Re (2012b) Natural catastrophes worldwide 1980–2011, NatCatSERVICE

Munich Re (2013) Significant natural catastrophe 1980–2012, NatCatSERVICE

Okada N (2004) Urban diagnosis and integrated disaster risk management. J Nat Disast Sci 26(2):49–54

Rahmato D (1988) Peasant survival strategies. Institute of Development Research, Addis Ababa University/International Institute for Relief and Development, Geneva

Rowan KE (1995) What risk communicators need to know: an agenda for research. In: Burelson BR (ed) Communication yearbook/18. Sage, Thousand Oaks, pp 300–319

Tatano H, Honma T, Okada N et al (2004) Economic restoration after a catastrophic event: heterogeneous damage to infrastructure and capital and its effects on economic growth. J Nat Disast Sci 26(2):81–85

UN-Habitat (2003) The challenges of slums: global report on human settlements 2003. Earthscan Publications, London

UN-Habitat (2010) State of the world’s cities 2010/2011–cities for all: bridging the urban divide. Earthscan, London and Sterling, VA

United Nations Department of Economic and Social Affairs/Population Division (2012) World urbanization prospects: The 2011 revision

Winchester P (1986) Cyclone vulnerability and housing policy in the Krishna delta, South India, 1977–1983. Ph.D. Thesis. School of Development Studies, University of East Anglia, Norwich

Winchester P (1992) Power, choice and vulnerability: a case study in disaster mismanagement in South India. James & James Science Publishers, London

Wisner B, Blikie P, Cannon T et al (2003) At risk: natural hazards, people's vulnerability and disasters. Routledge, London

World Bank (2012) http://www.worldbank.org/pos/specialevent.html. Accessed 24 September 2013

Yamagishi T, Yamagishi M (1994) Trust and commitment in the United States and Japan. Motiv Emot 18(2):129–165

Yamaguchi M (1998) Gendai no risuku to hoken. Iwanami Shoten Publishers, Tokyo (in Japanese)

# Chapter 6
# Community Dimension of Human Security in Urban Context

**Rajib Shaw**

**Abstract** Human security is an emerging concept that has gained interest in the last 15 years. Human security is concerned with reducing and, when possible, removing the insecurities that plague human lives. The human development approach, pioneered by visionary economist Mahbub ul Haq (under the broad umbrella of the United Nations Development Programme), has done much to enrich and broaden development literature. Human development is concerned with the removal of various hindrances that restrain and restrict human lives and prevent people from thriving. Human security is a concept that supplements the expansionist perspective of human development by focusing on what are sometimes called the "downside risks". Human security, like human development, highlights the social dimension of sustainable development's three pillars: environment, economy, and society. Although there are recent investigations on the broader perspective of human security from a "security" perspective, there are very few investigations on the community dimension of human security. This chapter summarizes some of the emerging issues at the community level, focusing on the urban context, and provides examples of tools and approaches of community involvement at the city level. Citing examples from an Asian context, the chapter focuses on innovation in community approaches to enhance support for disaster risk reduction and environmental improvements, thereby contributing to human security.

**Keywords** Climate and disaster resilience • Community dimension of human security • Disasters • Hyogo framework for action • Urban communities

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## 6.1 Introduction and Context

Human security is a multifaceted concept. Security is the state of feeling free from fear or anxiety. Soroos (1997) defines security as "the assurance people have that they will continue to enjoy those things that are most important to their survival and well-being". Human security is concerned with safeguarding and expanding vital freedoms. It requires both shielding people from acute threats and empowering them to take charge of their own lives (Ogata and Sen 2003). There were arguments in the late 1980s and in the 1990s (subsequently accepted), that environmental change was a security issue (Barnett 2003). In terms of environmental change, Lonergan et al. (1999) consider human security as the condition when and where individuals and communities have the options necessary to end, mitigate, or adapt to risks to their human, environmental, and social rights; have the capacity and freedom to exercise these options; and actively participate in attaining these options. Human security goes beyond the traditional understanding of security as a state-centered concept related to threats and conflict (O'Brien 2006). It is a people-centered concept that focuses on enabling individuals and communities to respond to change, by either reducing vulnerability or by challenging the drivers of environmental change (Sonak and Shaw 2008).

Ogata and Sen (2003) point out that human security is concerned with reducing and, when possible, removing the insecurities that plague human lives. The human development approach, pioneered by visionary economist Mahbub ul Haq (under the broad umbrella of the United Nations (UN) Development Programme), has done much to enrich and broaden development literature. Human development is concerned with the removal of various hindrances that restrain and restrict human lives and prevent people from thriving. Human security is a concept that supplements the expansionist perspective of human development by focusing on what are known as the "downside risks" Human security, like human development, highlights the social dimension of sustainable development's three pillars: environment, economy, and society (Khagram et al. 2003; Shaw 2006).

Shaw (2006) further points out that the relationship between human security and the environment is most pronounced in areas where humans are dependent on access to natural resources. Environmental resources are a critical part of the livelihoods of many people. When environmental changes threaten these resources, human security is also threatened, resulting in a movement from rural areas to marginal lands (e.g., arid land unsuitable for crops) leading to a decline in household income. Two other fields—environmental security and sustainable development—emerged and grew during roughly the same period as human security and Haq's human development approach (Khagram et al. 2003). Environmental security focuses on natural environment, however, increasing subject complexities have led to calls for a holistic view and synergies between natural and built environments.

Traditionally, security as a concept was primarily concerned with a state's ability to counter external threats. Human security complements state security, enhances human rights, and strengthens human development. It seeks to protect people from a broad range of threats to individuals and communities and, further, to empower them to act on their own behalf (Ogata and Sen 2003). There has been an overall change in thinking on security, moving from a focus on the state to a focus on people and individuals (Ogata and Sen 2003).

The Commission on Human Security's definition of human security is to protect the vital core of all human lives in ways that enhance human freedoms and human fulfillment. Human security means protecting fundamental freedoms—freedoms that are the essence of life. It means protecting people from critical (severe) and pervasive (widespread) threats and situations. It means using processes that build on people's strengths and aspirations. It means creating political, social, environmental, economic, military, and cultural systems that together give people the building blocks of survival, livelihood, and dignity (Ogata and Sen 2003).

Thus, the Commission on Human Security recognizes the importance of both protection and empowerment. Annan (2000), who served as the seventh Secretary-General of the UN, considered human security to encompass human rights, good governance, access to education and health care, and ensuring that each individual has opportunities and choices to fulfill his or her own potential. Alkire (2003) presents various concepts of human security. Mathews (1997) views human security as emerging from the conditions of daily life-food, shelter, employment, health and public safety—rather than coming from a country's foreign relations and military strength. The World Development report (2000/2001) (World Bank 2010) considers human security to mean that every person is entitled to be free from oppression, violence, hunger, poverty, and disease and to live in a clean and healthy environment. Khagram et al. (2003) present a broad perspective of sustainable security and sustainable development in the context of environment.

## 6.2 Human Security and Disaster Risk Reduction Framework

### *6.2.1 Human Security Against Disasters*

The 2011 Great Eastern Japan Earthquake demonstrated that natural disasters can be very difficult to predict and fully prepare against, and can have far-reaching consequences for the safety and wellbeing of individuals and communities. Previous large-scale natural disasters such as the 2004 Indian Ocean tsunami, Hurricane Katrina that struck in the United States in 2005, the Australian bushfires in 2009, the 2010 Haiti earthquake and the 2010 Pakistan floods, show that the impacts on people and society in affected areas are immediate and overwhelming. Such catastrophes tend to exacerbate pre-existing problems and inequalities, with vulnerable parts of the population often disproportionately impacted. For instance, initial estimates suggest that 65 % of the deaths from the Great Eastern Japan Earthquake were of people aged 60 or over. Disaster consequences can be felt for many years, with people suffering as refugees or being displaced within their own country, their livelihoods destroyed, and facing long-term health issues (Futamura et al. 2011).

Human security fosters a bottom-up, people-centered approach that emphasizes the needs, capacities, and experiences of individuals on the ground. It has been widely applied in a number of fields such as peace-building, humanitarian assistance, development, education, and health. Even so, as recent catastrophes such as the earthquakes in Haiti and Japan have clearly shown, the actual threats that people struggle with following a natural disaster are similar to those of a human-made crisis such as armed conflict: “fear” (aftershocks and deteriorating social order) and “want” (lack of food, water, and shelter). Likewise, many of the same actors are involved in the response effort, notably the UN and humanitarian non-governmental organizations (NGOs). Indeed, most of the organizations involved in natural disaster relief are working to protect human security, even if they do not label their work as such.

### *6.2.2 Development and Issues Relating to the Hyogo Framework for Action*

At the second UN World Conference on Disaster Reduction (WCDR) in January 2005 in Kobe City, Japan, the “Hyogo Framework for Action (HFA) 2005–2015: Building the Resilience of Nations and Communities to Disasters” (UNISDR 2007a) was adopted. The HFA is a 10-year plan to make the world safer from natural disasters. The UN secretariat for the International Strategy for Disaster Reduction (UNISDR) is the focal point within the UN System for promoting increased commitment to Disaster Risk Reduction (DRR) and strong linkages to sustainable development. The UNISDR served as the secretariat for both the WCDR process and the HFA development. Through the international efforts on DRR coordinated by the UNISDR, the inception of the HFA helped to recognize the importance of localizing DRR activities. Disaster impacts are immediately and intensely felt at local levels; therefore, the crucial and effective implementation of the HFA as adapted and owned by the citizens and officials of the local government is required at the local level. Hence, the local/city DRR governance is strengthened, and stakeholder roles and responsibilities are identified, clarified, and eventually carried out. The most important sets of actors are governments and local institutions. Local governments bear the ultimate responsibility for the safety of their citizens and communities. Aid is generally at an insufficient level to play more than a complementary role in addressing the challenges of risk management (Christoplos 2003).

The HFA mid-term review was conducted by the UNISDR in 2010. Since the adoption of the HFA in 2005, some progress was made on HFA implementation by national governments with support from international and regional agencies. The need for a comprehensive DRR approach, and thus HFA implementation at a local level, is well recognized. The HFA mid-term review report (UNISDR 2011a) admitted that there was still an insufficient level of HFA implementation at the local level. Moreover, the 2011 ISDR Global Assessment Report for DRR mentioned

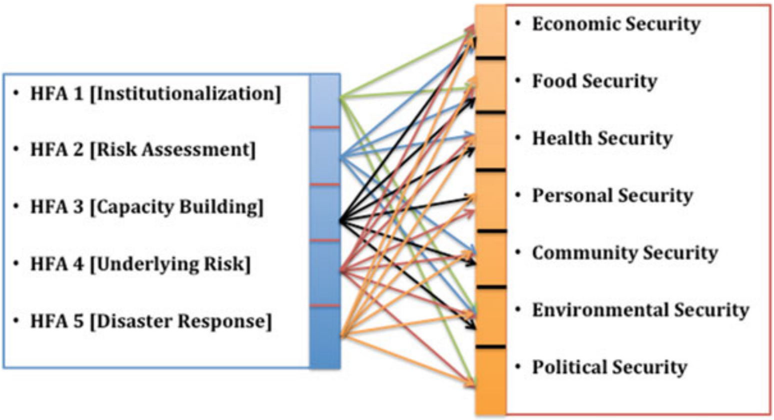

**Fig. 6.1** HFA priority areas (*left*) and human security components (*right*) correlations

that the central role of local governance in Disaster Risk Management is widely acknowledged by most countries, and added that a failure to strengthen local governments and make progress in community participation means that the gap between rhetoric and reality is widening (UNISDR 2011b). These findings clearly demonstrate that the HFA implementation by local governments is an important area for the international community to support and work on together. Such recognition and efforts are supported through international initiatives such as the ISDR global DRR campaign “Making Cities Resilient” (UNISDR 2010) that encourages local governments from around the world to implement DRR activities.

### *6.2.3 Human Security and the HFA*

Figure 6.1 shows the relationship between human security and the HFA. Human security is built on seven different components, economic, food, health, personal, community, environmental, and political security (Fig. 6.1). These components are closely related to the safety and sustainability of communities and nations. The five HFA priority areas also focus on the safety and sustainability of community and nations. HFA 1 focuses on institutionalization that is related to the economic, food, environmental, and political security components of human security. HFA 2 focuses on risk assessment that is closely related to the economic, food, health, community, and environmental security components. HFA 3 focuses on capacity building and awareness and is closely related to the economic, food, health, personal, community, and environmental security components. HFA 4 (underlying risk) and HFA 5 (disaster response and its effectiveness) are related to all seven security components. In several instances, a lack of disaster response has resulted in political insecurity, had serious environmental consequences, and affected the economic, food, and health security of communities.

**Table 6.1** The 20 tasks drawn from the five HFA priorities for local governments and stakeholders

Local/city governance (HFA Priority 1)
Task 1. Engage in multi-stakeholder dialogue to establish foundations for DRR
Task 2. Create or strengthen mechanisms for systematic DRR coordination
Task 3. Assess and develop the institutional basis for DRR
Task 4. Prioritize DRR and allocate appropriate resources

Risk assessment and early warning (HFA Priority 2)
Task 5. Establish an initiative for community risk assessment to combine with country assessments
Task 6. Review the availability of risk-related information and the capacities for data collection and use
Task 7. Assess capacities and strengthen early warning systems
Task 8. Develop communication and dissemination mechanisms for disaster risk information and early warning

Knowledge management (HFA Priority 3)
Task 9. Raise DRR awareness and develop school and local community DRR education programs
Task 10. Develop or utilize DRR training for key sectors based on identified priorities
Task 11. Enhance the compilation, dissemination and use of DRR information

Vulnerability reduction (HFA Priority 4)
Task 12. Environment: Incorporate DRR in environmental management
Task 13. Social needs: Establish mechanisms for increasing resilience of the poor and the most vulnerable
Task 14. Physical planning: Establish measures to incorporate DRR in urban and land-use planning
Task 15. Structure: Strengthen mechanisms for improved building safety and protection of critical facilities
Task 16. Economic development: Stimulate DRR activities in production and service sectors
Task 17. Financial/economic instruments: Create opportunities for private sector involvement in DRR
Task 18. Emergency and public safety; disaster recovery: Develop a recovery planning process that incorporates DRR

Disaster preparedness (HFA Priority 5)
Task 19. Review disaster preparedness capacities and mechanisms, and develop a common understanding
Task 20. Strengthen planning and programming for disaster preparedness

### 6.2.4 Tasks Under the HFA

To support local governments in taking comprehensive DRR actions, the HFA implementation guideline for local governments, "A Guide for Implementing the Hyogo Framework for Action by Local Stakeholders", (UNISDR and RTF-URR 2010) was developed (Matsuoka and Shaw 2011), in view of the importance of local government DRR actions and the challenges faced in terms of limited capacity. The guide is for local governments and other local stakeholders to implement DRR in their cities. In the "Words into Action" document of ISDR, 22 tasks are identified to implement the HFA Priority for Action. The 22 tasks were adapted for use at local/city levels, and a slightly modified 20-task list was provided for local government use (Table 6.1). The guide provides tools for implementation, evaluation, and monitoring at a local level.

## 6.3 Urban Risk and Resilience in Asia and Issues Related to Human Security

### *6.3.1 Disaster Risks in Asian cities*

There has been an increasing trend in climate-induced disasters in the Asia Pacific region in recent decades, with the region being the most disaster-prone in the world. Disaster studies in many of the affected areas suggest that, in a typical disaster, densely populated cities see high levels of mortality and numbers of people affected, in conjunction with inevitable high economic losses across the region. In most Asian countries, 65–90 % of economic activities are concentrated in urban areas (Sharma et al. 2011). The Asia-Pacific region experiences some of the world’s worst natural hazards—frequent earthquakes, volcanic eruptions, cyclones, and annual monsoons. It also includes many of the world’s megacities—those with over ten million inhabitants—hence the number of people exposed to risks in the region is very high. Moreover, disasters are increasing in number and size every year because of a number of factors, including rapid population growth, urbanization, and climate change. It seems inevitable that the Asia-Pacific region will see one or more ‘mega-disasters’, seriously affecting millions of people, in the 21st century. Some researchers have predicted that an earthquake could occur in the Himalayan belt of South Asia causing a potential one million fatalities, and there is an argument that megacities in China, Indonesia, and the Philippines are further candidates. The population explosion in the mega-deltas and coastal areas of Asia, combined with increasing vulnerability to climate change, indicates that a flood, cyclone, or tsunami event affecting tens of millions of people is also likely. The fast-growing cities of the Asia Pacific region are at very high risk. Therefore, the mainstreaming of risk reduction within the urban planning and development process is non-negotiable since the emergence of risk is ingrained in a city’s very inception. When populations migrate to a new location and settle in unfamiliar settings with alien status because of to economic reasons, they face relatively high risks of disasters. Urban areas often have developed industries and complex transportation networks; as a result, many people may face chaos in the immediate aftermath of a disaster.

### *6.3.2 Urbanizing Asian Megacities*

The very nature of population concentrations and developmental densities in urban areas gives rise to risk. City structures and infrastructures increase risk because of the informal nature of construction and population clusters. In urban areas, the safety net of a closely-knit community is lost and, in fact, there is frequent conflict between unrelated communities. Other factors adding to risks and, more importantly, weakening resilience, include environmental degradation and unhealthy living conditions.

In absolute numbers, Asia is the epicenter of the current urbanization surge where it is estimated that some 1.1 billion people will migrate to cities over the next 20 years—an average increase of 44 million people every year. Asian megacities have populations and economies as large, or larger, than some countries. East Asia's urban population produces 92 % of its wealth, with Southeast Asia not very far behind at 77 %, and South Asia at 75 %. This means that cities' resilience to future disruptions including disasters and climate change related threats can determine how fast a country's economy grows. About 250 million people in Asia's urban areas live on less than $1 USD (United States dollar) a day. The urban poor have few resources and low adaptation capacities and are very vulnerable. Alarmingly, Asian cities are likely to contribute over half the total greenhouse gas increases in the next 20 years, while being highly vulnerable to the consequences of climate change including flooding, landslides, heat waves, and water shortages (Asian Development Bank 2008).

### 6.3.3 Urban Poor Threatened by Disaster Risk

Removed from their traditional social safety nets, urban dwellers have little to fall back upon in times of crisis. This is particularly true for the urban poor, who live in marginal settlements in sub-standard housing with limited infrastructure and services and with very few assets. Urban areas have high concentrations of those vulnerable to disasters.

Most of the world's poor live in developing countries with rapidly growing populations, where poverty and population growth reinforce each other (Brown 2001). Population burdens coupled with a host of other reasons are resulting in the growth of cities at an unprecedented pace. There is little space to expand within city confines, hence cities are becoming denser and are growing vertically. People are now building, living, and working on previously unoccupied and hazard-prone lands such as steep slopes, low-lying lands, floodplains, riverbeds, and drains. Global warming arising from human activities (particularly in developed countries) over the last two centuries is now creating irreversible risks to all areas in general, and to mountain, riverside, and coastal habitations in particular.

Further unsettling statistics relating to urbanization are (1) by 2030 two out of every three people will live in cities, and (2) 65 % of the world's coastal population is currently living in urban areas. It is clear that as urban populations grow, cities will expand both horizontally and vertically. Current urbanization trends suggest phenomenal changes in the way cities are now planned and managed. The recent UN-Habitat report on cities states that "by 2050, the urban population of the developing world will be 5.3 billion; Asia alone will host 63 per cent of the world's urban population, or 3.3 billion people, while Africa, with an urban population of 1.2 billion, will host nearly a quarter of the world's urban population" (UN-Habitat 2008). It is true that "in Africa and Asia, still six out of every ten persons live in rural areas" (UN-Habitat 2008). Despite that, the same document reveals that Asia was home to about half of the global urban population in 2007.

Asian cities provide, on average, 80 % of each country's economic base; however, poor people predominantly inhabit them. In most cases, people living in slums and/or classified as living in poverty constitute over half of the city population. In contrast to the 'rural poor' where access to alternative livelihoods, transport, health, and education remains a dream, this new class of 'urban poor' has access to these at the cost of absolute marginalization. Slums that were originally formed as temporary accommodation have now become permanent features and it is not difficult to find three generations of the same family having lived their entire lives in a slum that has undergone little improvement. Paths to resilience are not yet clearly defined and straightforward. It must be remembered that adaptation can also be unsuccessful (Barnett and O'Neil 2010), and since the understanding of this complex subject is still developing, it may potentially result in being detrimental. Physical and social planning fundamentals must thus ensure safety nets in the resilience building processes.

