



# Sustainable Infrastructure in Asia

## Overview and Proceedings



Seoul Initiative Policy Forum on Sustainable Infrastructure  
Seoul, Republic of Korea, 6-8 September 2006

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Environment and Sustainable Development Division  
United Nations Economic and Social Commission for Asia and the Pacific  
United Nations Building  
Rajadamnern Nok Avenue  
Bangkok 10200, Thailand  
[www.unescap.org/esd](http://www.unescap.org/esd)

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The publication was prepared by Mr. Jung Kyun Na and Ms. Vivian Raksakulthai, the Environment and Sustainable Development Division (ESDD) of ESCAP. Part I was prepared under the direction of ESCAP secretariat by Dr. Vilas Nitivattananon and Dr. Shinya Hanaoka, the Asian Institute of Technology, with the contribution from colleagues in ESDD. Cover design by Mr. Eric Roeder.

# Background

Asia now has 71 per cent of the global population that is without access to improved sanitation and 58 per cent of those without access to safe drinking water. In the coming decades, a growing population and increased urbanization requires Asian countries to build the water, energy, waste management, and transport infrastructure that will support their needs. At the same time, “Green Growth” calls for continued economic growth while ensuring that resources are used sustainably. Yet, environmental infrastructure is insufficient, and as a result, environmental carrying capacities throughout the region are being overwhelmed. Many countries in Asia often face challenges of developing sustainable infrastructure due to institutional, technological, and financial insufficiency.

What are the fundamental and essential factors to facilitate and accelerate this shift towards Green Growth? As home to some of the world’s fastest growing economies, one of the most important issues for the region’s policy makers to consider is that of sustainable infrastructure. New innovations and the incorporation of eco-efficient principles into the infrastructure development process play a critical role in improving environmental sustainability.

## SEOUL INITIATIVE ON GREEN GROWTH

The Seoul Initiative on Green Growth was proposed by the Ministry of Environment of the Republic of Korea at the Fifth Ministerial Conference on Environment and Development in Asia and the Pacific 2005 (MCED 2005) and endorsed by the 61<sup>st</sup> Commission Session of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), held in May 2005. The Seoul Initiative provides a regional cooperation framework for Green Growth, taking into account the economic, social, cultural, and geographical features of the region. It also provides a framework for policy consultations, capacity-building, and networking for the promotion of Green Growth at the regional level. The Seoul Initiative Network on Green Growth (SINGG), with countries in the Asia-Pacific region as its members, facilitates the implementation of the Seoul Initiative and its activities to create synergies between economic growth and environmental sustainability, and to contribute to the achievement of an economically vibrant and environmentally sustainable future for Asia and the Pacific.

SINGG focuses on the following three targets: (1) improving environmental sustainability; (2) enhancing environmental performance; and (3) promoting environmental sustainability as an opportunity for economic growth and development. To achieve these targets, the Network focuses on the following four activities: (1) establishing and supporting an action-based network; (2) promoting policy consultation for Green Growth; (3) enhancing members’ capacities to pursue Green Growth; and (4) conducting pilot projects to disseminate the Green Growth approach.

## FIRST POLICY FORUM OF THE SEOUL INITIATIVE

In support of these activities, ESCAP and the Ministry of Environment of the Republic of Korea, in cooperation with the Korea Environment Institute, held the First Policy Forum of the Seoul Initiative from 6 to 8 September 2006, in Seoul, Republic of Korea. It was jointly organized with the generous funding from the Government of the Republic of Korea. The Forum brought together approximately

100 experts, policy makers, researchers, and other stakeholders to discuss systematic, integrated approaches to promoting sustainable infrastructure.

Participants shared their wealth of knowledge and experiences from across the region, and reviewed various options and policies to promote eco-efficient and environmentally sustainable infrastructure development. This included topics such as environmental law, institutions, and governance. They also discussed a range of economic instruments that support sustainable infrastructure development. One of the key recommendations was to deliver the messages from the Policy Forum to a broader audience of decision makers and stakeholders who are involved in infrastructure development. This publication aims to contribute to increased understanding of these issues by including several of the papers on sustainable infrastructure in a range of sectors, as well as describing examples of civil society participation in the decision making process.

## ABOUT THE PUBLICATION

The members of SINGG recommended that a regional overview of the current state of sustainable infrastructure in Asia would help policy makers identify the challenges and opportunities for Green Growth in their countries. ESCAP conducted research for the “Regional Study on Sustainable Infrastructure Development in Asia”, included in Part I of this publication, to provide an overview of regional experiences and to point out the good practices that have the potential to be implemented in other locales. The second part of this publication includes the proceedings of the Seoul Initiative Policy Forum on Sustainable Infrastructure: participants’ papers, the agenda, and the meeting report. Parts I and II discuss water, waste management, and transport infrastructure, while Part II also includes two papers on energy infrastructure.

## TOWARDS SUSTAINABLE INFRASTRUCTURE IN ASIA

Many Asian countries recognize the need to rethink infrastructure development, taking into account eco-efficiency and resource conservation over the lifetime of the infrastructure. It is hoped that this SINGG, through its members and collaborating organizations such as ESCAP, can help to broaden the dialogue on sustainable infrastructure and the promising actions that may be taken in Asia. This can provide a basis for future discussions on policy guidelines for incorporating the Green Growth approach and eco-efficiency concept into the infrastructure development system, for example through financing mechanisms and innovative partnerships. Achieving this is vital not only for environmental sustainability, but also for sustainable economic growth.

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<sup>1</sup> The original manuscript of Part I was prepared by Dr. Vilas Nitivattananon and Dr. Shinya Hanaoka, the Asian Institute of Technology.

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# PART I:

## REGIONAL STUDY ON SUSTAINABLE INFRASTRUCTURE DEVELOPMENT IN ASIA<sup>1</sup>

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<sup>1</sup> The original manuscript of Part I was prepared by Dr. Vilas Nitivattananon and Dr. Shinya Hanaoka, the Asian Institute of Technology.

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# Executive summary

## OVERVIEW AND ISSUES

Infrastructure has a significant impact on sustainability, and promoting environmentally sustainable and eco-efficient infrastructure is an important goal for Asia. Infrastructure is normally viewed as the physical assets that are defined as “fundamental facilities and systems serving country, city, or area, as transportation and communication systems, power plants, and schools”. However, the non-physical aspects of infrastructure including management also play major role in achieving sustainability. *Sustainable infrastructure* can be defined as “infrastructure in harmony with the continuation of economic and environmental sustainability”. The majority of existing infrastructure has great impact on the environment and some of these facilities are not sustainable. There is an urgent need to implement strategic changes in the provision of infrastructure. One way is to adopt the *Green Growth*, which is an approach to pursuing economic growth necessary for enhancing quality of life, while simultaneously minimizing pressure on the environment’s limited carrying capacity. This should be done by improving *eco-efficiency* of infrastructure development, or “creating more value with fewer resources and less impact, or doing more with less”.

Key issues in the current situation of sustainable infrastructure development in Asia include the following:

- The development of infrastructure in the past has not seriously considered a systems or holistic approach. There is a need for institutional integration among different stakeholders and sectors both horizontally and vertically including public-private partnerships.
- There is a need to utilize existing infrastructure to better manage the supply side for greater efficiency, while there is lack of the focus on demand-side management.
- There is serious lack of comprehensive statistical data and valuable information to understand the current status in terms of eco-efficiency. Although currently there are no standardized eco-efficiency indicators for infrastructure development, some existing indicators may be used while developing a more comprehensive set of indicators.

## SUSTAINABLE WATER AND WASTE INFRASTRUCTURE

Water, wastewater, and solid waste management infrastructures are environmental infrastructure, which is characterized as high degree of public goods, with intangible values and externalities. This is a major challenge in developing eco-efficient infrastructure in this sector. Furthermore increases in population and economic growth are another challenge in terms of how to improve or maintain the efficiency under this condition and resource constraint. However the development of technology and enhancement of public awareness can provide opportunities for improved efficiency, for example, water saving, wastewater reuse technology and community-based management in solid waste reuse and recycling. The 3R approach, economic instruments, and public-private partnerships are opportunities for developing sustainable water and waste infrastructure, although methods in one country may not be appropriate for implementation in other countries.

## SUSTAINABLE TRANSPORT INFRASTRUCTURE

There has been a significant quantitative and qualitative increase in demand for transport infrastructure in Asia due to population growth, rapid urbanization and socio-economic development. Eco-efficiency varies with each transport mode. A comparative analysis of different modes of transport focuses on energy consumption and air pollution, especially of public and private transport. Public

transport, in general and rail in particular, is more eco-efficient than private vehicles. Congestion and its assessment, in economic terms by different agencies and at different places, have shown that congestion costs lead to significant losses in the gross domestic product of some cities. The measures and activities to improve eco-efficiencies in transport infrastructure may be guided by the following principles: (1) increase the use of public transit; (2) encourage walking, cycling; and other non-motorized transportation modes; (3) restrict the use of automobiles; and (4) develop land use plans that minimize the need for travel. Depending on economic and geographical conditions, planners may also consider investing in new rail lines, bus systems, and the development of methodologies to estimate traffic congestion costs that include environmental and social aspects.