## 6.4 Urban Resilience Analysis: Tools and Approaches

### *6.4.1 Urban Resilience Concepts*

Practitioners and the academic community, in recognition of the importance of urban ecosystem resilience (where cities are central to discussions), propose several urban resilience concepts. These include the 'Megacity Resilience Framework' as introduced by the Institute of Environment and Human Security, UN University (UNU-EHS); the 'Asian Cities Climate Change Resilience Network (ACCCRN)' as aided by the Rockefeller Foundation; the 'Coastal Community Resilience (CCR) Guide' developed by the United States Agency for International Development (USAID) following the Indian Ocean Tsunami; and the 'Urban Resilience Program' currently being researched by the Resilience Alliance. These initiatives suggest that investment in enhancing resilience to climate and disaster risks in an urban setting is advancing in different parts of the world. Some of these initiatives are discussed below (Surjan et al. 2011).

These approaches justify the importance of resilience in today's world challenged by climate change. They also reflect on various perspectives and processes aiming at achieving resilience. Resilience seems to incorporate a reduction in vulnerability, addressing root causes of localized stresses, provisioning redundancy in the system, synergizing bottom-up and top–down approaches, stakeholder engagement in developmental interventions, and engaging the informal and formal systems prevailing in cities, among other approaches. Practices such as identifying risks, assessing vulnerabilities and integrating methods to reduce human vulnerability into development practices are also moves towards resilience (Joerin et al. 2012a, b).

Carpenter et al. (2001) define resilience, in relation to a socio-ecological system, as:

- the amount of change the system can undergo and still remain within the same domain of attraction;
- the degree to which the system is capable of self-organization;
- and the degree to which the system can build the capacity to learn and adapt."

Accordingly, Twigg (2007) related the term resilience to disasters at a community level where he described a community's ability to absorb, maintain, and bounce-back 'after' an incident or disturbance (disaster).

The UNISDR (2007b) explains resilience to disaster as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions". Here, the terms "system" and "community" are attributes targeted to be resilient following a disturbance or disaster. This definition allows the interpretation of disaster resilience in urban areas to a certain extent, where a city or urban area is simply a system consisting of different actors, and physical and natural contexts (Joerin and Shaw 2011).

This brief review of the term shows how resilience gradually transformed into a context where it can be applied to disasters. Although the term resilience to disaster is to some extent defined, it is not yet clear how this resilience is measured in urban areas and how to develop an adequate tool for this process. Therefore, it is vital to consider who or what is expected to be resilient to a disaster. Briefly, the aim of this chapter is to contribute to the urgent need (Klein et al. 2003) to develop a set of tools capable of addressing the relevant sectors in an assessment to make cities more resilient to weather- or climate-related hazards, such as cyclones, floods, or droughts. Others (Surjan et al. 2011) also address this aim.

### *6.4.2 Climate and Disaster Resilience Initiative*

A Climate and Disaster Resilience Initiative (CDRI) tool was developed to assess urban resilience in a certain framework.

The CDRI provides a comprehensive baseline assessment and addresses the linkages between various actors, and aspects of the physical, social, economic, institutional, and natural components of a city or urban area. Accordingly, the CDRI is a planning tool that aims to reveal the sectors that are least resilient, or unable to adequately respond, in the event of a climate-related disaster. Table 6.2 shows the five dimensions and 25 parameters/indicators shaping the overall content of the latest CDRI questionnaire. Table 6.3 shows the detailed variables that assess the 25 parameters.

The CDRI methodology has been modified several times since its establishment in 2008; the latest revision being in 2010. The questionnaire used in the original

**Table 6.2** Current CDRI questionnaire content, 5 × 5 matrix

| Physical | Social | Economic | Institutional | Natural |
|---|---|---|---|---|
| Electricity | Population | Income | Mainstreaming of DRR and CCA | Intensity/severity of natural hazards |
| Water | Health | Employment | Effectiveness of zone's crisis management framework | Frequency of natural hazards |
| Sanitation and solid waste disposal | Education and awareness | Household assets | Knowledge dissemination and management | Ecosystem services |
| Accessibility of roads | Social capital | Finance and savings | Institutional collaboration with other organisations and stakeholders | Land-use in natural terms |
| Housing and land-use | Community preparedness during a disaster | Budget and subsidy | Good governance | Environmental policies |

**Table 6.3** Current CDRI questionnaire dimensions, parameters, and variables

| | |
|---|---|
| Physical | Electricity (access, availability, supply capacity, alternative capacity) |
| | Water (access, availability, supply capacity, alternative capacity) |
| | Sanitation and solid waste disposal (access to sanitation, collection of waste: treated, recycled, collection of solid waste after a disaster) |
| | Accessibility of roads (percent of land transportation network, paved roads, accessibility during flooding, status of interruption after intense rainfall, roadside covered drain) |
| | Housing and land-use (building code, temporary buildings, buildings on water-logged ground, ownership, population living in proximity to polluted industries) |
| Social | Population (population growth, population under 14 and over 64, population of informal settlers, population density at day and night) |
| | Health (population suffering from waterborne/vector-borne diseases, population suffering from waterborne diseases after a disaster, access to primary health facilities, health facility capacities during a disaster) |
| | Education and awareness (literacy rate, population's disaster awareness, availability of public awareness programs/disaster drills, access to internet, functionality of schools after disaster) |
| | Social capital (population participating in community activities/clubs, community leader acceptance (in-ward), ability of communities to build consensus and to participate in city's decision-making process (level of democracy), level of ethnic segregation) |
| | Community preparedness during a disaster (preparedness (logistics, materials, and management), provision of shelter for affected people, support from NGOs/CBOs (community-based organization), population evacuating voluntarily, population participating in relief works) |
| Economic | Income (population below poverty line, number of income sources per household, income derived in informal sector, % of households with reduced income due to a disaster) |

(continued)

**Table 6.3** (continued)

| | |
|---|---|
| | Employment (formal sector: percent unemployed, percent of youth unemployed, percent of women employed, percent of employees from outside the city; percent of child labor in zone) |
| | Household assets (households have: television, mobile phone, motorized vehicle, non-motorized vehicle, basic furniture) |
| | Finance and savings (availability of credit facility to prevent disaster, access to credit, access to credit for urban poor, household saving, household insurance) |
| | Budget and subsidy (disaster risk management (DRM) funding, budget sufficient for DRR, availability of subsidies/incentives for residents to rebuild houses, alternative livelihood, health care after a disaster) |
| Institutional | Mainstreaming of DRR and CCA (mainstreaming of CCA (Climate change adaptation ) and DRR (disaster risk reduction) in: zone's development plans, ability (manpower) and capacity (technical) to produce development plans, extent of community participation in development plan preparation process, implementation of disaster management plan) |
| | Effectiveness of zone's crisis management framework (existence and effectiveness of an emergency team during a disaster: leadership, availability of evacuation centers, efficiency of trained emergency workers during a disaster, existence of alternative decision-making personnel) |
| | Knowledge dissemination and management (effectiveness of learning from previous disasters, availability of disaster training programs for emergency workers, existence of disaster awareness programs for communities, capacity (books, leaflets, publications) to disseminate disaster awareness programs (disaster education), extent of community satisfaction with disaster awareness programs) |
| | Institutional collaboration with other organizations and stakeholders during a disaster (zone's dependency on external institutions/support, collaboration and interconnectedness with neighboring zones, zone's cooperation (support) with central corporation department for emergency management, cooperation zone's ward officials for emergency management, zone's institutional collaboration with NGOs and private organizations) |
| | Good governance (effectiveness of early warning systems, existence of disaster drills, promptness of zone body in disseminating emergency information during a disaster to communities and transparency of zone body to disseminate accurate emergency information, capability of zone body to lead recovery process) |
| Natural | Intensity/severity of natural hazards (floods, cyclones, heat waves, droughts (water scarcity), tornados) |
| | Frequency of natural hazards (floods, cyclones, heat waves, droughts (water scarcity), tornados) |
| | Ecosystem services (quality of city's: biodiversity, soils, air, water bodies, urban salinity) |
| | Land-use in natural terms (area vulnerable to climate-related hazards, urban morphology, settlements on hazardous ground, amount of urban green space (UGS), loss of UGS) |
| | Environmental policies (use of zone level hazard maps in development activities, extent of environmental conservation regulations reflected in development plans, extent of implementation of environmental conservation policies, implementation of efficient waste management system, implementation of mitigation policies to reduce air pollution) |

CDRI primary study undertaken in 15 Asian cities did not include five parameters for each dimension; however, the use and importance of the five dimensions (physical, social, economic, institutional, and natural) were recognized. Following earlier studies (Joerin et al. 2011; Fernandez et al. 2011; Gulshan et al. 2011), Joerin et al. (2012a, b) adopted a 5 × 5 matrix to harmonize the CDRI and to give each dimension the same weighting. This harmonization was important because (1) each dimension is important and thereby no dimension will be favored in the final outcome, and (2) the calculation of the CDRI scores became more transparent and structured since each parameter was further defined by another set of five variables, resulting in a total number of 125 variables. The various CDRI modifications over time and at different urban levels (cluster-, city-, or micro-level) led to the current version (Table 6.3) where different aspects of resilience per parameter define the CDRI.

The key organization completing the questionnaire depends on the context at hand. Generally, different local government departments, mainly the planning department, provide answers through secondary data for quantitative questions or through a well-thought perception (best answer) for qualitative questions and for those quantitative questions where no data are available. The data collection context varies from study to study hence the key organization also changes.

The collected data are transferred to spreadsheets, for example Microsoft Excel, and the weighted mean is calculated. Further analysis is conducted on the 125 variables and numerous weightings, and various examples of these are given in the following chapters where the results of CDRI studies are presented. Spider diagrams are generally used to illustrate the varying conditions of different dimensions and parameters for selected urban areas. Dimension, parameter, and variable correlations have the potential to develop connections between different aspects in addition to this mapping of results. Gulshan et al. (2011) show a high correlation between income and household asset parameters, emphasizing that there is a clear connection between availability of money (income) and transformation into wealth (household assets). Hence, context-based analysis allows the effective development of comprehensive solutions/practices in those sectors where conditions are lowest.

CDRI scores range between 1 (low) and 5 (high), but the numerical value itself is not the most important aspect in understanding the overall CDRI or dimension-wise results. The most important element in interpreting the scores is to evaluate which dimensions, parameters, or variables are particularly low or high to act where most needed. This qualitative results interpretation is needed because CDRI scores are not yet standardized, and are premature at this stage because of the limited number of case studies. Moreover, the context of each city or part of a city varies from a topographical and geographical aspect. The key aims of the CDRI are to reduce risks and to make cities more prepared and capable to withstand climate-related disasters: this means that a qualitative interpretation of the weak and strong sectors of a city is sufficient to spur this process in terms of planning aspects.

CDRI is non-scale specific. It can be used at a city level or at a sub-city (district or ward) level, and can even be used at a neighborhood level, depending on data availability. Thus, the more data points a city have the higher the CDRI result resolution. CDRI can compare individual city values at a regional, national or city cluster level, and cities can be classified according to geographic location (coastal, mountain, riverside, or arid area) or by size (small, medium, large, and mega). The analysis results (overall CDRI values and dimension: physical, social, economic, institutional, and natural) can be used to characterize cities either based on their size or their geographic locations or both. This non-scale dimension of CDRI allows its use for human security analysis at a city and /or community level.

The CDRI is a unique approach that analyses the risks to a specific city and assesses its services and systems. It is a balanced mix of qualitative and quantitative approaches, with a baseline assessment embedded in an overall initiative to make urban areas more resilient to climate-related disasters. The baseline assessment maps the strengths and weaknesses of a particular urban area and a cross-sectorial analysis draws linkages between different dimensions, parameters, and variables in the form of correlations coefficients. On identification of the resilience of all sectors, the process of addressing the potential sector deficits by participative action planning begins. The strong focus on local government involvement in each presented study highlights the importance of the CDRI as an institutional body to effectively develop, apply, and implement disaster risk reduction measures for making cities more resilient to climate-related disasters (Shaw and Sharma 2011).

### *6.4.3 CDRI Indicators, Human Security, and the HFA*

Hastings (2011) proposed the Human Security Index incorporating economic, environmental and social elements. The economic elements include income, debt, and savings. The environmental issues relate to nature, ecosystems etc. and the social issues include elements such as education, gender, food security, and population. Several of these factors relate to the CDRI parameters and variables. The different dimensions presented in the analysis reflect the human security issues at regional, country, city, and sub-city levels.

The CDRI approach also relates to the HFA. The HFA is considered a comprehensive tool for holistically addressing DRR issues. Its framework has been agreed on by experts in the field, and is approved by national governments. The HFA is possibly the first measurable tool for risk reduction measures with specific targets and indicators. Five priority areas focus on five key risk reduction pillars. While the first 5 years of the HFA focused on national level implementation, the next five will focus on local level implementation. Training and capacity building at a local government level (Matsuoka and Shaw 2011) has established HFA and CDRI linkages. HFA implementation identifies 20 tasks and CDRI analysis identifies 25 parameters. This 20 × 25 matrix (500 cells representing 500 specific actions) can be the guiding tool for the local governments to monitor their activities, and see the impacts of the programs.

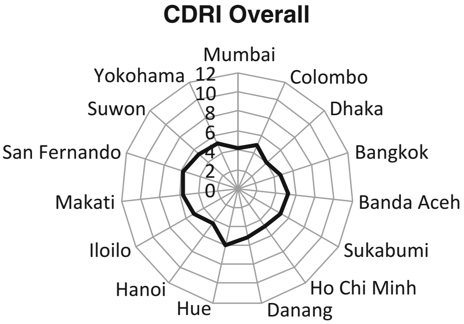

**Fig. 6.2** Overall CDRI results from a study of 15 cities

HFA and CDRI linkages also strengthen the link between the CDRI and human security issues. The seven human security components mentioned earlier are economic, food, health, personal, community, environmental, and political security. CDRI is an attempt to look at five different dimensions (physical, social, economic, institutional, and natural resilience) from a city perspective. HFA, on the other hand, has five priority areas: institutionalization, risk assessment, capacity building, underlying risk, and disaster response. Enhancing physical resilience in the CDRI analysis can improve the water, sanitation, and electric conditions; these, in turn, contribute to economic, health and environmental security. Similarly, the education and health components of social resilience and the income and budget related issues of economic resilience contribute to economic, food, health and personal security. Institutional resilience has a strong implication on political security at both the local and national level.

### *6.4.4 CDRI at the Regional Level*

The questionnaire used in the first CDRI study undertaken in 15 Asian cities (Fig. 6.2), was slightly different from that used in later studies (Razafindrabe et al. 2009). The five dimensions were included in the first study but the different parameters defining it did not take the 5 × 5 format; as a result, the dimensions consisted of unequal numbers of parameters and variables. However, the weighted mean formula was in use at that time. The overall CDRI results from that first survey are shown in Fig. 6.2, the scores ranging from 4–6. City governments were targeted to provide answers about the condition of their city. In this context, a workshop was held in Danang, Vietnam in 2009 to train city managers. A self-evaluation matrix was distributed to members of the Danang city government at this event to ask them about how different parameters (e.g., roads, solid waste disposal) could be improved, and the time horizon for the implementation of certain actions, short-term (2–3 years), medium-term (up to 5 years), and long-term (up to 10 years).

**Table 6.4** Highest scoring sectors (CDRI parameters) in three cities

| City name | Most important CDRI parameters | Average score (out of 5) |
|---|---|---|
| Chennai, India | 1. Electricity | 4.9 |
| | 2. Institutional collaboration | 4 |
| | 3. Road accessibility | 4 |
| | 4. Health | 3.9 |
| | 5. Crisis management | 3.9 |
| Delhi, India | 1. Water | 4.2 |
| | 2. Income | 4.2 |
| | 3. Employment | 4.1 |
| | 4. Community preparedness | 4.0 |
| | 5. Land use in natural terms | 3.9 |
| Dhaka, Bangladesh | 1. Ecosystem services | 4.3 |
| | 2. Environmental policies | 4.2 |
| | 3. Education and awareness | 4 |
| | 4. Employment | 3.7 |
| | 5. Road accessibility | 3.6 |
| | 6. Community preparedness | 3.6 |

### *6.4.5 CDRI at City- and Micro-Level*

The CDRI questionnaire experienced several modifications and is tailored to the specific context of a particular study, meaning that the CDRI questionnaire used at city (Joerin et al. 2011) or city-cluster level (Fernandez et al. 2011) is not the same as the one applied at micro-level (Gulshan et al. 2011). In addition to tailoring certain questions to the local study characteristics, the CDRI questionnaire addresses the changing administrative context (institutional dimension) whereby the focus at micro-level concentrates on local level-decision making rather than on the powers available at city-level. For example, at a micro-level the involvement of ward officials is more important than at a city-level to analyze the institutional condition of a specific area within a city. In the institutional dimension, the development of housing or transport plans/policies is dealt with at a city level rather than at the micro level. Furthermore, at the micro-level the 'newest' CDRI version addresses more specifically the priorities set out in the HFA. Hence, at the micro-level CDRI questionnaires are tailored to the specific administrative conditions where the policy framework is already given; accordingly, the city-level questionnaires assess the conditions from the higher administrative level of power. This variation addresses the local contexts in different urban areas (Table 6.4).

Three cities were selected and an analysis was undertaken on ten zones in Chennai, and nine districts in Delhi, both in India, and on ten zones in Dhaka, Bangladesh. Each zone or district authority was asked to prioritize the sectors (parameters) and issues (variables) that they consider as important to enhance the climate disaster resilience of the respective areas. Zone officials ranked the parameters and variables using a five-point rating scale. The average scores of each

**Table 6.5** Highest scoring development issues (CDRI variables) in three cities

| City name | Most important CDRI variables | Average score (out of 5) |
|---|---|---|
| Chennai | 1. Extent of environmental conservation policy implementation | 4.1 |
| | 2. Zone electric supply authority's capability to provide electricity | 4 |
| | 3. Population awareness or knowledge about disaster threats and impacts | 4 |
| | 4. Extent that zone population participate in community activities | 4 |
| | 5. Percent of youth formally unemployed | 4 |
| | 6. Effectiveness of emergency team during a disaster (leadership/competence) | 3.9 |
| | 7. Floods | 3.9 |
| | 8. Extent of zone's population that provides shelter or emergency support for affected people after a disaster | 3.8 |
| | 9. Percent of zone's annual budget targeting disaster risk management | 3.8 |
| Delhi | 1. Percent of buildings constructed following building codes | 4.8 |
| | 2. Percent of district population living below poverty line | 4.4 |
| | 3. District's health facility capacity to face an emergency/hazardous situation | 4.2 |
| | 4. District's population under 14 and over 64 | 4.1 |
| | 5. Extent that district population participate in community activities | 4 |
| Dhaka | 1. Incorporation of DRR and CCA measures in zone's development plan | 4.4 |
| | 2. Extent that zone population participate in community activities | 4.1 |
| | 3. Zone's health facility capacity to face an emergency/hazardous situation | 4 |
| | 4. Total percent of zone population living in proximity to polluted industry/dumping ground/sea beach | 4 |
| | 5. Percent of zone's annual budget targeting disaster risk management | 4 |
| | 6. Existence of disaster emergency team | 4 |
| | 7. Extent of use of zone level hazard maps in development activities | 4 |
| | 8. Population awareness or knowledge about disaster threats and impacts | 3.9 |
| | 9. Extent of support from NGOs/CBOs or religious organizations after a disaster | 3.9 |
| | 10. Interconnectedness (network)/collaboration with neighboring zones for emergency management during a disaster | 3.9 |
| | 11. Promptness of zone body to disseminate emergency information during a disaster to communities | 3.9 |

parameter and variable in the different zones or districts were calculated for each city, hence identifying important sectors and issues. Table 6.4 identifies the most important sectors and issues needed to enhance each city's climate disaster resilience.

The results for Chennai show that the highest and most important sectors (parameters) are government led or influenced aspects such as the provision of electricity, institutional collaboration, or the accessibility of roads; this reflects the fact that data were retrieved from local governmental authorities (zones). This confirms that crisis management should perform well and should provide the response needed in the case of a disaster. Table 6.5, however, emphasizes the areas where improvements are needed throughout the city because of lower CDRI scores in some aspects of urbanization and its associated consequences such as the high use of natural resources or limited solid waste management.

In the case of Delhi, water supply, income and employment, community preparedness and land-use are the priority sectors, all scoring approximately four out of five, showing that they are crucial for climate disaster resilience. The Delhi water supply system does not ensure even and equal distribution in all parts and for all communities. Those who live in close proximity to the city's water tanks have a relatively better supply than others do. Therefore, for a large part of the city, having adequate water is a big concern and the city authority has recognized this by prioritizing it. Income and employment are also prioritized in view of the belief that employment and adequate income reduces vulnerability, leaving people more resilient by having awareness of disaster and being prepared to face it. Land use is another important sector, in the last decade Delhi's built-up area increased by 10 % in an unplanned fashion (Government of NCT of Delhi 2006). This was reflected in the prioritizing of development issues (variables) and hence a building code was selected as the most important issue. The city authority also considers that poverty, health facilities, community participation, and population burden are priority issues for Delhi's climate disaster resilience.