## THE ROLE OF STAKEHOLDERS

The intertwining roles of various stakeholders such as the government, international organizations, NGOs, civil society groups, and the private sector are essential in the development and management of sustainable infrastructure. The role of the private sector lies in improved management and higher efficiency, as well as increased access to private capital for maintenance and expansion. The international community can also contribute to sustainable infrastructure by support the implementation of best practices in infrastructure management as well as promoting sustainable development initiatives. The public sector, meanwhile, could strengthen provision of sustainable infrastructure through economic, financial, legal, and institutional reforms as well as adopting eco-efficient practices in management and provision. Civil society and NGOs can play an important role in the accountability of infrastructure institutions through consumer participation or through participation in monitoring and evaluation.

## POLICY FRAMEWORK AND FUTURE DIRECTIONS

The scope of an infrastructure policy framework can incorporate both growth and sustainability over the long-term in order to achieve eco-efficient infrastructure and green growth. This requires a systems approach to identify the relationships between various system elements and to integrate them with the goal of sustainability. Greater integration of different development stages and viewing infrastructure as a system to facilitate the delivery of services – rather than an end-product in itself – is also needed. International organizations such as ESCAP can support these efforts. In promoting eco-efficiency of infrastructure, the following principles may be considered:

- Use resources efficiently to obtain greater value from fewer resources and to reduce waste and impacts.
- Minimize externalities when considering market failures, including life cycle costs and the social benefits of policy tools, such as tolled roads.
- Use both mandatory and voluntary systems for assessing and reducing environmental impacts, including raising awareness of policy makers and the public.
- Promote the use of eco-efficient indicators to measure environmental sustainability for infrastructure development.
- Promote appropriate technology for eco-efficient infrastructure in the region focusing on local and renewal energy, climate responsive design for building, and waste management and treatment.
- Promote effective multi-stakeholder partnership involving key actors.
- Use innovative financing and procurement methods such as cost sharing and partnering.
- Promote demand-side management or a service-focused approach keeping in mind the end users' needs.

Areas	Guidelines and policy directions
<b>Capacity-building and awareness</b>	<ul style="list-style-type: none"> <li>• Promote application of systems or holistic approach in infrastructure development.</li> <li>• Consider development and use of national strategic infrastructure development plan.</li> <li>• Disseminate the information on the importance and good practices of eco-efficiency in infrastructure development.</li> <li>• Establish a network for capacity-building of sustainable infrastructure development in the region.</li> <li>• Develop guidelines for achieving eco-efficient infrastructure development in the region.</li> </ul>
<b>Specific infrastructure sectors</b>	<ul style="list-style-type: none"> <li>• Propose methodologies to improve eco-efficient infrastructure.</li> <li>• Develop eco-efficient infrastructure according to following – economic, physical/topographical, and demographic conditions.</li> <li>• Integrate development sectors such as transport and land use systems.</li> <li>• Improve the quality of infrastructure services.</li> <li>• Improve implementation, monitoring and evaluation of infrastructure projects.</li> <li>• Increase in the use of public transport and low energy-consumption vehicles.</li> <li>• Develop methodology to estimate traffic congestion, environmental and social costs.</li> </ul>
<b>Stakeholder participation and financing</b>	<ul style="list-style-type: none"> <li>• Governments and policy makers look at areas in relation to other stakeholders to achieve sustainable infrastructure development.</li> <li>• Integrate capacity-building and technical support activities to enhance partnerships among sectors and stakeholders.</li> <li>• Involve civil society and NGOs in formulating government policies and major actions.</li> <li>• Education and awareness on adopting sustainable management practices.</li> <li>• Promote dialogue and consensus-building among stakeholders.</li> <li>• Improve environmental management capacities of local authorities.</li> <li>• Governments be prepared to gradually shift their role from principle financier and operator to overseer and regulator.</li> <li>• Promote the development of environmentally sound technology and the environmental industry.</li> </ul>

Priory actions for SINGG members to promote sustainable infrastructure include the following:

- Develop guidelines for achieving eco-efficient infrastructure development in the region, considering potential policy tools and strategies for different sectors, development stages, and economic and geographical conditions.
- Utilize the SINGG network for capacity-building of sustainable infrastructure development, considering different members' needs, research, and eco-efficiency indicators.
- Disseminate/publish good practices of eco-efficiency in sustainable infrastructure development among decision-makers, planners, academics, and related stakeholders.
- Integrate capacity-building and technical support activities to enhance partnerships. International organizations such as ESCAP can provide support for capacity-building throughout the region.
- Enhance manpower capacity among the sectors to improve productivity, quality, and efficiency in providing sustainable infrastructure services.



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# 1. Overview of sustainable infrastructure

## 1.1 SUSTAINABLE INFRASTRUCTURE CONCEPTS

This chapter presents the background and concepts of Green Growth and how it can contribute to sustainable infrastructure through the application of eco-efficiency concepts. It also attempts to cover what sustainable infrastructure is, why it is important, and its impact on the economy and environment.

### 1.1.1 Green growth

In terms of economic growth, Asia is the fastest growing region in the world. However, the fast pace of economic growth is placing increasing pressure on the ecological carrying capacity of the region. Signs of stress on the region's natural resources are already apparent. Now the challenge for the region is continuing its economic growth and reducing poverty, while ensuring environmental sustainability.

The Fifth Ministerial Conference on Environment and Development in Asia and the Pacific, held in March 2005, in Seoul, Republic of Korea, focused on the linkage between economic growth and environmental sustainability under the theme of "Achieving Environmentally Sustainable Economic Growth". The Ministerial Conference concluded that a shift towards environmentally sustainable economic growth or "Green Growth" would be necessary to continue economic growth while maintaining environmental sustainability. *Green Growth is an approach to pursuing the economic growth necessary for enhancing quality of life, while simultaneously minimizing the pressure on the environment's limited carrying capacity, by improving the eco-efficiency of our society as a whole.* In this regard, Green Growth is an appropriate tool for achieving the Millennium Development Goals, in particular, MDG1 (eradicate extreme poverty) and MDG7 (ensure environmental sustainability) in the region.

Infrastructure, especially water, waste, energy, and transport infrastructure, is intimately and essentially intermeshed with economic growth, people's lives, and environmental sustainability. So far, discussions on infrastructure development have focused mostly on financing issues and engineering aspects. However, the countries in the region need to also consider the long-term impact of infrastructure development on the sustainability and eco-efficiency of their economic growth. It is time to think differently about infrastructure development, taking into account eco-efficiency and resource conservation over the lifetime of the infrastructure. In this process, the concept of Green Growth, especially eco-efficiency, needs to be incorporated into policies for infrastructure development throughout the life cycle.

### 1.1.2 Eco-efficiency

On average, more than 90 per cent of the resources harvested from nature are wasted in the process of producing food, machines, vehicles, and infrastructure. Hence, if Asian countries are to reduce the environmental impacts of the current consumption patterns, numerous analysts have endorsed the concept of a Factor 10 efficiency in the use of resources, whereby economies must find ways of producing equivalent outputs with about 10 per cent of the current consumption rates of resources. Otherwise, a scarcity of resources—a likely scenario at the current rate of extraction—would eventually lead to increase in the costs of production resulting from higher commodity prices.

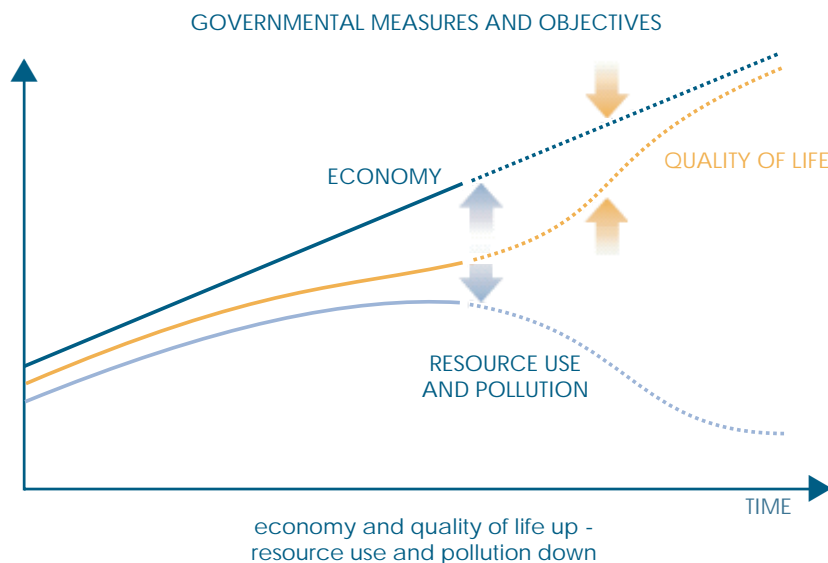
Eco-efficiency is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the earth's estimated carrying capacity. *Eco-efficiency is often expressed as the creation of more value with fewer resources and less impact, or doing more with less* (WBCSD, 2000: 9).