Dhaka is one of the fastest growing cities in the world, hence its built-up area is increasing and green spaces and overall environmental conditions are degrading rapidly. Therefore, most zone officials emphasize ecosystem and environmental policies. They also consider that education, awareness and community preparedness are crucial to enhance the city's climate disaster resilience; these aspects increase a community's ability be prepared for and face disaster. Employment and road facilities would be complementary factors to enhance any community's CDRI. Taking climate disaster resilience as the prime concern, during prioritization of the development issues most of the zone authorities consider the issues that are directly related to climate disaster. As a result they prioritize the incorporation of DRR and Climate Change (CC) in the zone development plan, community participation, NGO and CBO participation, annual budget for disaster management, and interconnectedness and promptness during disaster.

The different development sectors and issues that are examined during CDRI assessment influence each other and correlation analysis has been conducted to identify these. This type of correlation analysis would help to formulate effective sector development policies to enhance the climate disaster resilience of cities.

There are interesting correlations for income with household assets in Chennai, confirming the assumption that people with higher incomes have more household assets. The high correlation coefficient between social capital and environmental policies may point out that better functioning and interlinked communities have a higher awareness of environmental protection and comply with environmental policies. High education levels correlate with community preparedness; a more knowledgeable community is likely to be better prepared for a climate-related disaster and may respond (resilience) more positively to such an incident compared with a less educated community.

Delhi's CDRI results show that the population has a positive correlation with income and employment. This is mainly due to the increased contribution of the service sector to Delhi's state domestic product. The service sector contribution to state domestic product was 71 % in 1993–1994 and increased to 78 % in 2003–2004. The increased population was well absorbed in the service sector. The number of people living below the poverty line has declined in the last few decades; nearly half of Delhi's population was living below the poverty line in 1973–1974, this declined to 8 % by 2001. This shows that, in conjunction with a rapid increase in population, the number of people living below the poverty line declined significantly in the past 30 years. This shows a positive population correlation with employment and income. Environment policies and health shows positive correlations with each other. Environment policies are sound measures for environmental issues such as air and water pollution. If these issues are not properly addressed, they affect human health. Therefore, improved environmental policy creates a positive impact on health.

In the planned residential areas of Dhaka, people have higher incomes and good employment, and subsequently have better household assets. This is supported by the high correlation values in the cases of housing and land use vs. household assets, of housing and land use vs. income, and of income vs. land use in natural terms. A further interesting correlation is between accessibility to road and land use in natural terms. The areas that are more vulnerable to climate related hazards and have fewer green spaces are also poor in different aspects of road accessibility (Dhaka zones one and three). It is also interesting that household asset levels have a strong correlation with ecosystem services. In fact, the higher income groups who have better household assets live in planned residential areas that have comparatively better ecosystem services.

## 6.5 Community Based Approaches in Enhancing Human Security

### *6.5.1 Community Dimension in Enhancing Human Security*

Ogata and Sen (2003) in their pioneering Human Security Report mentioned that: "At the center of sustainable development is the delicate balance between human security and the environment". They further pointed out that the "Governments and other stakeholders are increasingly aware of the relationship between ecological stability and human security. The emphasis is more on the environment management. However, there have been little concrete actions at local level to ensure the participation of affected communities and people in such management.

.... Critical to this is the need to explicitly plan for improved environment management and sustainable development to disaster prevention and preparedness".

There has been little change in implementing human security components at the local or community level in the past 10 years. For the most part, human security remains confined to national and/or international levels. Basic human needs and their prioritizations have been long discussed. Shaw (2006) argues that the people and community dimension of human security should include livelihood security, environmental security, social security, self-security, and information security. Livelihood security is the first and foremost priority, where lifestyle improvement is sought through income generation via different options such as agriculture, aquaculture, fishing, and animal husbandry. Environmental security is the second dimension, and is important in many rural areas where community natural resource management is the key issue. Social security is the third dimension that ensures different social benefits for people, and enhances social service choices such as health and education. Self-security is the fourth dimension where people and communities are engaged in self-help and co-operation, therefore increasing their degree of freedom. Social security and self-security are closely related. The fifth dimension is information security; it is extremely important for people and communities to obtain the correct information to take the right decisions and actions.

Prashar et al. (2013) developed a community-based action planning process in Delhi, and applied it in different urban communities to understand the individual and collective priorities based on the CDRI framework. This is closely related to the community dimensions of human security in terms of the collective local community actions in understanding the problems and providing locally adaptable solutions.

### *6.5.2 Community Action Planning*

Community action planning (CAP) is a participatory approach that aims at community development through problem solving (Prashar et al. 2011; Hamdi and Goethert 1997). The key essence of CAP is the development of community led action plans. It mainly targets risk reduction by focusing on specific themes including physical improvement, strengthening of community structures, and identification of community led environmental improvement initiatives (Bhatt et al. 1999). The concept of action planning emerged from traditional urban planning that was orthodox and less proficient at delivering benefit on the ground (Hamdi and Goethert 1997); consequently, very few urban planning benefits were reaching the poor. Thus, involving local communities can improve urban planning.

The first stage of CAP is problem and opportunity identification, for which there are several tools and methods. Various participatory rural appraisal (PRA) methods can be used including community mapping, time-line development, problem mapping, and development of problem matrix (Bhatt et al. 1999). Several other tools and methods are described (Hamdi and Goethert 1997) including, direct observation, semi-structured interviews, resource survey, diagramming, mapping and modeling, role-playing, and group work intermixing. These tools help communities in identifying the problems and solutions through their local knowledge. Thus, local knowledge is the key aspect of this stage. Previous community development activities were reviewed to develop community actions for this study. Several brochures and pamphlets describing residential and welfare associations (neighborhood community) community development actions were reviewed for developing community actions for this study. In addition, PRA exercises, direct observation, and resource surveys were completed with East Delhi locals to identify problems and opportunities. Finally, consultations were undertaken with key personnel from the district disaster management authority of East Delhi and local NGOs for the development of community actions.

The second stage of CAP is based on how to get what is needed or on building a program. It involves making strategies to deal with the problems and trade-offs through selection of solutions or options that can be handled by the community itself or with the support of intermediary organizations. The outputs are in the form of community-prioritized actions that are mainly community based and seek to reduce disaster risk. Various tools and methods can be used such as questionnaire survey, brainstorming, diagramming, time lines, daily routines, and seasonal calendars. These methods are chosen as per the setting and environment. The output from this stage is community-prioritized actions that are necessary and viable, and can be taken by the community in the near future with some support from intermediary organizations.

The third stage of CAP is implementation and monitoring. This stage mainly deals with how prioritized actions can be implemented or what type of platform is required to implement prioritized actions. For example, project teams are formed and a plan of action is made, where timetables or timelines, costs, commitments, and responsibility are discussed. Monitoring of implemented actions is essential for measuring the output from CAPs. Monitoring also helps project managers realize the impact of their work at two levels by assessing (1) if the program successfully achieved the target objectives at the local level, and (2) the type of impact the program is likely to have at a city level. The indicators developed for monitoring during this stage will be both qualitative and quantitative. Beaudox et al. (1992) describe several project monitoring indicators including technical indicators, economic indicators, operating or organizational indicators, social indicators, and environmental indicators. For example, the environmental indicator will describe the impact of intervention on the environment, including measuring the impact of improved sanitation on the health and ecology of neighborhoods (Prashar et al. 2011; Hamdi and Goethert 1997). Monitoring and learning from CAP can also be useful in modifying and improving the strategic plans at city levels (Hamdi and Goethert 1997). The objective is to channel lessons learned from the local to the city level. Communities can also lobby city authorities for strategic city level change through CAPs (Hamdi and Goethert 1997). Thus, it can be useful in influencing policy and ensuring community or local level participation in city governance.

### *6.5.3 Action-Oriented Resilience Assessment*

Action-oriented resilience assessment (AoRA) adopts the same five dimensions and 21 of the 25 CDRI parameters (Table 6.6). The initial CDRI assessment findings show that three action measures are defined for each parameter to understand the current implementation level of the selected actions and how important the involved key identified stakeholder (local government, communities, academia, private organizations, and NGOs) roles are in this process. Thus, the objective of the AoRA is to reveal the importance of different actors in the implementation of selected action measures that have the potential to enhance the disaster resilience of communities (wards). The level of responsibility for the AoRA defined actions is likely to be perceived differently among the five actors; however, this tool concentrates on the perceptions of councilors to represent the views of their constituencies. The practical approach of this assessment aims to find out to what extent different actions require multi-stakeholder engagement or if a top–down, governmental-led planning is sufficient (Joerin et al. 2012a, b).

Sixty-three actions (equally divided into 21 parameters) were identified based on previously conducted CDRI results and a literature review on how resilient communities are understood. Moreover, the actions formulated in the AoRA were derived from various on-site visits, extensive desktop studies focusing on lessons learned from previous disasters and other guidance (UNISDR 2007b).

The following key points, for each dimension, emphasize the importance of the availability and functioning of the selected 21 parameters in a disaster resilient urban community:

- *Physical*: studies (Twigg 2007; Cannon et al. 2003; Gaillard et al. 2008) on post-disaster livelihood assessments emphasize the need for people to have secure electricity and water supplies to recover quickly from a disaster. In other words, a solid physical infrastructure is crucial for urban areas to absorb a disaster and thus, apart from functioning urban services, the built environment (e.g. houses) needs to meet the highest building and engineering standards.
- *Social*: various scholars (Cannon et al. 2003; Paton 2003; Murphy 2007) stress the beneficial support of having strong social capital, social networks, and disaster awareness among communities to not only withstand a disaster, but also to better respond to it. Furthermore, having intact and well-functioning health capacities (facilities, networks) during disaster situations are essential to reduce avoidable loss of human lives (Tobin and Whiteford 2002).
- *Economic*: the adequate allocation of financial resources and the effective organization of the economic sector to support and develop incentives to reduce losses from disasters are stressed (Rose 2004, 2007). Available insurance schemes and financial systems would have the potential to provide pre- and post-disaster funding (public and private) that are beneficial to sustain a disaster from the economic perspective.
- *Institutional*: the mainstreaming of CCA (Trohanis et al. 2009) alongside effective emergency management (McEntire 2001) requires a strong institutional

**Table 6.6** AoRA dimensions and parameters from the CDRI

| Dimensions | Physical | Social | Economic | Institutional | Natural |
|---|---|---|---|---|---|
| Parameters considered for AoRA | Electricity<br>Water<br>Sanitation and solid waste disposal<br>Road accessibility<br>Housing and land-use | Population<br>Health<br>Education and awareness<br>Social capital<br>Community<br>Preparedness during a disaster | Employment<br>Finance and savings<br>Budget and subsidy | Mainstreaming of DRR and CCA<br>Effectiveness of zone's crisis management framework<br>Knowledge dissemination and management<br>Institutional collaboration with other organizations and stakeholders<br>Good governance | Ecosystem services<br>Land-use in natural terms<br>Environmental policies |
| Outstanding parameters not considered in AoRA | | | Income<br>Household assets | | Intensity/severity of natural hazards<br>Frequency of natural hazards |

setup to ensure their implementation before, and respectively their functioning during, a disaster.
- *Natural*: the protection of the natural environment (ecosystems, urban green space) is crucial to reduce the probability of disasters occurring and to uphold its coping capacity during times of disasters.

This summary reveals that the application of the term resilience in the field of disaster risk management is multi-disciplinary. Hence, the AoRA proposes a set of actions for the five dimensions and identifies key parameters to understand community leader perceptions about who are the key stakeholders to enhance or build resilience in their community. The selected actions aim to correspond to the needs of a particular urban area in relation to enhancing its resilience to climate-related disasters. The detailed description of the actions is shown in the results from the applied case study in Chennai in Sect. 6.4.5. Four CDRI parameters (income, household assets, and the severity and frequency of climate-related hazards) are not attributed with actions because of their complex nature. For example, the amount of available household assets depends on the available income a household has and on the employment situation of household members. Thus, specific actions to increase income depend on the availability and quality of employment. It is equally difficult to limit the severity and frequency of climate-related hazards, as their occurrence and strength depend on processes only indirectly related to human activities and are they difficult to predict exactly (Climate Change 2007).

Briefly, the overall aim of the AoRA is to understand the role of different stakeholders in implementing actions that enhance an urban community's resilience to climate-related disasters. Knowing who the key stakeholders are for different resilience enhancing actions has the potential to ease their actual implementation and potentially offers more participatory-led development. Accordingly, processes aiming to enhance the resilience of an urban area are to be more widely accepted among communities.

### 6.5.4 Social Institutional and Economic Resilience Actions

Communication is the final element in a comprehensive urban resilience assessment. It is the final stage of urban assessment; how the risk and resilience information collected at the root level is conveyed to wider city communities to trigger them to take action. Social institutional and economic resilience actions (SIERA) is a tool for conveying risk and resilience information in a social, institutional, and economic resilience manner (assuming that the physical and institutional actions will be delivered by local authorities) to communities as widely as possible. It operates through community-based society organizations (CBSOs) identified in cities such as women's groups, youth unions, and faith-based organizations (Mulyasari et al. 2011; Mulyasari et al. in press). The SIERA approach analyzes the DRR activities through primary indicators for different disaster phases—before, during, and after. It is important to have SIERA in different disaster phases to describe women's coping strategies during the entire disaster cycle. McEntire (2001) emphasizes that a holistic approach is needed for a disaster problem where disaster agents are no longer limited to natural and technological hazards. Moreover, disaster management should no longer only imply a response attitude. An approach is needed that addresses all agents, all actors and all phases pertaining to disaster vulnerability. In this respect, the SIERA approach sets the course of DRR activities corresponding to three dimensions and 15 primary indicators. In total, 45 DRR activity scopes describe the whole SIERA approach (Mulyasari et al. in press). These actions can be promoted and delivered by various means including community activities, printed and electronic media (newspapers, television, and radio), and social media (interactive communication through social networks).

## 6.6 The Way Forward

Human security is about the security of individuals and communities rather than the security of states, and it combines both human rights and human development (Kaldor 2007). The efforts to define human security along economic and development lines faltered in the mid-1990s, and its position was increasingly challenged by discussions on physical protection during the late 1990s (MacFarlane and Khong 2006). Amartya Sen, in the late 1990s, moved his earlier work on human development toward a substantial consideration of the relationship between development and freedom, explaining development as freedom of choices. He emphasized the people and community dimensions. In 1998, as prime minister of Japan, Kenzo Obuchi embraced human security as an element of Japanese foreign policy and established the UN Trust Fund for Human Security. The people-centered concept of human security brought together physical protection, rights, and development. 'Human Security Now' (2003) emphasized safeguarding and expanding people's vital freedom, and is closely linked to environmental management and disaster risk reduction. Ensuring human security is crucial in developing countries to reduce urban risk, keeping in mind the high development rate and rapid urbanization. Women, children, and displaced people, considered as vulnerable groups in MacFarlane and Khong (2006), are a special needs group in the human security concept. Advocacy and norm building for specific vulnerable groups is important.

There is a strong link between human security and DRR, especially for the urban area, and therefore, the HFA and the CDRI are a useful analytical framework and tool respectively. From an urban context, the key missing link is community involvement and participation, and for DRR three different approaches are mentioned (CAP, AoRA and SIERA). Figure 6.3 shows the integrated framework of the community dimension of human security, developed by IEDM and GSGES (2012) through a series of lectures and discussions. The diagram points to the different dimensions of human security as the core of the framework with other development sectors like water, health, and education and the issues linked to human security.

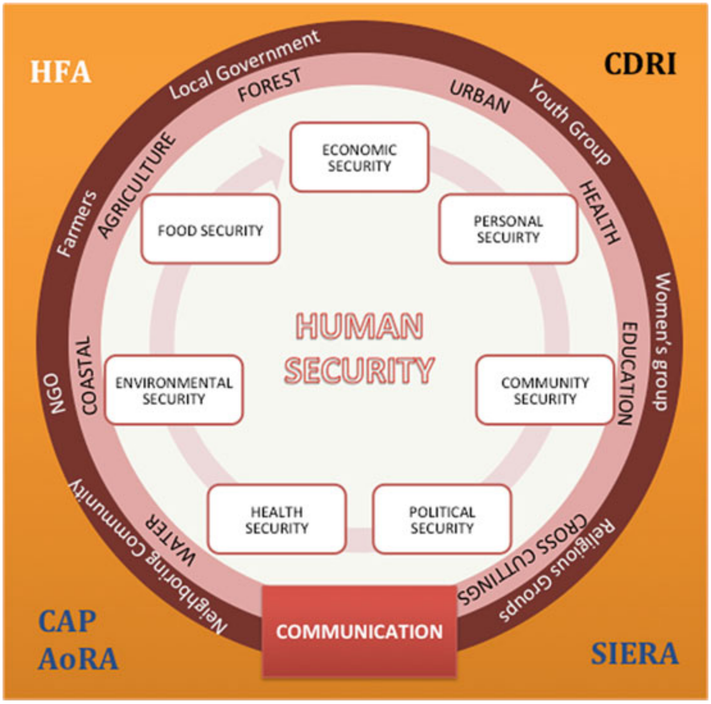

**Fig. 6.3** An integrated framework of the community dimension of human security (IEDM and Kyoto 2012)

One of the key points of human security is communication, exemplified through the community-based approaches of CAP, AoRA and SIERA. Communication needs to come via appropriate change agents like youth unions, women's unions, and other groups appropriate to the local context. Different stakeholders, including local governments, local community based organizations, and NGOs play important roles in implementing community-based actions at the local level, thereby enhancing human security.

## References

Alkire S (2003) A conceptual framework for human security, working paper 2. Centre for Research on Inequality, Human Security and Ethnicity, CRISE Queen Elizabeth House, University of Oxford, Oxford. http://economics.ouls.ox.ac.uk/13003/1/workingpaper2.pdf. Accessed 26 September 2013

Annan K (2000) Secretary-general salutes international workshop on human security in Mongolia, Press Release SG/SM/7382, Ulaanbaatar, 8–10 May 2000. http://www.un.org/News/Press/docs/2000/20000508.sgsm7382.doc.html. Accessed 2 October 2013

Asian Development Bank (2008) Managing Asian cities: sustainable and inclusive urban solutions. Asian Development Bank, Manila

Barnett J (2003) Security and climate change. Glob Environ Chang 13:7–17

Barnett J, O'Neil SJ (2010) Maladaptation. Glob Environ Chang 20:211–213

Beaudox E, de Crombrugghe G, Douxchamps F et al (1992) Supporting development action from identification to evaluation. Macmillan, London

Bhatt M, Gupta M, Sharma A (1999) Action planning, from theory to practice. Doc Centre Urban Plann 24(3):16–23

Brown LR (2001) Eco-economy: building an economy for the earth. W.W. Norton & Company, New York

Cannon T, Twigg J, Rowell J (2003) Social vulnerability, sustainable livelihoods and disasters. Report to Department for International Development, Conflict and Humanitarian Assistance Department (CHAD) and Sustainable Livelihoods Support Office, London

Carpenter S, Walker B, Anderies JM, Abel N (2001) From metaphor to measurement: resilience of what to what? Ecosystems 4:765–781

Christoplos I (2003) Actors in risk. In: Pelling M (ed) Natural disasters and development in a globalizing world. Routledge, New York, pp 95–109

Fernandez G, Takeuchi Y, Shaw R (2011) Climate and disaster resilience mapping in city clusters. In: Shaw R, Sharma A (eds) Climate and disaster resilience in cities. Emerald Publisher, Bingley, pp 81–102

Futamura M, Hobson C, Turner N (2011) Natural disasters and human security. http://unu.edu/publications/articles/natural-disasters-and-human-security.html. Accessed 26 September 2013

Gaillard J, Pangilinan MRM, Cadag JR et al (2008) Living with increasing floods: insights from a rural Philippine community. Disast Prev Manag 17(3):383–395

Government of NCT of Delhi (2006) Delhi human development report 2006: partnerships for progress. Oxford University Press, New York

Gulshan PA, Joerin J, Parashar S et al (2011) Climate and disaster resilience mapping at micro-level of cities. In: Shaw R, Sharma A (eds) Climate and disaster resilience in cities. Emerald Publisher, Bingley, pp 103–128

Hamdi N, Goethert R (1997) Action planning for cities: a guide to community practice. Academy Press, Washington

Hastings D (2011) Human security index: an update and new release. HumanSecurityIndex.org. Accessed 1 October 2013

IEDM, GSGES (2012) Community governance and disaster risk reduction in Asia. Lecture series. Kyoto University, Kyoto

Intergovernmental Panel on Climate Change (2007) Summary for policymakers. Climate change 2007: the physical science basis. In: Solomon S, Qin D, Manning M et al (eds) Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change, 2007. Cambridge University Press, Cambridge