Eco-efficiency can save companies money as a means for developing and successfully implementing a business strategy towards sustainability. Similarly, applying eco-efficiency as a concept can support governments in deriving a national strategy for sustainable development. According to WBCSD (2000: 7), establishing framework conditions that foster innovation and transparency and that allow sharing of responsibility among stakeholders will amplify eco-efficiency for the entire economy and deliver progress towards sustainability.

Governments can stimulate progress by enacting legislative, financial, and technical measures to create the right incentives for innovation and changes in performance. Factors 4 and 10 are eco-efficiency targets for the economy at large. By calling for increased welfare and reduced use of natural resources, and for environmental space to be more equally distributed, one is really setting macro-economic eco-efficiency objectives. Based on Weizsacker *and others* (1998: xviii), "Factor Four" means that resource productivity can – and should – grow fourfold. In other words, the amount of wealth extracted from one unit of natural resources can quadruple, or reach a factor of four material inputs per service unit (MIPS) reduction (equivalent to a 75 per cent reduction). Through this, society can live twice as well, and yet only use half as much.

In terms of infrastructure development, which has been traditionally provided by the public sector, it is important to seek how governments can measure eco-efficiency, particularly during each of the infrastructure development stages (planning, design, etc.). Figure 1.1 presents how governments can measure both economic and environment-related aspects that are the key elements of eco-efficiency.

Figure 1.1 Eco-efficiency and its impact on the economy



Source: WBCSD (2000: 23).

Integrated environmentally sound technologies and fundamentally new systems solutions will be needed to deliver eco-efficiency improvements over today's solutions by a factor of four or more (Weaver et al, 2000: 66). However, technical solutions alone are not sufficient in tackling the challenge. In fact, the environmental progress achieved due to technical solutions is most often offset by stark increases in consumption. As such, the increases in eco-efficiency that are required to curtail the environmental impacts of Asian economies are unprecedented. Despite the progress achieved, relying on pollution control alone cannot decrease the pressure resulting from the current patterns of economic growth. Furthermore, sustainability calls for "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs". To truly achieve this, it is also imperative to improve efficiency in using natural resources.

As many developing countries in the region are now undergoing a process of designing their infrastructure and laying the foundation for their consumption and production patterns, it is the optimum moment for these countries to apply and integrate eco-efficiency into their infrastructure development, consumption patterns, and production patterns.

### 1.1.3 Infrastructure

The development of infrastructure is one of the main drivers of growth in an economy. Infrastructure systems such as water supply and sanitation, solid waste and wastewater, power, and transport form the backbone of the economy as they provide social as well as economic benefits to the people. Moreover, infrastructure provides the organizing structure and support for the organization or system it serves, either vertically (local, regional, or national level) or horizontally (public or private).

According to Howes and Robinson (2005: 16), technical infrastructure, often referred to as economic infrastructure, comprises the long-lived networks and capital-intensive and engineered structures directly supporting economic production. It normally includes public utilities (water supply, energy, etc.), public works (roads, dams, etc.), transport (railways, ports, etc.), and sanitation systems (sewerage, solid waste collection, etc.). The provision of environmental infrastructure and services includes the service for water supply, sanitation, drainage, and solid waste disposal (Nitivattananon, 2006: 3). These infrastructure and services are the basic components, especially for urban areas, that are needed for economic growth and development.

It is recognized that infrastructure displays the following characteristics (NZIER, 2004: 2):

- Capacity can only be adjusted in large, "lumpy" increments.
- High initial fixed costs and low marginal costs of supply.
- High sunk costs and the risk of stranded assets as conditions change.
- Multiple users of the services spanning production and final consumption.
- Externalities not reflected in service charges that have attracted regulation.
- Scale and regulatory hurdles create long lead times for installing new capacity.

### 1.1.4 Sustainable infrastructure development

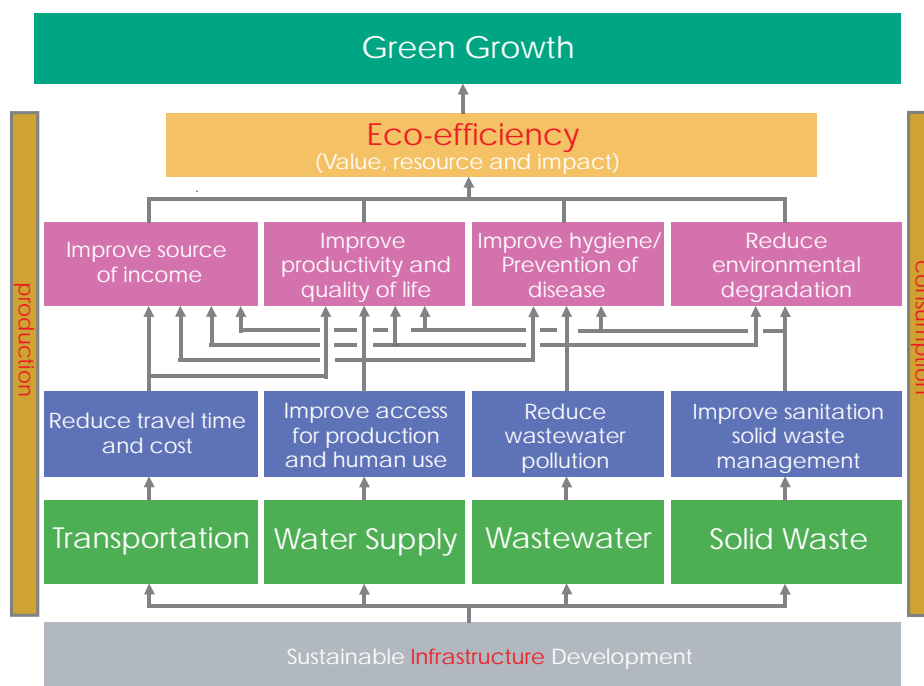
Infrastructure is normally seen as physical assets, which are defined as the "fundamental facilities and systems serving the country, city, or area, as transportation and communication systems, power plants, and schools" (Leong, 2004: 5). While infrastructure alone could achieve economic and/or social development, the environmental aspects are sometimes compromised for the sake of the first two objectives. In order to achieve sustainability, decision makers have sometimes adopted policies

on infrastructure development that would conform to environmental protection policies. As such, NZIER (2004: ii) noted that an infrastructure policy must increase the efficiency of resource use to obtain more from less and reduce waste. This supports sustainable infrastructure development, a concept still unfolding in local and international literature.

In order to support the achievement of MDGs1 and 7, the *Sustainable Infrastructure Report* of the City of Portland in the United States (Office of Transportation, Portland City, 2001), examined the manner by which the infrastructure is designed, constructed, maintained, and taken out of service. It must meet present needs while not hindering the ability of future generations to meet their economic, social, and environmental resource needs. Bohne (2006: 3) further noted that the dimensions of sustainable infrastructure include service to an increasing population, reducing the impact from infrastructure, and adapting to a changing climate. Moreover, the non-physical aspects of infrastructure, including management, also play major roles in the sustainability goal. This guiding principle, if internalized among various stakeholders, could lead to achieving environmental sustainability while still maintaining productivity in their activities.

Infrastructure supports growth and sustainable development by providing services as inputs to other productive processes (e.g., energy, transport) and as outputs going directly to final demand consumption (e.g., potable water and sanitation) (NZIER, 2004: 8). According to the World Bank (1994), infrastructure can deliver major benefits in economic growth, poverty alleviation, and environmental sustainability – but only when it provides services that respond to effective demands and does so efficiently. Figure 1.2 provides a simple diagram of how sustainable infrastructure, such as for water, wastewater, solid waste, and transportation, can contribute to green growth.

Figure 1.2 Sustainable infrastructure development in relation to green growth



Two basic components of infrastructure development include the level of provision and the types of infrastructure projects (Howes and Robinson, 2005: 18). In addition, the economic literature is clear that infrastructure's value is its services and its ability to work with other components of the economy (NZIER, 2004: 2). A recurrent theme in the economic literature is the shifting boundary between which services are best provided by infrastructure in the face of new technologies, new uses of existing technologies, changes in the economies of scale, and changes in the scope of particular types of service provision. This is very important for the understanding and application of sustainable infrastructure development.

Infrastructure development plays an important role in determining environmental sustainability since it locks in consumption patterns for decades to come (ESCAP, 2006c: 18). For example, developing highways in preference to mass transit systems implies heavy future fossil fuel demand for personal modes of transport and continued growth in greenhouse gas emissions. Based on Chung (2006: 13, 16), eco-efficiency should be the focus of consumption patterns. Consumption patterns include products, infrastructure, and services/systems, while stakeholders influencing consumption patterns are consumers, the private sector, and the public sector.

Areas of eco-efficiency application to infrastructure include: transport facilities, utility services, and community buildings; supporting the delivery of community services; strategic asset management; services delivered by other means; integration, sharing, and co-location of services and infrastructure; and longer-term thinking, allowing for future changes (Ness, 2006: 4).

Key questions regarding sustainable infrastructure development (SID) can include the following:

- What are the problems and risks facing SID in the region?
- Can typical and/or regular interventions solve/mitigate the problems?
- How can SID most practically be achieved?