Joerin J, Shaw R (2011) Mapping climate and disaster resilience in cities. In: Shaw R, Sharma A (eds) Climate and disaster resilience in local governments. Emerald Publishers, London, pp 47–61

Joerin J, Sharma A, Chakrabarti PD et al (2011) Climate and disaster resilience mapping at national level. In: Shaw R, Sharma A (eds) Climate and disaster resilience in Cities. Emerald Publisher, Bingley, pp 63–80

Joerin J, Shaw R, Takeuchi Y, Krishnamurthy R (2012a) Action-oriented resilience assessment of communities in Chennai, India. Environ Hazards 11(3):226–241

Joerin J, Shaw R, Takeuchi Y, Krishnamurthy R (2012b) Assessing community resilience to climate-related disasters in Chennai, India. Int J Disast Risk Reduction 1:44–54

Kaldor M (2007) Human security. Polity Press, Cambridge, p 183

Khagram S, Clarke WC, Radd SF (2003) From the environment and human security to sustainable security and development. In: Chen LC, Fukuda-Parr S, Seidensticker E, Narasimhan V (eds) Human insecurity in a global world. Harvard University Press, Cambridge, pp 108–135

Klein RJT, Nicholls RJ, Thomalla F (2003) Resilience to natural hazards: how useful is this concept? Environ Hazards 5:35–45

Lonergan S et al (1999) Global environmental change and human security: science plan, IHDP report 11, Bonn

MacFarlane SN, Khong YF (2006) Human security and the UN. Indiana University Press, Bloomington, p 157

Mathews JT (1997) Power shift. Foreign Aff 76(1):50–66

Matsuoka Y, Shaw R (2011) Linking resilience planning to Hyogo framework for action at local level. In: Shaw R, Sharma A (eds) Climate disaster resilience in cities. Emerald, Bingley, pp 129–147

McEntire DA (2001) Triggering agents, vulnerabilities and disaster reduction: towards a holistic paradigm. Disast Prev Manag 10(3):189–196

Mulyasari F, Shaw R, Takeuchi Y (2011) Urban flood risk communication for cities. In: Shaw R, Sharma A (eds) Climate and disaster resilience in cities. Emerald Publisher, Bingley, pp 225–260

Mulyasari F, Shaw R, Takeuchi Y (2013) Women as disaster risk reduction drivers in Bandung, Indonesia: paving towards a resilient-community, in Disasters (in press)

Murphy BL (2007) Locating social capital in resilient community-level emergency management. Nat Hazards 41:297–31

O'Brien K (2006) Are we missing the point? Global environmental change as an issue of human security. Glob Environ Chang 16:1–3

Ogata S, Sen A (2003) Human security now. Commission on Human Security, co-chairs, New York

Paton D (2003) Disaster preparedness: a social-cognitive perspective. Disast Prev Manag 12(3):210–216

Prashar S, Sharma A, Shaw R (2011) From action planning to community-based adaptation. In: Shaw R, Sharma A (eds) Climate and disaster resilience in cities, vol 6, Community, environment and disaster risk management. Emerald Group, Bingley, pp 163–182

Prashar S, Shaw R, Takeuchi Y (2013) Community action planning in East Delhi: a participatory approach to build urban disaster resilience. Mitig Adapt Strat Glob Chang 18(4):429–448

Razafindrabe BHN, Parvin GA, Surjan A et al (2009) Climate disaster resilience: focus on coastal urban cities in Asia. Asian J Environ Disast Manag 1(1):101–116

Rose A (2004) Defining and measuring economic resilience to disasters. Disast Prev Manag 13(4):307–314

Rose A (2007) Economic resilience to natural and manmade disasters: multidisciplinary origins and contextual dimensions. Environ Hazards 7:383–398

Sharma A, Surjan A, Shaw R (2011) Overview of urban development and associated risks. In: Shaw R, Sharma A (eds) Climate and disaster resilience in cities. Emerald Publisher, Bingley, pp 1–16

Shaw R (2006) Community-based climate change adaptation in Vietnam: inter-linkages of environment, disaster, and human security. In: Sonak S (ed) Multiple dimensions of global environmental change. TERI Press, New Delhi, pp 521–547

Shaw R, Sharma A (2011) Beyond resilience mapping. In: Shaw R, Sharma A (eds) Climate and disaster resilience in cities. Emerald Publisher, Bingley, pp 281–287

Sonak S, Shaw R (2008) Integrating human security concerns in ICZM: an emerging challenge. In: Krishnamurthy R et al (eds) Integrated coastal zone management (ICZM). Research Publishing Services, Singapore, pp 225–239

Soroos M (1997) The endangered atmosphere: preserving a global commons. University of South Carolina Press, Columbia

Surjan A, Sharma A, Shaw R (2011) Mapping climate and disaster resilience in cities. In: Shaw R, Sharma A (eds) Climate and disaster resilience in cities. Emerald Publisher, Bingley, pp 17–46

Tobin GA, Whiteford LM (2002) Community resilience and volcano hazard: the eruption of Tungurahua and evacuation of the faldas in Ecuador. Disasters 26(1):28–48

Trohanis Z, Shah F, Rnghieri F (2009) Building climate and disaster resilience into city planning and management processes. The World Bank, Washington

Twigg J (2007) Characteristics of a disaster-resilient community: a guidance note, version 1 (for field testing). Disaster Risk Reduction Interagency Coordination Group, Department for International Development, London

UN-Habitat (2008) State of the world's cities 2008/2009. Earthscan, Oxford

UNISDR (2007a) Hyogo framework for action 2005–2015: building the resilience of nations and communities to disasters. http://www.unisdr.org/files/1037_hyogoframeworkforactionenglish.pdf. Accessed 26 September 2013

UNISDR (2007b) Words into action: a guide for implementing the Hyogo framework. http://www.unisdr.org/files/594_10382.pdf. Accessed 26 September 2013

UNISDR (2010) Local governments and disaster risk reduction: good practices and lessons learned: a contribution to the "making cities resilient" campaign, Geneva. http://www.unisdr.org/files/13627_LocalGovernmentsandDisasterRiskRedu.pdf. Accessed 1 October 2013

UNISDR, RTF-URR (2010) A guide for implementing the Hyogo framework for action by local stakeholders. Kyoto University, Kyoto. http://www.preventionweb.net/files/13101_ImplementingtheHFA.pdf. Accessed 26 September 2013

UNISDR (2011a) Hyogo framework for action 2005–2015: building the resilience of nations and communities to disasters: mid-term review 2010–2011. http://www.preventionweb.net/files/18197_midterm.pdf. Accessed 1 October 2013

UNISDR (2011b) Global assessment report on disaster risk reduction 2011. http://www.unisdr.org/we/inform/publications/19846. Accessed 26 September 2013

World Bank (2010) World development report 2000/2001: attacking poverty. Oxford University Press, Oxford

# Chapter 7
# Asset Management

**Kiyoshi Kobayashi**

**Abstract** Many national or local governments and public enterprises that operate and manage infrastructure are attempting to introduce asset management approaches to carry out efficient infrastructure maintenance and repair activities amid funding constraints. This chapter discusses the asset management framework that is compatible with the concept of ISO5500X. ISO5500X is an asset management process standard and does not prescribe concrete asset management technology. A de facto standardized asset management system is under development that implements a statistical deterioration model using the Markov deterioration model among others, and has been applied to pavement asset management operations in Japan. The chapter illustrates endeavors to set up international asset management platforms in Vietnam and other Association of Southeast Asian Nations countries.

**Keywords** Asset management • International standard • ISO5500X • Pavement management

## 7.1 What Is Asset Management?

### *7.1.1 Background to Asset Management*

Infrastructure is indispensable in enabling the "freeing of people from threats to their lives and livelihoods" for which human security engineering aims. Infrastructure such as roads, bridges, dams, and water and sewage systems provide protection from natural threats, providing a foundation for social activity. Infrastructure is a physical asset; the effects required of infrastructure are not necessarily enduring. Conversely, if infrastructure degrades, the possibility of health or stable

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socioeconomic activity being jeopardized increases. Accordingly, it is necessary to not only construct infrastructure but also to monitor its condition after construction and implement appropriate maintenance and repair measures to enable infrastructure to perform their prescribed functions.

In the United States, the rapid aging and deterioration of infrastructure because of insufficient infrastructure maintenance and repair became an issue in the late 1980s. The Federal Government conducted a survey (titled "America in ruins") that found that approximately 45 % of bridges were defective and required emergency response measures (Choate and Walter 1983). Broadly speaking, people take an interest in their own assets but show little interest in the aging and deterioration of public assets. Prior to the report, infrastructure managers had stressed the necessity for maintenance and repair; however, financial resources could not be secured and appropriate maintenance and repair work was postponed. Consequently, the aging and deterioration of infrastructure throughout the United States progressed, in some cases to dangerous levels, which was intensively resolved in 1990s. The cause of "America in ruins" lies in the systematic defect of leaving infrastructure to age and deteriorate over many years. Carrying out precautionary maintenance and repair on infrastructure such as bridges at a stage where damage and aging are minor enable the service life of the infrastructure to be extended, resulting in life cycle cost savings. Conversely, if maintenance and repairs are postponed, maintenance and repair costs increase, forcing future generations to bear the burden of enormous maintenance and repair costs. Such situations led to the concept of positioning infrastructure as assets of the people and implementing asset management to systematically and steadily carry out infrastructure maintenance and repair.

### *7.1.2 Current Asset Management Status in Japan*

In Japan, there is a progressive aging and deterioration of an enormous amount of infrastructure constructed during the postwar period of high economic growth. Japanese infrastructure maintenance is considered 30 years behind that in the United States. The infrastructure built en masse from the end of the Second World War through the period of high economic growth is now reaching the end of its service life and the aging of infrastructure is progressing at an accelerated rate. Estimations for 2011 were that the number of bridges constructed 50 or more years ago was approximately four times more than in 2001; figures for 2021 are estimated at approximately 17 times the 2001 number. This pace of deterioration exceeds that of "America in ruins". While awareness of the importance of maintenance and repair has been increasing of late, under the current budget implementation system it is difficult to secure sufficient financial resources for carrying out appropriate maintenance and repair. Furthermore, the reduced tax revenue and increased social security expenditure in Japan because of an aging society and a declining birth rate, means that the funding base for infrastructure maintenance in the future is expected to shrink even further. Once deterioration begins, Japan will find it difficult to rejuvenate to the same extent as the United States. This awareness of the issues involved means that the national government, local governments, private-sector businesses, and others have deepened their understanding of asset management, and have introduced many asset management examples. However, appropriate financial resources for asset management are far from secure, and many systematic defects are apparent.

Private-sector management techniques have recently been introduced to public-sector operations as part of administrative and fiscal reforms, with new public management (NPM) concepts such as utilization of market mechanisms gradually becoming widespread. However, because of the large number of assets and the long-term and widespread nature of their functions, it is impossible to apply private-sector asset management techniques to infrastructure asset management without making changes. To maintain and improve infrastructure functions, there is a need to increase the efficiency of maintenance/repair and renewal of existing infrastructure while meeting the needs for constructing new infrastructure.

## 7.2 Purpose of Asset Management

Many national or local governments and public enterprises that operate and manage infrastructure are attempting to introduce asset management approaches to carry out efficient infrastructure maintenance and repair activities amid funding constraints. In Japan, there is a focus on macro-level management systems for asset management. The purpose of such systems is to plan desirable infrastructure maintenance and repair that can achieve reductions in life cycle costs (from infrastructure construction through operation and renewal/disposal), and to obtain the maintenance and repair budgets necessary for maintaining infrastructure service standards. Macro-level asset management systems are necessary for establishing sustainable implementation systems for infrastructure maintenance and repair activities. Particularly, sometimes large-scale maintenance or repair work may not be carried out immediately even when infrastructure monitoring discovers that urgent maintenance and repair are necessary. The question of why maintenance and repair work must be performed immediately has to be answered to carry out large-scale repairs, and this requires substantial administrative and human effort.

If an asset management system is introduced and an appropriate budget set for asset management, the problem faced by those in charge of infrastructure maintenance and repair becomes not “Why must maintenance and repair work be performed right now?” but rather “What infrastructure maintenance and repair should be carried out this year?” This changes infrastructure manager decision-making from issues related to the necessity of maintenance and repair to those related to deciding priority, and introduces asset management systems on a macro-level. From this standpoint, when international financial institutions fund projects, national governments seeking loans must secure financial resources for asset management. In Japan, as there is no specific asset management account, it is necessary to secure the necessary financial resources through the budget process.

Many local governments have introduced asset management systems and repeatedly carry out budget negotiations and consensus-building for realizing infrastructure service standards. The establishment of management accounting systems for governance of asset management budget plans and viable action programs for infrastructure maintenance and repair is essential for their implementation. Unfortunately, it appears that there are no examples in Japan of asset management implemented based on management accounting principles. Moreover, there do not appear to be any examples of asset management functioning at full-scale.

## 7.3 Implementation of Asset Management and Related Issues

### 7.3.1 *Asset Management Systems*

Currently, the asset management systems introduced by governments and infrastructure enterprises assess infrastructure health, and formulate maintenance and repair plans for aging and deteriorating infrastructure. Figure 7.1 summarizes the asset management cycle. The smaller the cycles within the diagram, the shorter the time-period in which the cycles revolve. The outermost cycle (strategic level), decides repair scenarios and budget levels for infrastructure groups from a long-term perspective. In the middle cycle (tactical level), an important issue is

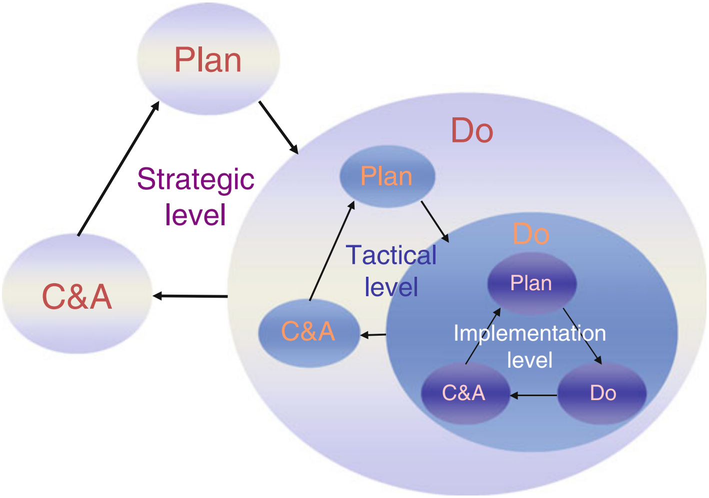

**Fig. 7.1** The asset management cycle

formulating mid-term budget plans—for the next 5 years, for example—and strategic repair plans based on new monitoring results. In the innermost cycle (implementation level), priority is assigned to places requiring repair, and repair work is carried out under a repairs budget for each fiscal year. The basic management cycle functions of plan, do, check, and action (PDCA cycle) are required at each level.

1. Strategic Level Management
   The strategic level management aims are to set maintenance and repair targets; formulate basic maintenance and repair policies and long-term optimum maintenance and repair plans; implement these plans; verify the results of implementation; and undertake continual improvement. Since managers formulate long-term maintenance and repair policies for the overall infrastructure they manage from a macro perspective, the management models used should be as simple as possible. To this end, based on information obtained from monitoring and repair records, the current condition of infrastructure is ascertained; the usage status, surrounding environment, and state of damage of the infrastructure are summarized; the infrastructure is divided into groups according to importance; and maintenance and repair strategies for each group are decided. On ascertaining the current infrastructure condition, deterioration predictions are calculated based on the summarized data and optimum repair and monitoring strategies formulated. At the strategic level, it is impossible to remove the uncertainties involved with deterioration because of long-term investment plans for overall infrastructure and the need for long-term predictions. Hence, the average deterioration of overall infrastructure is ascertained rather than deterioration predictions for individual infrastructure objects. The desirable repair strategies are determined for each group based on the deterioration predictions. The maintenance and repair strategies for minimizing infrastructure life cycle costs, or infrastructure investment strategies for maximizing expected net benefit, are set. Long-term budget plans are formulated based on the infrastructure investment and repair strategies set for each classified group. In formulating long-term budget plans, various scenarios are simulated—such as concentrated investment for group units—and desirable investment strategies are prepared. Long-term budget planning records the budget levels necessary for maintaining infrastructure service levels over the long-term, and the infrastructure service levels to be maintained using these funds.
2. Tactical Level Management
   At the tactical level, mid-term budget plans are formulated and concrete investment and maintenance and repair plans drawn up, based on the most recent infrastructure damage status obtained through regular monitoring. The PDCA cycle must then function in accordance with these plans. The mid-term infrastructure repairs are selected and repairs prioritized based on monitoring data, strategic-level infrastructure investment and repair strategies, long-term budget plans, and information on planned service levels, and the required budgets for each fiscal year are calculated. Where infrastructure with questionable structural safety is discovered through monitoring, detailed follow-up investigations are

carried out and structural safety reviews are conducted. Mid-term budget plans may not correspond with long-term budget plans formulated at the strategic level. Infrastructure deterioration prediction is also carried out at the tactical level. At the strategic level the aim is to formulate investment plans for overall infrastructure, hence deterioration prediction at this level focuses on overall infrastructure. Deterioration prediction at the tactical level provides basic information for determining the order of priority for repairs. Accordingly, there is a need to identify the cause of deterioration and predict deterioration for each individual infrastructure in addition to reliably predicting deterioration. Infrastructures for which structural safety problems are forecast are given repair priority.

3. Implementation Level Management
   The implementation level refers to the management level at which actual maintenance and repairs are carried out. Repair plans are made for the infrastructure selected under mid-term budget plans for the relevant fiscal year. Actual repair sections are selected based on conditions at the infrastructure location and the scale of the repairs required. In cases where an adjacent infrastructure is also targeted for repairs, simultaneously repairs are considered. Repair designs are ordered and the quantity and cost of repairs are determined. However, here is the possibility that repairs may be postponed for some infrastructure because of budget constraints. Actual repairs are carried out on the infrastructure ultimately selected for repair work. Work undertaken is recorded in a database, and the repair results are used for ex-post evaluation at the strategic and tactical levels.

### 7.3.2 Structure of Asset Management Systems

The purpose of asset management is to plan overall infrastructure maintenance and repairs and carry out efficient maintenance management. Asset management systems comprise three different levels—strategic, tactical, and implementation—and at the upper level activities are undertaken at a macro perspective, targeting overall infrastructure from a long-term viewpoint. At the lower level, individual infrastructure are targeted at a micro perspective from a short-term (single fiscal year) viewpoint.

Generally, to formulate and implement asset management plans, a basic plan setting out the basic thrust is formulated and a concrete implementation plan is devised for implementing the basic plan; actual maintenance and repairs are carried out based on the implementation plan. The implemented maintenance and repair policies are reviewed and an overall PDCA cycle constructed. In contrast, in asset management systems a basic plan for infrastructure maintenance and repairs is formulated at the strategic level, determining the basic strategies for long-term maintenance and repair work. Mid-term implementation plans follow for putting the basic plan into effect at the tactical level, and maintenance and repair activities are carried out to enable individual infrastructure objects to fulfill their required performance at the implementation level. The implementation status of maintenance and repairs is reviewed at each level and improvements are made bearing the formulation of the next plan in mind.

The PDCA cycle needs to be undertaken at each management level and efforts made to resolve asset management-related issues and continually improve management skills. Checks are conducted at the implementation level; evaluations are carried out to ascertain whether actual maintenance and repair activities have been accomplished in accordance with the plan formulated at the beginning of the fiscal year. Implementation-level evaluations are compiled, and evaluations undertaken of implementation plans carried out at the tactical level. Management accounting information and other data are used in conducting the evaluations. Strategic level evaluations are conducted by further compiling tactical-level evaluations, and the results of these are reflected as appropriate in the subsequent plan in an effort to improve system efficiency and accuracy. The results of maintenance and repair activities are released to the public as necessary, ensuring transparency and fulfilling the role of accountability.

## 7.4 Internationalization Standardization of Asset Management

### *7.4.1 ISO5500X*

International module development and inter-system competition is intensifying. International standardization of design and technology standards, the spread of international accounting standards, and a raising awareness of business ethics all require changes in corporate technology development and management systems. ISO5500X—an International Organization for Standardization (ISO) standard for asset management to be implemented in the spring of 2014—is expected to be widely and rapidly acknowledged as an international standard supporting future international infrastructure works such as build-operate-transfer (BOT) projects, private finance initiatives (PFI), and public-private partnerships (PPP).