There is a need for greater integration of different development stages and for society and planners to view infrastructure as a system to facilitate the delivery of services rather than as an end-product. Infrastructure development generally consists of several key stages: (1) planning; (2) design; (3) construction; (4) operation; and (5) recycling and disposal (Howes and Robinson, 2005). Applying eco-efficiency throughout all stages is one way to integrate the processes that stakeholders go through at each development stage, and therefore increase sustainability.

However, infrastructure development is subject to the following constraints (NZIER, 2004: 16-23), which make it more complicated to achieve sustainable development:

- Economies of scale.
- Information failures.
- Coordination failures.
- Externalities and social objectives.
- Public/merit goods.

As such, developing infrastructure that is sustainable means improving the processes and mechanisms in building infrastructure, as such it not only meets the present needs of the people but also reduces the impacts it would provide in the future. It looks at the aspects of how we build, what we build, and whether we should build the infrastructure at all. Sustainable infrastructure could be seen as designing and maintaining buildings, structures, and other facilities with an eye towards

resource conservation over the life of the infrastructure. It also means testing new materials and practices that leave lighter impacts on the environment yet are effective (Office of Transportation, City of Portland, 2001: 2).

## 1.2 INFRASTRUCTURE AND ITS IMPACT ON THE ENVIRONMENT

The role of infrastructure in contributing to economic development is an essential one. Good quality infrastructure is necessary to avoid bottlenecks and service disruptions and to support a range of important activities in the economy. The economic role and significance of infrastructure should not be accorded precedence over the other dimensions of sustainable development – the social, cultural, and environmental aspects. Impacts of infrastructure on these aspects of well-being are equally important, and the positive contribution that well-designed infrastructure can make to improve other dimensions of sustainability is also vital (Chapman, *and others*, 2003: 2).

Infrastructure provides people with the services they need and want. It has an important impact on poverty through growth. Infrastructure is an input to production and raises the productivity of other factors. Through its impact on welfare, it provides people with the capabilities to fill and create employment (ADB, JBIC, and WB, 2005: xxvii). Infrastructure connects goods to the markets, workers to industry, people to services, and the poor in rural areas to urban growth centres. Infrastructure lowers costs, enlarges markets, and facilitates trade (see figure 1.3).

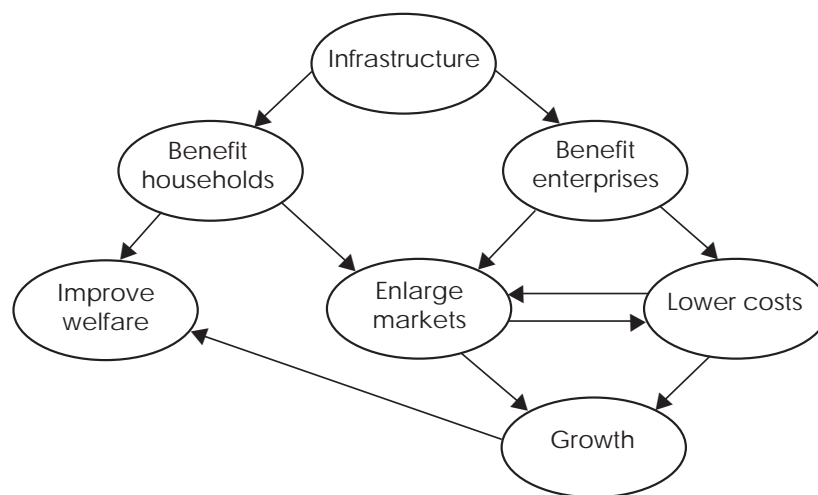
However, it is generally accepted that the majority of existing infrastructure throughout the world has some direct or indirect impacts on the environment. While some of these projects are not sustainable, countries feel an urgent need to implement strategic changes in the provision of infrastructure. Infrastructure has become a focal point in resolving issues about economic growth in many developing and developed countries in the past few years. Ingram (1995: 5) pointed out that infrastructure is a key determinant of economic growth and that sustainable economic growth requires accelerated infrastructure investment. While infrastructure is needed to facilitate economic growth, it is now recognized that a more responsible approach should be undertaken to improve growth through the emphasis on social and environmental integrity.

According to the World Bank (1994: 21), the relationship between each infrastructure sector and the environment is complex. The most positive impacts of infrastructure on the environment concern the removal and disposal of liquid and solid wastes. But much depends on how disposal facilities are planned and executed. For example, under-investment in municipal sewerage relative to water supply in densely populated cities has been found to lead to harmful contamination of water reserves, and to reduce the health benefits from water investments.