The concept of simply exporting tangible and infrastructure technologies is not viable in the international construction market; added value is only generated when infrastructure projects are supported by comprehensive intangible technology enabling the infrastructure to be operated as a system. The global competition for international standardization of this intangible technology is intensifying. ISO5500X is an international asset management standard. It is a model for the standardization of management processes for strategically implementing infrastructure renewal whereby governments and enterprises evaluate the risk positions of their enormous infrastructure and reorganize infrastructure portfolios for the continuous growth of these organizations. Asset management is a central issue for organization continuation and growth and is not a trivialized concept with the sole aim of maintaining and repairing infrastructure. The ISO5500X functions are very diverse, but two of its roles are noteworthy here: (1) as a means of governance for operating PDCA cycles in organizational asset management, and (2) as a method for establishing competitive strength in international construction and engineering markets.

### *7.4.2 Is the Standardization of Management Proving Useful?*

In Japan, several enterprises implement the ISO900X and ISO1400X international management standards. There are various motives for Japanese companies to implement ISO standards. These include public procurement reasons—for which such certification is required—or efforts to establish a company's reputation; only rarely is corporate management governance the direct motive. There are, in fact, frequent complaints that the introduction of ISO has increased the burden of document preparation. Although Japanese certification methods are not without problems, there remains a question as to why Japanese companies do not attempt to (or cannot) establish management governance through the introduction of ISO standards. Despite many organizations introducing asset management systems, there are numerous cases where the implemented management systems do not function, leading to the view that asset management of asset management may be necessary. In addition, despite many organizations proclaiming the importance of PDCA cycles in administrative and corporate management, there are only a few examples of PDCA cycles operating successfully. In many cases, the plan-do-check process is functioning, but the check-action process is not.

It is important to remember that the ISO900X and ISO1400X standards and the ISO5500X asset management standard are process standards for achieving continuous improvement of management. Companies in Europe and the Unites States also find the check-action process a difficult part of the management cycle to operate voluntarily. Thus, ISO process standards act to semi-forcefully ensure the check-action process. ISO5500X is designed to make the basic asset management check-action process work by having managers answer several basic questions related to asset management. Many Western organizations would consider the ISO process standards useful. This gives rise to the question on the fundamental differences that exist between "Japanese organizational culture" and "Western organizational culture". Although difficult to answer simply, the response focuses on whether there is a management target whose improvement can be carried out immediately following the check function when, for example, improvement is discovered to be necessary. Current management systems and business models often require restructuring, or business reengineering, to implement ISO. Moreover, management system monitoring and management information systems supporting this monitoring are necessary for implementing continuous management improvement. However, there are many cases in Japanese organizational culture where the implementation of ISO process standards remains at a perfunctory level outside the scope of management system modifications and applications. For example, in the ISO self-assessment element the assessment items do serve as a checklist; however, even if problems are discovered they are only partially corrected and do not lead to continuous process system improvements.

This does not mean that management systems do not exist in the Japanese organizational culture. In fact, Japanese organizations often have more tightly knit and detailed management systems than those of Western organizations. However, governance of management systems depends on local organizational rules and customs in addition to the ad-hoc decisions and instructions of organizational managers. When governance depends significantly on human resources, the movement of these risks the dramatic decline of management productivity or governance. In contrast, the organizational culture envisioned by ISO standards is an environment where subordinates are not as emotionally involved or as competent as their superiors. Thus, running through this culture is a management philosophy of reducing regulations to simple rules and describable norms, as well as undertaking continuous improvement through experiences in the workplace to enable management systems to rely on human resources as little as possible. This reflects the "think while walking" Anglo-Saxon concept that is alien to both the "think before walking" Germanic concept and the "preserving harmony between people" Japanese concept of "consensus". Nevertheless, it is important to examine both the circumstances where PDCA cycles do not function in the Japanese organizational culture and those causing asset management to malfunction. This stresses the importance of creating management targets that can enable the implementation of improvements, if necessary, through the check function in the management cycle.

### *7.4.3 PDCA as Meta-Management*

Management in government organizations operates around budget implementation management. The asset management cycle shown in Fig. 7.1 comprises budget planning (plan), budget implementation (do), and management activities (check and action). The basis for this is the planning and implementation of single fiscal year budgets. To manage infrastructure accumulation and its deterioration, it is necessary to evaluate the long-term performance of infrastructure. Furthermore, hierarchical management is essential because of the uncertainty involved in both the aging and deterioration process and in the need for infrastructure at some future point. Asset management clearly operates under the budget implementation management system shown in Fig. 7.1 for both government and business organizations. However, asset management under ISO5500X aims to continuously improve the budget implementation management system shown in Fig. 7.1. It is difficult to achieve improvement of such management systems within everyday budget implementation system operations.

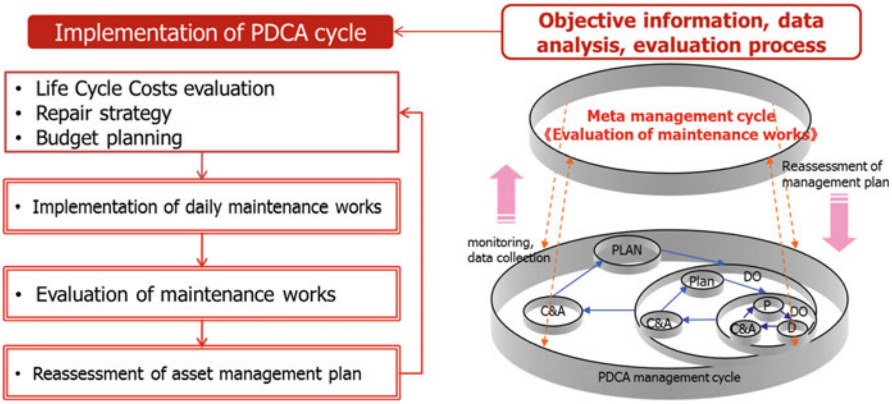

**Fig. 7.2** The meta-management system

Asset management under ISO5500X requires monitoring of the performance of budget implementation management systems, as shown in Fig. 7.2, as well as the construction of a management system to improve the budget implementation management systems themselves. Namely, a meta-management system to oversee management systems is necessary.

The maintenance and repair work carried out on site and budget implementation management processes involve numerous formal or informal rules and norms, guidelines and manuals, information systems, usable resources, human resources, maintenance and repair technologies, contract methods, and contract management systems. The collective techniques for implementing this asset management are asset management techniques. Within asset management, the PDCA cycle aims to uncover issues and problems in carrying out management and to improve and renew asset management techniques for resolving these issues and problems. The reason the PDCA cycle does not perform in asset management in Japan is that management cycle evaluators and management technique managers/operators are disconnected, so that management-related monitoring information and improvement policy-related communication do not function. Management techniques are distributed to and retained by the relevant departments and offices within the organization in an ad hoc manner. Moreover, many management techniques are informally preserved as the experience of the relevant managers or as customary practices of the relevant departments and offices.

Accordingly, management cycle evaluators need to expend significant energy in gathering information on “targets for improvement” such as what needs to be improved, which department and office is responsible for management techniques, and who is the contact for communication. Specifically, the transaction costs for operating the PDCA cycle within the organization are extremely large; hence, the PDCA cycle does not function. To enable its functioning, asset management techniques distributed within the organization need to be centralized (or a directory constructed).

## 7.5 International Standards and International Construction Market

### 7.5.1 *Types of International Standards*

Currently, the World Bank and other international financial institutions make asset management implementation a condition for borrowing countries to obtain financing for projects in developing countries. They recommend standard software to support asset management implementation. For example, the pavement management software, HDM-4, is recommended for pavement management, hence HDM-4 now dominates international markets as the de facto standard. Consultant businesses have been established that use HDM-4 for pavement asset management, and business models using software other than HDM-4 are being marginalized. The current HDM-4 version calculates the budget amounts necessary for implementing pavement asset management at the macro-level. This makes it impossible to provide support for pavement management at the implementation level using HDM-4.

ISO5500X is a management process standard incorporating implementation-level asset management and does not prescribe specific asset management techniques or software. However, software is essential to carry out asset management using process standards. The software available for ISO5500X directly supports on-site asset management activities, and de facto standards for support software pose the danger of driving tangible and intangible asset management techniques to which the de facto standards do not apply out of the market. One view is that de facto standards are developed to marginalize competitive techniques. The authors are undertaking the development of software based on ISO5500X through a consortium including Vietnam. In future, it is expected that infrastructure projects will increase at an accelerated rate in international construction markets through initiatives such as PPP, and enterprises participating in projects from 2014 (when ISO5500X comes into effect) onwards will likely be required to obtain ISO5500X certification. Thus, enterprises wishing to participate in international construction market projects need to master asset management techniques using ISO5500X.

### 7.5.2 *Standardization Competition and the Principle of Relationships*

There are "de jure" (obligatory) international technology standards prescribed by public institutions such as the ISO and related government organizations. For example, in the field of computer operating systems Microsoft has an overwhelming market share and a high growth rate and profit ratio, emphasizing the importance of de facto standards in market competition. Various de jure and de facto standards are simultaneously involved in infrastructure construction, management, and operation. Infrastructure is a complex system, and there is competition over infrastructure technology standards.

Technology standards include interface/compatibility standards and quality standards (Doi 2001). Interface/compatibility standards are standards related to interpersonal relationships, such as manuals, work processes, and management systems. In contrast, quality standards include technology standards related to product quality, specifications, production, and processes. In a broad sense, quality standards provide essential boundary information for coordinating objects and objects, people and objects, and people and people; hence, it is possible to consider them interface standards. ISO5500X is simultaneously both an interface/compatibility standard and a quality standard. The economic value of technology standards lies in the reduction of direct transaction costs because of interface standardization and the increase in relationships (connected resources) through interface-sharing. Moreover, interface improvement increases the amount of resources connected by the interface, resulting in the functioning of positive feedback via a further increase in relationships. The economies of scale from such positive feedback are referred to here as the principle of relationships. In addition, technology standards have the indirect effect of providing users with a psychological sense of security. In particular, infrastructure product quality is information that governments and customers purchasing the infrastructure have difficulty understanding, and hence the various technology standards for infrastructure projects convey information related to infrastructure product quality to customers. In Japan, trust relationships regarding infrastructure product quality are established between stakeholders through long-term contractual relationships. There is sometimes a reputational effect for "Japanese brands" in overseas markets, but this is no more than a vague reputation based on hearsay. In international markets, quality standards fulfill an important role in forming trust.

When exporting infrastructure technology overseas, it is necessary to strategically consider competitive relationships with conflicting technology standards. To win in market competition, technology standards supporting infrastructure must have superiority as international standards. Furthermore, strategies are needed to enable positive feedback through the principle of relationships by increasing the number of users of the same technology standards in international markets. To realize the principle of relationships, the infrastructure to be exported must contain appropriate technological content for the socio-economic situation in the importing country. There are numerous examples of Japanese infrastructure technology being of excessively high quality and function for the importing country, and having lost the price competition. A different viewpoint is that Japan does not have the technology to construct simple and inexpensive infrastructure appropriate to the economic level of such importing countries; Japan has not developed infrastructure customization or modularization technologies. Knowledge management is extremely important for businesses responsible for infrastructure operation. Furthermore, ISO5500X ultimately aims to achieve continuous improvement of asset management through infrastructure modularization and customization technologies.

There has been a recent trend toward increasing the value of technology standards through the formation of alliances; thus enabling the functioning of positive feedback through the principle of relationships. In forming alliances, it is important to have an open policy on intellectual property rights. Suematsu (2004) summaries this and emphasizes the importance of open source strategies:

1. Proprietary (Closed) Specifications
   The company owns 100 % of intellectual property rights for its products and collects high royalties when others use this intellectual property. Since standardization must be carried out independently, both costs and risks are large, but when standardization is successful, the company can monopolize the market, gaining enormous profits.
2. Open Specifications
   The company discloses the specifications for its products and allows the entry of others into the industry, expanding the market share of its specifications. Licensing fees take various forms, but anyone can use the specification free of charge since the company's aim is to make its own specifications the industry standard. It becomes widely known that creating numerous standards is not profitable; the trend toward integrating alliances and lowering license fees strengthens.
3. Open Sources
   The strategy of lowering the price of products to zero to widely diffuse products becomes the norm. Open sources is a strategy for eliminating the prices of products and services targeted for sale.

### *7.5.3 International Standardization Strategies*

When the Japanese infrastructure is exported overseas, it is not uncommon for the importing countries to have existing technology standards. For Japanese companies to contemplate the introduction of new technology standards, the importing companies must understand the merits of introducing such standards. Where the importing country has existing technology standards, the switching cost for changing the technology standards is significant. It is necessary to present a roadmap for switching over technology standards in the medium- and long-term while ensuring compatibility with the preexisting standards. For an importing country to agree to switch technology standards, the Japanese standard contents must clearly be more appropriate for conditions in the country than the preexisting technology standards. There is a lock-in effect once preexisting technology standards are introduced, and even if subsequent technology standards are slightly superior, there is often no merit to replacing the existing standards with new technology standards. For example, the South Korean Government embarked on the development of a road pavement management system (PMS) as a national policy in 2005. To contribute to the expansion of Korean companies in the international road construction market, the government decided to implement HDM-4 (the international de facto standard for PMS) domestically. Concurrently, aware of the limitations of HDM-4, the Korean Government is developing a hybrid pavement management system (Han 2012) that is compatible with both the Kyoto Model (Aoki 2011) developed by a Kyoto University research group and HDM-4, and the practical application of this system is progressing.

Individual technology standards are not uniformly accepted worldwide; customization of technology standards is always necessary. Added value is created through the expansion of technology standards. This creates new business chances such as incidental business using and implementing standards, sale of know-how, sale of supplementary products, utilization of brand and customer-attracting ability, utilization of brands as a strategy for recruiting and corporate invigoration, and improvement of customer satisfaction from accumulation of market information. The more complex a technology becomes the more important the services using that technology become. Where intellectual property rights are made open-source, the products targeted for standardization are provided free of charge. However, the incidental business based on these products becomes the object of profit-making businesses such as product display and description, order processing, settlement, product quality assurance, maintenance, support, integration, consulting, education and publishing, lectures, and brand utilization. This does not mean that closed standards or business expansion stemming from the direct value of standards should be ignored; these should also be thoroughly pursued where possible. However, in cases where this is difficult, rather than persisting with the introduction of new standards, it is important to seek business chances in the utilization of preexisting technology standards (Suematsu 2004). In the case of infrastructure technology, even if there are international standards for the core technology, business opportunities can be created in incidental businesses for adding value such as safety and security technology, health, and comfort. ISO5500X is a de jure standard in addition to a process standard, and so there is no likelihood of ISO5500X itself taking over international markets as a de facto standard. However, there is the possibility of ISO5500X-compliant asset management-supporting software becoming de facto standards. Specifically, because ISO5500X is a technology standard for on-site management processes, if a certain software takes root as a de facto standard, there is the danger of incompatible tangible and intangible technologies being excluded from international project markets centering on developing countries.

International alliances are effective strategies for achieving the internationalization of technology standards. To form international alliances, systematic infrastructure (internationally fluid platform) for achieving the diffusion, distribution, and customization of technology standards must be prepared. The following items should be achieved under this platform:

1. Participants can easily access core technology.
2. Generation of shared knowledge related to the value of technology standard models between participants.

3. Support functions that allow the easy use of technology standards by participants.
4. Conflict resolution functions related to technology standards.
5. The nurturing of technology standard models as brands.
6. Design of technology standard model modularization and establishment of product quality differentiation for module functions (similar to traditional Japanese *sho-chiku-bai* (pine-bamboo-plum) rankings, where *sho* refers to the highest quality, while *bai* the lowest).

## 7.6 Examples of Asset Management Implementation

### *7.6.1 Pavement Asset Management in Vietnam*

The author and colleagues are endeavoring to establish international platforms for asset management in Vietnam and other Association of Southeast Asian Nations (ASEAN) countries. HDM-4 is in more than 150 countries and dominates the market as the international de facto standard for pavement management. Pavement surveys were conducted in Vietnam in 2002, 2004, and 2007, and budget plans formulated using HDM-4. However, input of over 150 data items is required for HDM-4 to function completely. The performance of deterioration prediction models based on dynamic models is poor, and arbitrary calibration is required to adapt the models to actual conditions. Local governments are aware of the problems associated with HDM-4, but because no alternative pavement management software exists and there is an insufficient supply of engineers to implement pavement management, pavement management is not functioning.

The author and colleagues developed a simplified pavement management system in conjunction with Vietnam's University of Transport and Communications. Using a database created by the Vietnamese Government, the system could simply and accurately predict pavement deterioration and evaluate life cycle costs. This alternative system employs a statistical deterioration model using the Markov deterioration model among others, and was also tested on pavement asset management operations in Japan (Kaito et al. 2010). This system has the benefit of estimating the pavement deterioration process as a performance curve based on actual measurement data, enabling the consideration of pavement management issues in line with actual conditions.

Each year since 2005 intensive training courses on asset management for road administrators and engineers employed by the Vietnamese Government or its agencies, in addition to university researchers, are run with the aim of diffusing asset management technology (Fig. 7.3). Currently, the Vietnamese Government uses HDM-4 as the de facto standard, but expressed willingness to experiment with alternative software. As a result, it was decided to conduct a road surface condition survey in 2012 and experimentally apply the Kyoto Model developed by

**Fig. 7.3** Annual summer school, Vietnam

the author and colleagues in northern Vietnam. It is possible that an asset management model based on statistical deterioration predictions could be widely diffused through such experimental operational applications in the future. Once software is established as the de facto standard, it is difficult to diffuse it even if better software is developed. However, establishing alliances with local researchers is an effective method for counteracting existing de facto standards. The Kyoto Model developed by a Kyoto University research group aimed specifically at the development of ISO5500X-compliant software. The establishment of ISO5500X could become a strategic bridgehead for forming alliances and counteracting existing de facto standards.

### *7.6.2 Diversified Standards Systems*

In the field of asset management, HDM-4 and RoSy have spread as international standard software for pavement management, and BridgeMan has spread as international standard software for bridge management; systems developed independently in Japan are isolated in international markets. The World Bank and other international financial institutions recommend the use of these international standards systems, with the reality being that Japanese asset management systems are not recognized overseas. Many international standards systems are black-box systems, specification-based international standards systems that specify input and output modality (uniform standards systems that despite the diverse needs of various countries must respond to these needs with a single software system). While these systems are methodically implemented, in reality most do not function at the worksite level. The author and colleagues wish to propose a diversified standards system in contrast to such uniform standards systems. In a diversified system, there is a uniform covering of the minimum technology required, while employing standardization strategies such as separate customization of requirements for individual functions. In other words, these are performance-based standards systems based on strategies for the performance required of individual technologies.

The author and colleagues developed the Kyoto Model with the aim of developing a diversified standards system capable of matching existing uniform standards systems. The basic concepts of this system are (1) ensuring data compatibility with existing systems, (2) opening up of software, and (3) system-supplemental customization in response to actual conditions in each country. De facto system standardization was undertaken through the development of diversified standards systems such as this and testing in the field. Adhering to the fundamental policies of such systems and based on discussions with Vietnamese researchers, a prototype for the Kyoto Model was created.

A major driving force behind the experimental implementation of the Kyoto Model in Vietnam is the annual road infrastructure asset management training course run in Hanoi by Kyoto University since 2005. In addition to enabling participants to acquire basic asset management concepts, this training course provides lectures on deterioration prediction methods (focusing on the Markov deterioration model), life cycle cost evaluation, budget planning, financial simulations, and other basic management technologies. Moreover, the software supporting asset management is open and Kyoto University jointly customized software with researchers from a local cooperating Vietnamese university (University of Transport and Communications, Hanoi). These training courses produced researchers' intent on gaining doctoral degrees, and others who lobbied the Vietnamese Government in addition to being involved in current course organization. Building up local human capital is critical for developing diversified standards systems. A road administrators' committee was established in 2011 with the aim of experimentally implementing the Kyoto Model, and agreement was reached with the Vietnamese Government to initiate a project. A decision was taken to develop a pavement maintenance and management system for Vietnam using the Kyoto Model under the Japan International Cooperation Agency (JICA) road Official Development Assistance (ODA) "Project for Capacity Enhancement in Road Maintenance" in Vietnam (July 2011—January 2014). Based on the outcome of the discussions held with the Vietnamese Ministry of Transport's Road Administration in June 2012, a survey on road surface condition was conducted in northern Vietnam, and pavement management using the Kyoto Model was implemented experimentally. It is hoped that Indonesia, the Philippines, Cambodia, Laos, and other ASEAN countries will use the Kyoto Model in the future.

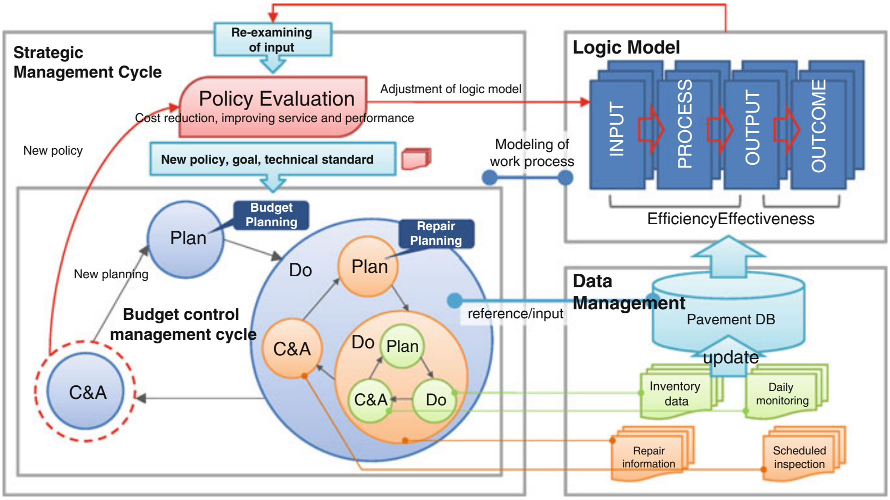

**Fig. 7.4** Basic Kyoto model structure

### 7.6.3 The Kyoto Model

Figure 7.4 shows the basic structure of the Kyoto Model, comprising a database, management support functions, and logic models. The Vietnamese project had a specifically tailored database. The database contained the following minimum information as register data: manager information (office), locational information (kilo-posts, up and down lanes, number of lanes), road specifications (road width, length), and other information (traffic volume, pavement structure). Regular inspection data included cracking ratio, amount of wear rutting, and International Roughness Index (IRI), and repair record data included repair times and methods.

Management support functions have a hierarchical structure comprising budget implementation and status management support functions for everyday operations, and strategic management support functions for regular monitoring of everyday operations from a panoramic perspective and for identifying aspects of everyday operations requiring improvement through policy evaluation. Pavement maintenance and management activities are expressed by a hierarchical management cycle, and a model for the overall operational process is created using logic models. The various groups of data required for pavement maintenance and management activities are archived in a pavement database to be used as reference materials for decision-making in everyday operations in addition to as logic model evaluation indicators for evaluating policies.

As mentioned in Sect. 7.3.1, the budget implementation and status management cycle are divided into three levels—strategic, tactical, and implementation—according to project differences. At the strategic level, the repair and renewal costs required for the long-term maintenance of the relevant road pavement are calculated and budget plans formulated. Future deterioration is estimated based on the current pavement condition and deterioration prediction models, and budget allocations are set for eligible roads in accordance to a time scale. At the tactical level, all sections of the relevant pavement requiring repair and renewal are identified, and a plan drawn up for repair based on urgency. At the implementation level, individual pavement sections undergo repair and renewal in accordance with the repair plan. Information obtained through everyday management is stored in the pavement database archives on an ongoing basis, and used again as reference data. It is desirable for ex-post evaluations of hierarchical management cycles every 3–5 years, and for new plans to be drawn up in accordance with the input improvements determined through policy evaluation in strategic (growth) management cycles.

Strategic management cycles aims to regularly review everyday management methods and set new policies, targets, and technology standards for achieving reduced costs, improved services, and enhanced performance (lengthening service life), and to apply these to everyday operations. There is a review of the budget implementation and management cycle results and new targets are set based on the degree of target achievement. The input necessary for setting targets is reviewed and the results summarized as new technology standards, with improvements made to everyday operations. Policy evaluation is undertaken based on logic models; operational processes are reviewed and logic models reconstructed.

Logic models express maintenance and management targets as results (outcomes) from a service perspective, logically linking the activities required for achieving the targets with the results and expressing the overall operations systematically. The results of carrying out operations based on logic models are evaluated quantitatively as output and outcome indicators. In accordance with these evaluations the degree to which everyday operations and individual activities contribute to overall operations are analyzed and the operations (activities) making a low contribution are identified, hence clarifying input improvement targets. When targets have not been achieved as planned, the reasons for this are analyzed using logic models and the combination of methods (input) for achieving targets are reconsidered when reviewing new plans. Thus, logic models are tools for creating overall pavement maintenance and management activity models, in addition to monitoring and improving operations. Pavement maintenance and management methods and targets to be set differ depending on the individual system, and customization of management systems focuses on the construction of logic models. Policy evaluations based on logic models require regular monitoring, and information management for calculating and evaluating output/outcome indicators is necessary. The information required through everyday maintenance and management is determined in accordance with logic model evaluation items.

The experimental implementation of the Kyoto Model in Vietnam is in the early stages and there is a focus on getting the initial PDCA cycle for pavement management to function. Although the system is incomplete, kilo-posts are installed along Vietnam's national roads. Kilo-posts are basic units for gathering

**Fig. 7.5** Checking kilo-posts with Vietnamese engineers

road-related data, with register, regular inspection, and repair record data comprehensively stored for each unit interval determined by the kilo-posts. A detailed examination of the kilo-post system for the targeted road sections was undertaken prior to the experimental implementation of the Kyoto Model. Where kilo-post signs were missing, the information was temporarily painted on the road surface (Fig. 7.5). The Vietnamese Government is aware of the importance of kilo-post systems and plans to carrying out system improvement. Road inspection vehicles conducted the surveys on road surface conditions throughout northern Vietnam in 2012, and a regular inspection database was created. The vehicles were customized to local requirements and equipment was installed locally (Fig. 7.6). Furthermore, an attempt is underway to create a database of inspection data gathered in 2007 that can be correlated with kilo-post unit intervals.

The 2007 inspection was a manual one, without the use of road inspection vehicles, and there are problems with the accuracy of the survey results. Furthermore, it was not possible to correlate much of the data with kilo-post intervals. However, completing road surface condition surveys (although manually) throughout Vietnam is very significance for demonstrating to local road managers the necessity of pavement maintenance and repair. To create an effective database, it is essential to conduct surveys on road surface conditions on an ongoing basis.

Fig. 7.6 Road inspection vehicle

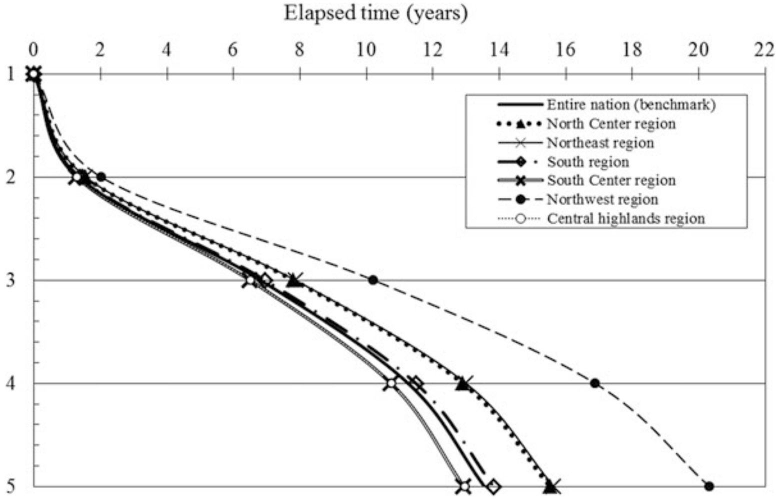

Fig. 7.7 Vietnamese pavement deterioration curve by region

Only limited road inspection data are available at present; however, an attempt was made to predict pavement deterioration using the Kyoto Model (relative comparison of deterioration speed for each route).

Figure 7.7 shows the pavement deterioration curves (performance curves) results for each area. The vertical axis shows the degree of pavement soundness, with the pavement becoming sounder the higher the curve climbs. The horizontal axis shows the length of time that has elapsed since repair; the greater the gradient of the deterioration curve, the greater the speed of deterioration. Figure 7.7 shows the large differences in deterioration speed between areas. The high speed of deterioration in southern Vietnam (around Ho Chi Minh, for example) is particularly striking. Vietnam has a long north-to-south land area and it experiences significant differences in weather and ground/geological conditions from region to region; consequently, there is no guarantee that current pavement design standards are appropriate for regional and traffic characteristics. Even these simple analyses uncover policy problems such as the need to review pavement design standards. These deterioration evaluations provide important information for the continual improvement of pavement design standards and assist in the implementation of PDCA cycles in policy management through the continual monitoring of road surface conditions, deterioration performance evaluations, and improvements to pavement design standards.

Construction of logic models for pavement management is time-consuming. Manuals, local customs and rules, inspection guidelines, and various other systematic management infrastructures are needed to prepare input for logic models. As of 2012, the Vietnamese Government had not prepared systematic infrastructure for the continual implementation of pavement management. Moreover, the management operation system for implementing pavement management is undeveloped, and it is not easy to create logic models. There is no value in consuming vast amounts of energy to construct a complete pavement management system. Pavement management is a continual process of improvement; it is enough to improve logic models gradually by analyzing new data and information, and to implement new technologies experimentally. Logic models indicate the technologies that can be used with management systems at the time. Even if logic models are incomplete, it is possible to consider such questions as the management improvements to be made, the systematic infrastructure (input) required, and the information needed to be gathered continuously to carry out ongoing improvement of pavement management.

## 7.7 Conclusion

Japan has progressed from lagging behind to being a leading pioneer in asset management technology. However, it is still developing the management implementation process of asset management; with its focus on elemental technology remaining unchanged, there is no sign of momentum being generated for integration or systemization. This is an issue not only for the construction industry but also for the Japanese economy overall. It is not possible to develop integration and systemization technology by simply making lists and accumulating individual elemental technologies and analytical techniques. What is required is a problem-solving approach, rather than generating ideas from the supply side. This approach is a break-down concept by which—based on market and organizational needs and on elemental technologies forming system cores—integration technology and system frameworks/functions are designed from a panoramic perspective, the elemental technology required for this is created, and interfaces with existing technologies are designed. ISO5500X clearly positions those responsible for asset management at the top of the organization, and these managers must initiate organizational and continual improvements to management.

ISO5500X is a process standard and does not prescribe concrete asset management technology. However, to undertake asset management in compliance with ISO5500X, asset management technology and information system technology supportive of ISO5500X must be established. There is intense international competition over the development of de facto international standards for asset management technology compliant with ISO5500X. Kyoto University is striving to develop a de facto international standard and proposes as development concepts (1) management rooted in a thoroughly hands-on approach based on actual monitoring data; (2) continual improvement of assent management through knowledge management; and (3) discovery of issues through benchmarking and problem-solving based on elemental technology. Concept (1) is realized by life-cycle evaluation using statistical prediction models, concept (2) is realized by information accumulation and knowledge management through continual improvement, and concept (3) is realized through benchmarking through data accumulation and the accumulation of elemental technology by Japan. These development concepts are appropriate considering the competitive relationship between Japanese and preexisting international de facto standards, and the relative global superiority of Japanese asset management technology.

The domestic construction market is currently shrinking and an increasing number of Japanese companies are considering expanding into international construction markets. However, is it possible for companies with no domestic competitive strength to survive in international markets where competition is more intense than in the Japanese market? Projects such as PPPs that package infrastructure operational and management services together are becoming the mainstream in the international project market. To survive in international markets, a company needs to have asset management skills superior to those of other companies and countries. The establishment of ISO5500X will have a significant impact on the international project market. It is important to establish Japanese business models embodying the relative superiority of Japanese asset management technologies to address these opportunities.

The effectiveness of Japanese technology development and management models may be declining as company environments dramatically change, but that does not mean that all of the elemental technologies these models incorporate are meaningless. Instead of single-mindedly pushing forward with the overseas expansion of Japanese technology development and management models from a Japanese perspective, Japanese companies need to consider how they can most rationally respond to the flow of internationalization that forms the bedrock of global free trade. They must then undertake joint development—based on Asian alliances—of new one-finds-own-size standards models tailored to the actual situation in each country, rather than using previous one-size-fits-all standards models. To construct one-finds-own-size standards models, new operational and management technologies, business models, and systemized platforms focused on the development of elemental technology and assembly technology—at which Japanese companies are particularly talented—and the ability to apply these technologies in the workplace need to be proposed. One-finds-own-size standards aim to realize a shift from Western-style specification-based standards to performance-based standards. It is important to propose specific new international standards models for technology development and management for which one-finds-own-size standards are the norm.

## References

Aoki K (2011) Hoso, Kaigai “de facto” hyoujyunka senryaku: the Kyoto model, (Pavement, International de facto standardization strategies, the Kyoto model). In: Kobayashi K (ed) The asset management summer school. Kyoto, Kyoto Business Research Center, pp 91–102

Chote P, Walter SM (1983) America in ruins. Duke University Press, Durham

Doi N (2001) Gijyutsu hyoujyun to kyoso (technology standards and competition). Nihon Keizai Hyouronsya Ltd, Kyoto

Han D (2012) Development of open-source hybrid pavement management system for an international standard. Ph.D. Dissertation, Kyoto University

Kaito K, Aoki K, Kobayashi K (2010) Jissen teki asset management to dai 2 sedai kenkyuu heno tenbo (Practical asset management and its perspective toward the second generation, Practical Journal, Japan Society of Civil Engineers). Doboku Gakkai Jissen Ronbunshu 1:67–82

Suematsu C (2004) Hyojyunka senryaku (Standardization strategies). In: Hioki K, Kawakita A (eds) Nihon-gata MOT (Japan-style MOT). Chuokeizai-sha Inc, Tokyo

# Chapter 8
# Human Security Engineering Education Program

**Minoru Yoneda**

**Abstract** It is not an overstatement to say that whether practical results are obtained depends on the qualities of leaders, irrespective of the field. A human security education program should foster the young generation as leaders by providing them with a solid foundation of both basic knowledge and the ability to structure problem-solving by strengthening their own capabilities and relating problems to one another from a human security perspective. The curriculum of Japan's Kyoto University human security engineering education program, where an overseas internship is strongly recommended as a mode 2 discipline, is provided as an example. Factors that should be considered in the administration of an education program are discussed, and the experiences of some program graduates are included.

**Keywords** Core subjects • Curriculum • Internship • Mode 2

## 8.1 Mastering Human Security Engineering

Realizing human security in a particular country or local region requires people with a solid basic knowledge of human society and a broad outlook. With those qualities serving as a foundation, such people can then create realistic strategies, and appropriately apply and develop the technologies needed to implement them.

Such people must have four strengths. The first strength is solid basic knowledge: civil engineering, construction engineering, and environmental engineering are basic disciplines that serve as a starting point only. It is critical to have an understanding that is reliable enough to invoke knowledge from related disciplines and expand upon it when the problems or conditions at hand require it. The next strength is the ability to apply the reliable knowledge flexibly and with technical,

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social and economic rationality, and to tailor it to the characteristics or unique social and historical contexts of the target geographic area and issues. Chapters 1 and 2 refer to "reflective practice" capabilities. The third strength required is an insight of the dynamism that exists between issues and solutions. Chapter 1 discussed this insight from the perspectives of technologies, systems, supporting approaches, and inter-relationships with society, and argued the importance of implementing strategies for their co-evolution. Chapter 3 used an example from Bangkok, Thailand to point out the importance of foresight in urban management. Both cases of Chaps. 1 and 3 highlight the importance of making use of and managing technology and systems in an integrated, long-term and prescient manner, while making allowances for issues and social contexts. The fourth strength is the ability to assign roles among, and elicit collaboration from, residents, communities, governments, international institutions, private-sector companies, non-government organizations (NGOs), and other actors to accomplish human security initiatives. In other words, the ability to understand the technical, funding, and control capabilities of all relevant actors and to combine these to design, build, manage, and operate a system that efficiently and fully meets human security objectives.

What educational setup is required to equip people with these strengths and what are the key concerns for implementing such a system? This chapter discusses the efforts of Kyoto University in Japan.

## 8.2 Implementation at Kyoto University

### *8.2.1 Human Security Engineering and the Human Security Engineering Educational Program*

As discussed in Chap. 1, human security engineering aims to strengthen and link its four foundation sub-disciplines—urban governance, urban infrastructure management, health risk management, and disaster risk management—from a human security perspective and systematize them as a problem-solving discipline. Systematizing these sub-disciplines as a problem-solving discipline is mode 2 knowledge production; hence, it is necessary to consider the following four principles:

1. A clear objective of ensuring the safety of people,
2. A strict emphasis on conditions on the ground and the taking of active initiatives appropriately tailored to local conditions,
3. Co-evolution of technology, organization, supporting approaches, and society,
4. The recognition of a multilayered governance structure and the active use of its complementarity.

Working from this perspective, five sections at Kyoto University have collaborated since April 2009 to offer a "Human Security Engineering Education Program": the Department of Civil and Earth Resources Engineering, the Department

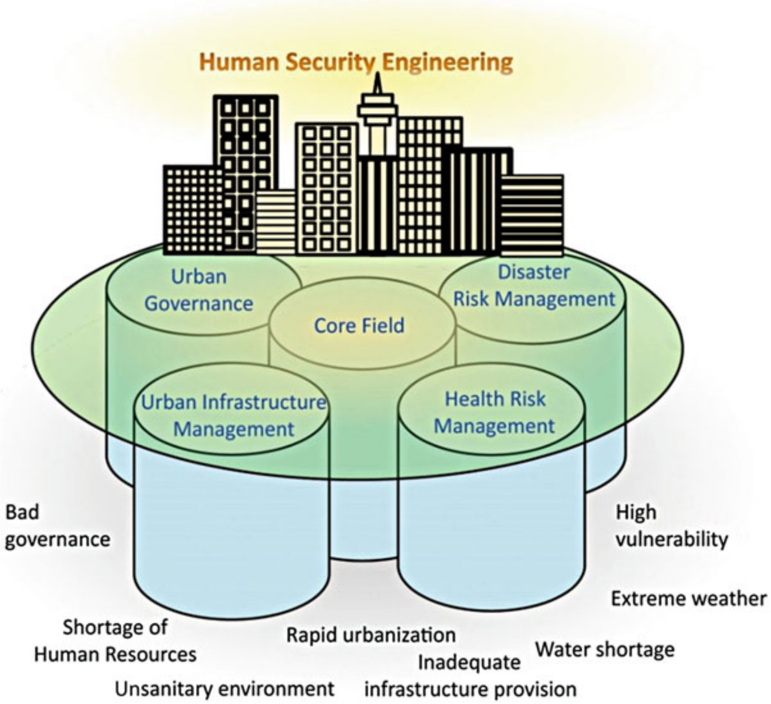

**Fig. 8.1** Core and related fields supporting urban human security engineering

of Urban Management, the Department of Environmental Engineering (all in the Graduate School of Engineering), the Graduate School of Global Environmental Studies and the Disaster Prevention Research Institute. The human security engineering education program aims to produce urban engineers and urban managers who take a birds-eye-view of complexly intertwined urban issues and have the desire and technical ability to address them from a base of scientific knowledge. Kyoto University has established supplementary courses for gaining a solid grounding in the four disciplines underpinning human security engineering, and core courses that combine the courses and distill them into a new discipline as mode 2 knowledge (Fig. 8.1). Students who take these courses gain knowledge elements that span multiple disciplines, and develop both the ability to integrate and apply these toward the achievement of urban human security objectives, and the ability to deepen and develop expertise in each discipline.

### 8.2.2 Applying Human Resources to Basic Capabilities

At present, the program at Kyoto University is for doctoral students only and aims to contribute to the development of Asian cities and countries by nurturing future leaders through the development of high-level practitioners and researchers who possess the capabilities described in Sect. 8.2.1. It is expected that students who participate in the program do so with the objectives of developing their creativity, internationality and independence. The goal of developing originality is based on the students having a broad range of knowledge and a high level of expertise related to human security engineering. These fundamentals are enhanced with the ability to combine knowledge from across boundaries, define existing fields of expertise and view the situation from a broad perspective, and the ability to continuously produce new knowledge within the mode 2 discipline of human security engineering. In developing their ability to work in international contexts, the students are expected to acquire the ability to perform research, engage in debates, and give presentations in English the language of international affairs. It is also anticipated that by acquiring the ability to build international networks of personal contacts, students will be able to expand the scope of their educational and research activities beyond the narrow bounds of their own countries to the international level. They will then be able to draw on the skills of many others in an internationally broad array of fields to manifest the human security engineering principles of having a local orientation, promoting the co-evolution of systems and societies, and recognizing multilayered governance structures. Learning to act autonomously means a student acquires the knowledge and background necessary to become a leader of society. Specifically, for doctoral students it means acquiring broad and deep knowledge and background including but not limited to the ability to solve problems on site, lead educational and research activities, plan research endeavors, and gather funding to support research activities. The human security engineering education program is structured so that students completing individual courses, while bearing in mind the three goals discussed above, will gain the knowledge and background the discipline of human security engineering requires.

The basic program structure includes a required core course, "Human Security Engineering," that is designed to engender the acquisition of solid knowledge and background in the field and to impart an understanding of its inter-disciplinarily. Required elective courses are selected from the four disciplines underpinning human security engineering.

All students are required to participate in an ORT (On the Research Training) overseas internship[1] to gain experience at the local level and to develop the ability to act autonomously and work in an international context. The structuring of internships to include activities being pursued at Kyoto University's overseas bases and with overseas research projects allows students to gain significant experience that will impart understanding of the importance of emphasizing local uniqueness and developing the ability to work in an international context. All of these courses are conducted in English, and intensive classes in the field, remote learning, and an e-Learning[2] system are used to enable students to take courses even

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[1] On the basis of research and experiments.

[2] Learning via technologies such as personal computers, television, and the internet.

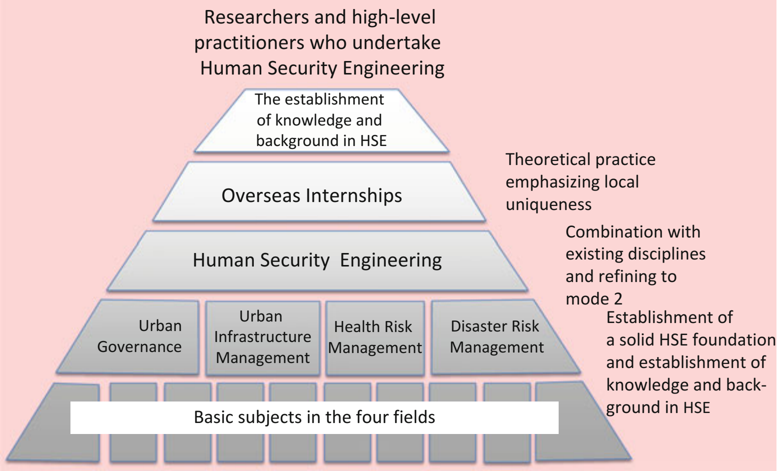

**Fig. 8.2** Human Security Engineering education system in Kyoto University, Japan [HSE: Human Security Engineering]

during the long-term overseas internships. Figure 8.2 provides a schematic of the human security engineering education program structure.

### *8.2.3 Required and Core Courses*

The Kyoto University human security engineering education program curriculum is shown in Table 8.1. To complete this program, students must earn two credits by taking “Human Security Engineering” as a required course. This is followed by two credits for the short-term internship course, “Internship for Human Security Engineering,” or eight credits for the long-term “Advanced Capstone Project”, and at least two credits for a core course from the course groups A to D, representing the four disciplines underpinning human security engineering. Students must also submit and gain approval for a research paper. While the minimum required number of credits is ten, many students will finish the program with almost twice that.

Descriptions of the required Human Security Engineering course and the core courses from the four disciplines underpinning human security engineering are presented in Table 8.2. Core courses in the four underpinning disciplines have been structured to allow students to gain a solid foundation in each of the disciplines. The Human Security Engineering core course has been structured to nurture the ability to address real-world problems based on the knowledge gained from these courses. The class schedule for the Human Security Engineering core course is shown in Table 8.3. As this shows, classes presenting overviews of each of the underpinning disciplines are followed by student presentations and instructor-student discussions on the subject discipline. Through these presentations by

**Table 8.1** Kyoto University human security engineering education program curriculum

| Subject grouping | Course/subject | Credits | Core subjects | ORT subjects | Note |
|---|---|---|---|---|---|
| | Human Security Engineering | 2 | ○ | | Compulsory |
| Group A | Urban Governance | 2 | ○ | | |
| | Lectures on Urban Governance 1 | 2 | | | |
| | Lectures on Urban Governance 2 | 2 | | | |
| | Global Environmental Law and Policy | 2 | | | |
| Group B | Urban Infrastructure Management | 2 | ○ | | |
| | Governance for Regional and Transportation Planning | 2 | | | |
| | Lectures on Urban Infrastructure Management 1 | 2 | | | |
| | Lectures on Urban Infrastructure Management 2 | 2 | | | |
| | Global Environmental Economics | 2 | | | |
| Group C | Environmental Risk Management Leadership | 2 | ○ | | |
| | Lectures on Health Risk Management 1 | 2 | | | |
| | Lectures on Health Risk Management 2 | 2 | | | |
| | Environmental Engineering for Asia | 2 | | | |
| | Management of Global Resources and Ecosystems | 2 | | | |
| | Environmental Ethics and Environmental Education | 2 | | | |
| Group D | Disaster Risk Management | 2 | ○ | | |
| | Lectures on Disaster Risk Management 1 | 2 | | | |
| | Lectures on Disaster Risk Management 2 | 2 | | | |
| | Internship for Human Security Engineering | 2 | | ○ | |
| | Advanced Capstone Project | 8 | | ○ | |
| | Research Paper | | | ○ | Compulsory |

students from various countries, students will gain problem awareness that is imbued with an appreciation for the importance of a local orientation and local characteristics. Discussions will provide opportunities to consider problem solutions and to develop awareness of human security engineering as a mode 2 discipline

### *8.2.4 Internship as a Mode 2 Discipline*

Undertaking on-site internships is extremely effective for realizing the importance of incorporating unique local characteristics and society co-evolution within an approach that emphasizes a local orientation. Establishing human security requires knowledge of local circumstances and a grasp of unique local characteristics. The objective of internships is to train students to develop solutions not by simply

**Table 8.2** Core subject descriptions, Kyoto University human security engineering education program

| | |
|---|---|
| *Human Security Engineering* | This course provides a comprehensive overview of human security engineering, a system of technologies for designing and managing cities that enable inhabitants to live in good public health conditions, and to live free from potential threats of large-scale disasters and environmental destruction. The Millennium Development Goals are evaluated from the viewpoints of four existing fields: urban governance, urban infrastructure management, health risk management, and disaster risk management. Lectures explore the relationships between the four existing fields |
| *Urban Governance* | The key to improving human quality of life lies in well-designed cities that make good use of human and physical resources. This course explores urban governance methodologies, including bottom-up decision making, based on the collaboration of various actors in solving the multi-dimensional human security problems of safety, health, convenience, comfort, amenity, and sustainability. Lecturers address interesting urban governance items, with concrete problems for students to discuss |
| *Urban Infrastructure Management* | This course aims to provide interdisciplinary knowledge on how urban infrastructure is managed, from both economic and human security engineering perspectives. The lectures address: (1) Urban Infrastructure Asset Management, (2) Urban Environment Accounting System, (3) Urban Energy Supply Management, (4) Urban Food/Water Supply Management, and (5) Urban Transport/Logistics Management |
| *Environmental Risk Management Leadership* | This course provides lectures on the theories of risk analysis, risk identification, risk assessment, risk evaluation, and risk reduction for human health and ecology. The main purpose is to provide the students with the basic knowledge required of environmental leaders who solve environmental issues almost as soon as they arise in developing countries. Several international environmental projects are reviewed as case studies |
| *Disaster Risk Management* | Natural disasters have low frequencies but high impacts. It is essential to develop an integrated risk management plan that consists of countermeasures such as prevention, mitigation, transfer, and readiness. This course presents the economic side to natural disaster risk management and designing appropriate countermeasures |

working with existing knowledge at a desk but by going to where the problems are, developing a grasp of them, and mobilizing knowledge from across a variety of fields.

In Kyoto University's human security engineering education program, students are assigned internships for which they submit reports; examples of these reports are included in the Appendix. Internships are not merely to allow students to observe on-site conditions. They are intended as opportunities for students to immerse themselves in real human security problems arising from the rapid formation of Asian megacities, develop an understanding of the problems, and work to find solutions while considering unique local characteristics. At the internships sites, students are expected to exercise capabilities and take responsibility as people with some degree of expertise. As students focusing on the field of human security engineering, they are also expected to exercise leadership and to implement

**Table 8.3** Human Security Engineering schedule, Kyoto University human security engineering education program

| No. | Theme |
|---|---|
| 1 | Orientation, self-introduction and photo session |
| 2 | Tentative overview of Human Security Engineering |
| 3 | Urban Governance (1) |
| 4 | Poverty Traps |
| 5 | Urban Governance (2)- presentation and discussion |
| 6 | Urban Infrastructure Management (1) |
| 7 | Human Rights, Property and Social Capital |
| 8 | Urban Infrastructure Management (2)- presentation and discussion |
| 9 | Disaster Risk Management (1) |
| 10 | Evaluation and report |
| 11 | Disaster Risk Management (2)- presentation and discussion |
| 12 | Health Risk Management (1) |
| 13 | Human Security and Environmental Security |
| 14 | Health Risk Management (2)-presentation and discussion |
| 15 | Discussion on Human Security Engineering |

concrete solutions. The program's internships, hence, are opportunities for students to test the basic knowledge they have acquired and their ability to assemble, further develop, and apply it to a real-world situation. Internships also serve as on-site training opportunities where students can polish their capabilities. Students who complete long internships outside their home countries develop the ability to work in an international context, while learning the rudiments of (and actually begin to) forming networks of people with some connection to their future research field. Internships, as on-site learning opportunities, provide students with valuable educational benefits not available through classroom study alone, and are indispensable elements of the human security engineering education program.

### *8.2.5 Short-term Courses for Working Professionals*

The human security engineering education program at Kyoto University is primarily a doctoral course of study. However, given its objective of nurturing leaders for establishing human security in megacities, the program offers courses for practitioners already engaged in megacity urban management and continuing education courses. Solving the various problems that have emerged with exploding populations and rapid urbanization in Asian cities requires the establishment of approaches that emphasize a field-oriented perspective to take account of unique local characteristics. A wealth of knowledge also exists that was previously developed amid efforts to solve pollution problems experienced in Japan and other countries and this remains valuable as a reference. It is possible, in other words, to learn from the past. It is often the case that the value of knowledge, not fully appreciated as a student, is finally understood when it is urgently needed to solve a real problem encountered in the field. It is important, therefore, to relearn past lessons as a practitioner. In recent years, there is a particular need for the rapid development and expansion of recent knowledge and technology to address the problems of warming and climate changes advancing on a global scale; this has happened in conjunction with a discarding of knowledge and technology considered obsolete. The knowledge and technology gained from past experiences however, is valuable and cannot be gained through cracking open old textbooks; the offering of opportunities by institutions focused on education for working professionals and recurrent education (lifelong learning)[3] is a must. In keeping with its human security engineering education program, Kyoto University offers refresher short courses for practitioners at its overseas bases and short courses where local practitioners learn state-of-the art technologies in Japan and other locations. Previous graduates of Kyoto University's doctoral course in human security engineering also need recurrent education: such opportunities should be made available at least once every 10 years. These short courses could last anywhere from one day to several months, depending on the course content. In an ideal situation, recurrent education courses would be offered on a regular basis and the university offering the short courses and its graduates would maintain a network for ongoing close information sharing. Leaders of municipal governments would recognize the importance of recurrent education and would implement the taking of short courses on a regular basis. Universities offering short courses should constantly, and systematically, provide the cutting-edge knowledge and technology that cities actually need. Indeed, this will be a university mission going forward. Human security engineering is a new discipline that has arisen as a result of the need to respond to the rapid birth and development of megacities in recent years.

Several matters should be considered in administering an education program.

1. Educational purpose
   The first thing that should be considered in administering an education program is the type of graduates it aims to turn out. Human security engineering is a mode 2 discipline hence there are no specialized textbooks and no generally accepted curriculum. The reference point in considering what should be included in a human security engineering curriculum, therefore, is found by examining the ultimate purpose of such a program: to nurture people who can become researchers and practitioners capable of applying engineering knowledge for the establishment of human security, and, at the highest level, become experts leading countries or regions. The education program can take various forms but it is vital to keep the fundamental purpose in mind. Neglecting it can result in a program that is incoherent, lacks integrity, and degenerates into a hodgepodge of courses. Care should be taken to ensure this does not come to pass.

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[3] Educational strategy where education is spread over the life span of individuals.

2. Solid basic education
   Pursuing locally oriented research in the mode 2 discipline of human security engineering requires a solid grounding in more than one of the four disciplines underpinning human security engineering. When structuring a discipline like human security engineering from a combination of existing disciplines, establishing a solid core in the beginning makes it possible to avoid major failures and the expense of unproductive efforts.
3. Curriculum not biased toward existing fields
   It is necessary to structure the education program in a way that does not lean toward any particular existing fields. If the program provides students with knowledge in only certain fields it runs the risk of turning out graduates who are deficient in their ability to identify the essence of problems and are only able to provide inefficient, temporary solutions. The program must preclude the possibility of students concentrating their studies in only certain fields and ensure they have a broad field focus so they are well versed when considering real-world problems at the local level. The curriculum must also avoid an excessive focus on classroom work and should require participation in on-site problem solving through internships or other means. It would be ideal to work with universities and other entities in different countries and regions to make on-site training possible in a broad range of areas.
4. Training and the joy of learning
   To help students gain skills in human security engineering—a mode 2 discipline in which knowledge is deepened through efforts to identify the essence of real problems and consider solutions for them—a program should include substantial classroom training in which students analyze, conduct presentations on, and discuss real problems. It should also use these opportunities to allow students to communicate with one another to foster awareness of their common association with the same program and to give them a chance to build a network of contacts within the program. In Kyoto University's program, doctoral students (who usually have contact only with other students working in the same research group and from the same country) enjoy discussions with fellow students from over ten different countries. Each student has knowledge of problems specific to certain places, and the program provides them with an excellent opportunity to build their own human networks. These opportunities allow students to experience the joy of learning and encourage them to choose human security engineering as their career, and are one of the factors behind the success of the program.

Considering the matters discussed above, together with the special characteristics of core courses discussed in Sect. 8.2.3, structuring a human security engineering education program enables the establishment of knowledge and background in human security engineering as a mode 2 discipline. Kyoto University's human security engineering education program content is shown in Fig. 8.3, including the departments under which various parts of the program are conducted.

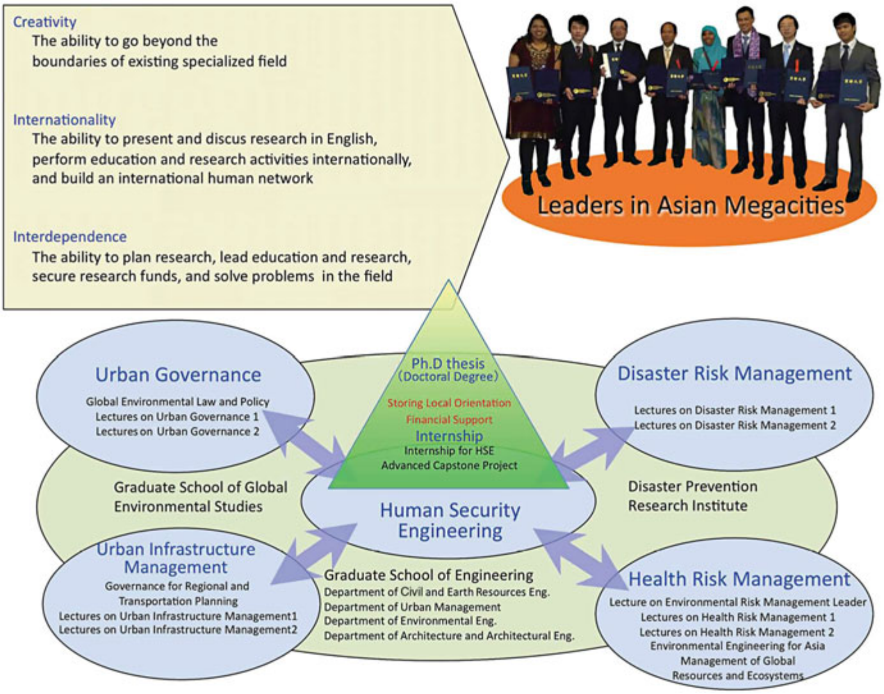

**Fig. 8.3** The contents of Kyoto University's human security engineering education program and the departments under which various parts of the program are conducted

## 8.3 Future Development

Human security engineering is based on a strong local orientation hence it requires the creation of an educational activity foundation in various countries and regions. One approach is to operate facilities based in foreign locations. Operating overseas facilities requires commensurate financial wherewithal, but overseas facilities that collect information on their host countries and local areas and develop local human networks are indispensable for effective on-site education. Kyoto University presently operates seven overseas bases. Improving the operation of these and creating new bases in other countries and regions would contribute to the expansion of its education programs.

The operation of overseas bases requires significant financial and human resources, making it very difficult for one university to operate multiple overseas facilities. One solution would be the formation of human security engineering education programs at universities in multiple countries. These universities could then form a network and operate facilities that would serve as overseas bases for network members. An ideal situation would be for such a network to employ, for example, instructor and student exchange programs and a credit transfer system to effectively form a single human security engineering education program spanning Asia and even the entire globe. This concept in recent years has often been referred to as “Campus Asia”. Its realization would mean the establishment of a uniform credit transfer system making it possible to count required and other courses taken at any of the leading universities of Asia as credits toward graduation. It would also mean the establishment of a double-degree system making it possible to simultaneously obtain degrees at two or more universities; this is sometimes referred to as a “dual-degree” or “joint-degree” system, with these terms often used to represent small differences in systems. There is no strict uniformity in double-degree system definitions as the systems have been considered and implemented in ways that differ by country or region. These systems are still in a developmental stage; partly it seems because of the difficulty of arriving at a single universally accepted definition of what a double-degree system is. It is possible, with the approaches described above, to structure a relatively low-cost system that permits the use of a large network of overseas bases and is highly effective from an educational perspective. Students who are acquiring or researching cutting-edge knowledge and technology in an advanced country would have the opportunity of experiencing urban problems in developing countries and, faced with the need to propose solutions, could develop firsthand understanding of the details and value of information needed to perform cutting-edge technological research in developed countries. Conversely, students attempting to acquire knowledge and technology for establishing urban human security in developing countries could absorb cutting-edge knowledge and technology more efficiently through studying in an advanced country. Developing countries face urban problems such as steeply rising populations and a lack of basic infrastructure: advanced countries face urban problems such as population aging and infrastructure deterioration. Furthermore, there is an extremely strong regional component to the lack of basic infrastructure in developing countries, meaning that the details and type of missing infrastructure differ greatly by country and region. A “Campus Asia” type concept would therefore be beneficial for studying the handling of various urban problems, and the establishment of systems, including those for credit transfers and double-degrees, is a matter of great urgency. The future establishment of human security engineering education programs in numerous countries and regions will enable acceleration of such systems.

A further future development path is the establishment of master’s degree programs. Such programs will have to provide a solid foundation for students, avoid bias toward any particular field of expertise, and require internships that give shape to on-site education. A particular challenge for master’s degree programs, however, will be the formulation of curricula that cultivate solid foundations in the disciplines underpinning human security engineering while not leaning too far toward any one of them. Kyoto University’s doctoral program expects that students have already developed some level of knowledge in the disciplines underpinning human security engineering and, therefore, can assure that students have established solid foundations in the disciplines by taking only one core course in each. For master’s students, however, it would be necessary to assemble curricula giving substantial coverage of these disciplines; this could require a system managed jointly with multiple representative programs in these disciplines. In addition, it is envisaged that a master's program would consist of content aiming to nurture graduates more focused on practical and governmental matters than would be their doctoral counterparts, and that it would, therefore, be a program that nurtures the human resources urgently needed in developing countries. Consequently, it would be effective to consider the establishment of a master's program together with the establishment of an international education network for human security engineering.

In the 4 years since the essential start of the human security engineering education program at Kyoto University, 148 students have taken the doctoral program, and over 80% of them have been foreign students from within Asia. The number of students from Asia indicates that there is currently a strong need for the human security engineering discipline among countries in that part of the world. If similar education programs were established at the universities of those countries, it could be expected that they too would host a mix of local and foreign students. Indeed, to establish human security in the Asian continent, and throughout the world for that matter, education programs should be international. It looks certain that the concept of human security engineering will be implemented in more universities in the future, and that graduates of human security engineering education programs will form networks and act to solve human security problems in Asia from an engineering perspective.

### 8.3.1 Experiences of Human Security Engineering Graduates

*Japanese Student*: I joined a Young Scientist Summer Program at an international research institute on a long-term internship as part of a HSE (Human Security Engineering) course. During the program, I acquired not only research skills but also communication skills required in international activities through the communications with foreign researchers and students. I also had a very wonderful time with many foreign students at the HSE course. I would like to thank the HSE administrators for their organizing, coordinating and supporting of the HSE program at Kyoto University.

*Japanese Student*: HSE provided a good opportunity for me to think about "Human Security (HS)". The theme of my doctoral thesis is governance, the background being "from government to governance" where resource decline and the lowering of confidence in the government sector have led to the transition to a pluralistic governance. HS is similar to governance in that it is based on the premise that the conventional concepts of security, such as military and foreign policies, have reached a limit. In addition to existing approaches, a human-focused approach like HS will be indispensable to create a truly peaceful and happy society such as that seen in the fairy tale "The north wind and the sun". I majored in history and was not involved in engineering as an undergraduate, but I specialized in environmental policy in graduate school and so got this good opportunity. It is said that doctoral students tend to stick to their own specialties and be removed from having free ideas. However, I have learned about various methodologies through the HSE course and have been able to enlarge my horizons.

*Japanese Student*: In the HSE course, I studied the toxicity of nanoparticles to evaluate the health risk to humans. In the classes, I refined the basic skills for working abroad through English presentations, discussions or reports. In the long-term internship, I stayed in the ITRI (Industrial Technology Research Institute) located in Taiwan and worked with Taiwanese researchers. These experiences will be helpful to work in my next workplace, Malaysia.

*Korean Student*: The HSE program helped me to realize anew the different types of environmental problems. Furthermore, it enabled me to study the methods of solving environmental problems as a doctoral student, whose major is environmental engineering, with professors and other students. Thank you very much.

*Vietnamese Student*: The HSE program's aim to provide education in the core field of HSE will enable us to properly integrate and apply our knowledge, and create new methodologies to ensure urban human security, as researchers and high level practitioners. Through course work and overseas internships, in which students from different areas actively meet and debate from various perspectives, each student will acquire the ability to understand research from a comprehensive viewpoint.

*Indonesian Student*: The objective and policy of the HSE course covers a wide range of abilities indispensable for students who have chosen human security as their research theme. Conducting internships in the field as a form of empirical research enables students to integrate theory with real case studies and seek appropriate problem solving approaches. Hence, I feel it is necessary to sustain and broaden the HSE program.

*Chinese Student*: I have studied interdisciplinary knowledge in the HSE course for 3 years. The HSE course has taught me to observe things in more perspectives. I will contribute what I learned in this course to society.

*Filipino Student*: I feel fortunate to be a part of the HSE course. The topics discussed in the lectures provided me with a multi-disciplinary mindset necessary for tackling today's environmental problems, while the internship opportunities enabled me to gain practical knowledge that I can apply in my future career and the chance to present my findings before an international audience.

## Appendix: HSE Students' Internship Reports

### *Malaysian Student*

Application of energy efficiency improvement to low carbon societies in Malaysia.

The period of internship was 26 days.

In February this year, I undertook my internship at my host organization, Universiti Teknologi Malaysia here in Skudai, Malaysia as part of the HSE internship program. The main objective was to evaluate technology adoption and sustainable practices in the Malaysian industrial sector that can lead to greenhouse gas emission reduction. The study will cover possible paradigm shifts in the type of industries and technologies that will be implemented in the coming years. Naturally, the strategies proposed for the promotion of a Low-Carbon Society (LCS) in Malaysia would be different from that of other countries because of the difference in natural environment and economic activities. For this reason, the internship focused on data collection activities and discussions with key persons such as policy makers and representatives from the Malaysian government, and representatives from Energy Commission, Department of Environment and research institutions such as the Malaysia Green Technology Corporation. The internship was worthwhile as it broadened my point of view regarding the importance of LCS implementation for future and existing societies all over the world.

### *Indian Student*

Towards sustainable urban densities: optimum density function for Asian megacities.

The period of internship was 19 days.

The internship allowed me to meet government officials, academics, private consultants and other organizations associated with the planning and mapping of Mumbai and Ahmedabad (in India).

The experiences obtained from the two cities were quite different. Mumbai is a megacity with 12 million people in the core city area of 430 $km^2$, with a very pronounced Central Business District that attracts migrants from the entire country, providing a rich heterogeneity. It has extreme contrasts in economic status, living conditions, purchasing power, and access to basic resources. Although complex systems of urban problems arise, the city thrives among its slums and extremes of density.

Ahmedabad is a growing city that has seen a radial sprawl. Its activity areas are dispersed and although some areas of congestion and overpopulation exist, the overall quality of life is high. The city is growing spatially to accommodate its growing population, hence not giving rise to exponential increases in density overall.

Extensive data has been collected to measure density, level of development and human security of the citizens. Nanoparticles are organized into a uniform format and then mapped, so that comparisons can be made.

## *Thai Student*

Multi-agent modeling for evaluating urban freight policy measures

The period of internship was 11 days.

This internship is focused on the distribution center that is one of several components of logistics management systems. The distribution center is a utility infrastructure that can decrease the inventory cost, is useful for loading and unloading goods, and makes high use of vehicle capacity.

The distribution center which supplies and delivers the goods to retail stores, where consumable goods demand is high and the frequency is almost 24 h a day, are subjected to the cross-docking concept to manage distribution, transportation and retail. Cross-docking is used to consolidate goods from several suppliers and sort them to outbound shipments to different retail stores to achieve economies of scale and environmental issues. I visited the logistics distribution center to discuss these issues and other relevant research issues on logistics management systems.

I had the opportunity to discuss with expert persons to about distribution center systems related with my research. A significant milestone in this internship was the establishment of common research interest about logistics stakeholders.

## *Nepalese Student*

Water security in Kathmandu.

The period of internship was 16 days.

The purpose of my 2-week internship in Nepal was to learn about existing water supply and sanitation system in Kathmandu, and to explore the issues concerning water supply and sanitation that needed to be addressed through research. The internship gave me an opportunity to build my network of contacts with governmental and non-governmental organizations working for water supply and sanitation. The consultation meetings and site visits provided me with preliminary information about the water supply and sanitation in Kathmandu. The officials and experts explained about the problems in fulfilling increasing water demand and the plans they have undertaken for solving those problems. They often stressed the preparation for the Bagmati Action Plan and the researches necessary to carry out the plan. I was under the impression that their efforts were concentrated more toward increasing water supply rather than managing water demand. Through further consultations with them and my supervisors, I plan to develop my research theme based on water demand management.

## *Indian Student*

Community action planning for disaster risk reduction in Delhi, India.

The period of internship was 27 days.

My internship had two main objectives: one was to share the results of my questionnaire survey that was done with Residential and Welfare Associations (RWAs) groups on community action planning for disaster risk reduction in East Delhi (India); the second objective was to develop a multi-stakeholder initiative for disaster risk reduction in East Delhi. For the first objective, the results were shared through meetings with key officials from the Delhi Government; Hon. Member of Parliament (MP) of East Delhi; and RWAs (Resident Welfare Associations). For the second objective, a multi-stakeholders workshop was conducted. It was organized by the National Alliance for Adaptation and Disaster Risk Reduction (NAADRR) with technical support from Kyoto University. The key officials from the Disaster Management Authority; RWAs; Hospitals, and local NGOs were invited and consulted during the workshop. A multi-stakeholders forum for disaster risk reduction was launched based on my previous study. The forum will have periodic meetings and will self-empower communities through knowledge sharing. It will have a training wing that will guide, train, and strengthen communities for better readiness for a disaster situation in East Delhi.

## *Vietnamese Student*

Study on the environmental situation of lead and zinc mine exploitation.

The period of internship was 45 days.

The main goal of this internship was to understand the excavation and environmental status of mines in Vietnam, as well as relevant problems in waste treatment and disposal at mining sites. I contacted related institutions, organizations, universities, and companies to approach the issues with full and exact information. The collected information helped me to clearly grasp the situation of the mining waste sites. I conducted a survey and on-site monitoring at lead and zinc mines in Cho Don district, Bac Kan province of Vietnam. This is the biggest mine that contains lead and zinc ores in Vietnam, and it has been reported by the media to be beset with many environmental problems. I took samples of soils, surface water, ground water, and some plants to analyze and identify the concentration of toxic parameters in the environment. From the internship, I learned the exploitation situation, and the current environmental issues of lead and zinc mining in particular, as well as metal mining in general. I strongly believe the internship has led me in the right direction for my doctoral thesis.

## *Japanese Student*

Occurrence of pharmaceuticals and personal care products in the water environment.

The period of internship was 61 days.

I am dealing with risk assessment and finding out solutions for the problems originated from pollution by Pharmaceutical and Personal Care Products (PPCPs) in the water environment. In my internship, I had an opportunity to conduct research on water pollution in China, as a part of the Advanced Capstone Project at the Graduate School at Shenzhen, Tsinghua University, China (Kyoto University–Tsinghua University Cooperative Center for Environmental Engineering). The analytical results of samples taken along a small river and its coastal region of Shenzhen indicated the occurrence of pollution due to PPCPs in some areas, implying the importance of the precise estimation of PPCPs and a risk assessment of their poisonous properties. Through international collaboration with many Chinese researchers, I found that building up a trustworthy relationship was important. The results of the research were presented at the first "International Symposium on Industrial Pharmaceutics and Clinical Pharmacology" at Guangzhou, and the first "GCOE (Global Center of Excellence) Shenzhen Overseas Base Symposium, Kyoto University–Tsinghua University". The internship prompted me to have a more international mind and acquire greater leadership.

## *Japanese Student*

Impact of geomorphological factors on glacier melting and associated glacial lake expansion in the Himalayas, Nepal.

The period of internship was 35 days.

My research topics are glacier melting and glacial lake expansion mechanisms in the Himalayas. Glacier melting is a very big issue in Himalayan countries. However, most of the glaciers are located at an altitude of around 5,000 m, thus there is not enough observation data. I investigated the Imja glacier and collected meteorological data for 10 days. I obtained a new hypothesis that the main factor of glacial melting is not increasing temperature caused by global warming as widely recognized, but the impact of weathering on glaciers. When I talked with local people, they said, "We don't like researchers, because they just take some photos and report to the world that Imja glacial lake is dangerous. We also feel that their investigation violates a holy mountain". Even though the Internet made it easy to get access to the latest reports and journal articles, I keenly realized that there were still a lot that were only locally available. I learned that it is important to explain the significance of the study to local people and get their assent for research. For such occasions, I would like to improve my communication skills, including not only language but also cultural understanding.

# Glossary

**Accountability** The responsibility that a party commissioned to take action has to explain or report its actions to the commissioning party.

**Advocacy** Acting to uphold the rights of others, for example, who are not socially empowered. For certain issues, the making of political policy statements.

**Alliance** Partnership or cooperation among multiple companies.

**Basic human needs** Primary basic human needs are the minimum food, housing, clothing, and other goods, necessary for human life. Secondary basic human needs are basic services that should be provided by communities such as safe drinking water, sanitation facilities, public transportation, education, culture, and other basic services humans require. In this book, basic human needs refer to all of the above.

**Capacity development** The United Nations Development Programme (UNDP) considers this the process of developing the ability to solve problems, or set objectives and achieve them, through individuals, organizations, systems, and society as a whole performing their roles either individually or together. This concept is considered to be very important in the field of development assistance. It has been adopted by most assistance institutions that value nurturing the ability of developing countries to initiate and lead the solving of problems.

**Catastrophe bond** A type of bond linked to natural disaster risk. Often referred to as "cat-bonds," they include provisions for the payment of interest at a high yield in exchange for a reduction of interest and principal payments in the event of a natural disaster.

**Co-evolution** Evolution of multiple closely related entities that mutually impact each other. In this book, the term co-evolution is used to describe the developmental process where technologies, system construction, and urban management influence each other.

**Community** A group with common interests, concerns, government, manners, customs, and residential areas.

**Compatibility** In this book, the term compatibility means making it possible to use a common database for different asset management systems (Highway Development and Management Model HDM-4 and the Kyoto Model).

Y. Matsuoka and M. Yoshida (eds.), *Challenges for Human Security Engineering*,
Environmental Science and Engineering, DOI 10.1007/978-4-431-54288-9,

**Disability-Adjusted Life Year (DALY)** An index summing years of life lost to disease, disability, and premature death, and years of life lost to ill health. Years of life lost (YLL) is calculated as the product of number of deaths and average life expectancy (by age group). Years lost due to disability (YLD) is based on the number of people with disabilities, seriousness of disability, and years of life expectancy lost. DALYs are calculated by summing YLL and YLD.

**Discipline** In this book, discipline means an academic discipline. Human security engineering comprises four disciplines—urban governance, urban infrastructure management infrastructure, health risk management, and disaster risk management.

**Empowerment** Providing individuals, groups, or organizations with the authority and capability necessary for autonomous action. Enhancement of capability.

**Engineering** An academic discipline the objective of which is to construct−from a foundation of mathematics and natural sciences, and with occasional application of knowledge from the social sciences−objects and comfortable environments that are useful for public safety, health, and welfare. Refer to Sect. 1.2.1 of Chap. 1.

**Environmental rights** The rights of people to pursue livelihoods amid sound environmental conditions.

**Exposure** The state of being subject to the threat of a hazard. Exposure in the context of natural disasters refers to the state of populations and/or assets threatened by natural disasters

**Field knowledge** Understanding and awareness gained from dealing with matters in individual places and times, with full consideration of ambiguity.

**Framing** Perspective from which conditions or issues are defined. Refer to Sect. 1.2.3 of Chap. 1.

**Good governance** The achievement of efficiency, effectiveness, transparency, legal control, and a dialogue with civil society in politics and administration.

**Governance** Forming and implementing mechanisms and rules for forming agreements, distributing authority or resources, and undertaking decision making among multiple actors.

**Government assistance, Community cooperation, Mutual** Government assistance; cooperative and mutual aid organized by local citizens; autonomous mutual assistance based on local organizations or family organizations; and self-reliance in responding to a certain issue are referred to, respectively, as public assistance, cooperation, mutual aid, and self-reliance. Cooperation and mutual aid are often not distinguished from one another and simply referred to as mutual aid.

**Hazard** Cause of danger. In the context of natural disasters, hazards are earthquakes, typhoons, torrential rain and other natural phenomena.

**Hazard map** A map showing the degrees of anticipated damage from exposure to hazards, and the geographic scope of anticipated damage. Natural disaster hazard map development is being pursued to address phenomena such as flooding, landslides, earthquakes, volcanic eruptions, tsunamis, and high tides.

**Human development** People expanding the breadth of life choices and opportunities they have, based on their own will. This refers not only to economic growth indicators like living a long, healthy life, fulfillment of intellectual needs, the opportunity to secure the economic means necessary for maintaining a certain standard of living; indeed, it emphasizes increasing essential choices for people. The concept of human development is advocated by the Pakistani economist Mahbubu ul Hag.

**Human Development Index (HDI)** An indicator of the quality of life and degree of development of the world's countries. It is defined as the average of three indicators - average life expectancy, literacy rate, and per capita gross domestic product. Each indicator is calculated using a definitional equation. The HDI is used in the Human Development Report issued every year by the UNDP.

**Human security** A security concept put forth in the Human Development Report 1994, issued by the UNDP. In contrast with national security, it is a view of security that focuses on people. Refer to Sect. 1.2.2 of Chap. 1.

**Human security engineering** A system of technologies for designing and managing a society that frees people from the threats of poor sanitation and unhealthy circumstances in daily life, as well as threats from major disasters and widespread environmental destruction, and enables the comfortable pursuit of life with dignity. Refer to Sect. 1.2.1 of Chap. 1.

**Hyogo Framework for Action** Comprehensive disaster prevention and reduction plan aimed at creating countries and communities well prepared to deal with disasters. Adopted at the World Conference for Disaster Reduction held by the UNISDR in 2005 in Kobe, Japan.

**Infrastructure** In this book, infrastructure is used synonymously with social infrastructure. The Japan International Cooperation Agency (JICA), 2004 states that "Infrastructure is a fundamental common foundation for protecting the lives and livelihoods of people and ensuring their rights to pursue their lives in safety and good health, and plays the role of enabling people to exercise their innate abilities and realize their potential." In this book, it is important to remember that infrastructure does not mean only physical assets like bridges and roads.

**Mega-city** Often defined as a city with a population exceeding ten million. In this book, mega-city also includes Singapore, Hanoi Vietnam, Kuala Lumpur Malaysia, and other cities with populations that do not exceed ten million but that are politically, economically, and culturally important to their countries. In Japan, city is a distinction with an administrative definition. This book, however, defines city based on certain principles rather than clearly defined administrative distinctions.

**Millennium Development Goals (MDGs)** The MDGs are a compilation of eight development objectives agreed on by 189 United Nations member states at the Millennium Summit of the United Nations in 2000. This compilation is based on various previously agreed international development objectives and serves to put them under a single framework. The eight objectives, which are to be achieved by 2015, are: eradicating extreme poverty and hunger; achieving universal primary education; promoting gender equality and empowering women; reducing child mortality rates; improving maternal health; combating HIV/AIDS, malaria, and other diseases; ensuring environmental sustainability; and developing a global partnership for development. Quantitative objectives have been established in each case. Refer to Sect. 1.2.2 of Chap. 1.

**Mitigation** In the context of disaster risk measures in this book, mitigation refers generally to measures taken to reduce risks to vulnerable assets before disasters occur.

**Mode 2 science** Michael Gibbons labels the sciences where issues that should be researched are determined based on theories internal to individual disciplines, and where research is reviewed by peers within the discipline, as mode 1 sciences. He distinguishes them from mode 2 sciences where issues are determined by social requirements and trans-disciplinary initiatives to address them. This book places human security engineering among the mode 2 sciences. Refer to Sect. 1.2.3 of Chap. 1.

**(Crude) Mortality rate** Figure equal to the number of deaths during a certain period, divided by the population during that period. Often written (as here) as the number of deaths per 100,000 of population during a year. When this figure is expressed as the mortality rate without adjustment for age, the term crude mortality rate is also used.

**Net benefit** In cost-benefit analysis, the results after costs are deducted from the benefits to be gained from implementing a project.

**Ownership** In this book, ownership refers to the consciousness of oneself as a concerned party or actor; thinking of oneself as directly involved in or related to a certain project or issue.

**Pandemic** An infectious disease affecting large numbers of people across a wide area spanning multiple countries or territories.

**Participatory Rural Appraisal (PRA)** An appraisal approach advocated by Robert Chambers in light of the need for local residents to participate in the proposal and assessment of development projects.

**Partnership** A relationship of mutual cooperation and shared responsibility among various actors pursuing common objectives.

**Project Cycle Management (PCM)** A project undertaken to achieve given objectives within a certain time period and budget. Project cycle management refers to the effective, efficient management of project planning, proposal, implementation, monitoring, and assessment as cycles.

**Reflective practice** Consciously and systematically re-examining conditions and experiences amid practice, adjusting actions, and deepening insight. Emphasis is placed on conversation with situation regarding the complicated, complex problem at hand. A professional who practices reflection in action is referred to as a reflective practitioner. Refer to Sect. 2.4.1 in Chap. 2.

**Reflexive** The quality of a practitioner re-examining his or her own actions and words.

**Residual uncertainty** The uncertainty that remains even after various risk management measures have been taken to address a certain risk.

**Resiliency** The ability of a system, community, or society to resist the impacts of hazards, and recover to the original condition. Refer to Sect. 5.2.3 of Chap. 5 and Sect. 6.4.1 of Chap. 6.

**Self-help** To conduct some activities by individuals or family themselves

**Slum** An urban area in which the poor live in high concentrations. A practical definition put forward by UN-Habitat, states that a slum is characterized by "inadequate access to safe water, inadequate access to sanitation and other infrastructure, poor structural quality of housing, overcrowding; and insecure residential status." Refer to Sect. 5.1.2 of Chap. 5.

**Social capital** A third concept of capital differentiated from physical capital and human capital (the knowledge and skills of people). Refers to good faith and reciprocity, norms, and social networks.

**Social rights** Rights to lead a life worthy of a human being. They include, for example, the right to exist, the right to receive an education, basic rights to work, and social security rights.

**Stakeholder** In this book, stakeholder is used to mean interested party.

**Standardization** The process by which certain standards are established from among multiple technical specifications being applied in a market. A de facto standard is a standard that has been adopted as the result of market competition. A de jure standard is a standard developed by a national government or group of experts.

**Subsidence** Phenomenon in which the ground sinks. Ordinarily, ground where subsidence has taken place will not return to its pre-subsidence height. Subsidence is irreversible. Principal causes of subsidence include excessive pumping of groundwater and extraction of natural gas.

**Tacit knowledge** Knowledge that cannot be expressed in words. Examples include personal skills or know-how, or a personal perspective or insight. Concept originally proposed by scientist and philosopher Michael Polanyi.

**Technical rationality** In practice, the criterion for using scientific theories and technologies as tools for assessing rationality to the extent possible with theories and technology.

**The United Nations Human Settlements Programme (UN-Habitat)** Abbreviated as UN-Habitat, a UN organization established in 1978 for the purpose of providing adequate shelter for all people, and promoting the formation of socially and environmentally sustainable cities and towns. The Secretariat is located in Nairobi, Kenya.

**The United Nations International Strategy for Disaster Reduction (UNISDR)** One of the secretariats of the United Nations. Established as the secretariat for disaster reduction strategies in December 1999, its purpose is to carry on the work of the International Decade for Natural Disaster Reduction (1990–1999) and implement international strategies for disaster reduction (UN General Assembly resolution 54/219).

**Vulnerability** The extent to which damage can be easily received from exposure to a hazard. Refer to Sects. 5.1.1 and 5.1.2 of Chap. 5.