The rise in income in Asian cities has produced dramatic increases in per capita car ownership, per capita waste generation, per capita levels of water use, energy consumption, sewerage, and industrial waste. Rapid and uncontrolled urbanization has exerted tremendous pressure on urban infrastructure and requires its expansion (IGES, 2005b: 98). This in turn has exerted greater pressure on the environment. For instance, greater transport efficiency caused by rapid motorization in many countries has brought higher efficiency in productive activities, facilitating the development of industries and expanding national economies. Progress in motorization leads to greater mobility and offers a wider range of choices. However, transportation problems today seem to relate more to having too much rather than too little – too much traffic, too much pollution, too many accidents, and too much to maintain. Car ownership, rail and bus commuting, and air travel all keep growing faster than the basic infrastructure to support them.

Growing motorization, especially in urban areas, has also led to an immense problem of traffic congestion in Asia. Aside from conflicts between public and private transportation, other factors that have contributed to the growing congestion include: the existence of too many narrow, poorly maintained roads; piecemeal road development; lack of road connectivity; oversupply of curbside kiosks and hawkers, resulting in the spillover of pedestrians and activities into streets; insufficient off-street parking; lack of land-use controls, resulting in the poor location of many traffic-generating developments; minimal enforcement of traffic laws, which reduces vehicle speed; and decreasing road capacity (Jacobs and Fouracre, 1974; Kirby, and others, 1986a, 1986b; Rimmer and Dick, 1980; Silcock, 1981, as cited by Cervero, 1991; and Shimazaki and Rahman, 2000).

Figure 1.3 Infrastructure's contribution to development



Source: World Bank (2004: 4).

Likewise, vehicles operating in heavy traffic pollute considerably more than those operating in free-flow conditions (ADB, 2003b: 15). Severe air pollution is also aggravated by the inefficient repair and maintenance of older vehicles (Development Associates, Inc., 2004). In most developing countries of Asia, there is a widespread demand among consumers for extremely low-priced cars and engines, which tend to be of poor quality and second-hand. Thus the increase in air pollution that is associated with the growth in mobility also has a relatively large negative impact on development, as it results in considerable financial and social costs to households and the economy as a whole with high costs of repair and maintenance.

Other environmental impacts could be more obvious, especially the construction of large infrastructure projects. For instance, the construction of large dams, highways, and land reclamation not only displaces communities but also endangers species that are endemic in the construction area. Building a dam for flood control and hydropower may provide significant economic benefits to the people in the community or country; however, constructing the dam would require extensive logging in the area and the reservoir will likely destroy natural habitats. Other possible threats of dam projects to public safety and environmental degradation include soil erosion, loss of wildlife, changes in the water table, etc. Similarly, while the completion of a highway into rural areas would greatly increase the volume of trade in their areas while reducing transport costs, it does not come without a price on



the environment. The construction of highways will cut through rainforests disrupting the ecosystem and perhaps cause biodiversity losses along with the obvious deforestation. This damage would be exacerbated directly by the traffic that would eventually use the highway.

As such, environmental sustainability is one of the key challenges that confront countries, as pointed out in the World Bank's *Strategy for Infrastructure Development in East Asia and the Pacific (EAP)* (cited by Eijbergen, 2006: 3). Infrastructure indeed plays a vital role in the well-being of society and it is therefore important to understand all aspects of its relationship to environmental sustainability. Thus greater efficiencies created by sustainable infrastructure will lead to reductions in waste, energy consumption, land degradation, biodiversity loss, and pollution, while at the same time leading to improved utilization and minimization in the consumption of non-renewable resources.

### 1.3 PERFORMANCE INDICATORS AND CURRENT STATUS

Driven by buoyant economic development and continuous population growth, Asia is exerting exponential pressures on natural resources and the environment. This is an important reason to promote eco-efficient development. To determine future demand for infrastructure, it is necessary to consider the efficiency with which existing capacity is being used and how well the services and goods fulfill users' needs. According to the World Bank (1994: 35), although each sector has special problems, there are common patterns – operational inefficiencies, inadequate maintenance, excessive dependence on fiscal resources, lack of responsiveness to users' needs, limited benefits for the poor, and insufficient environmental responsibility. The World Bank's approach to supporting investment in infrastructure covers performance-based aid schemes and using key performance indicators: access, quality, affordability, and financial sustainability (Halm, 2006: 11).

Table 1.1 Example of sustainability indicators in urban water supply

Infrastructure policy issue	Suggested indicators
<ul style="list-style-type: none"> <li>• What is the trend in asset condition, and what is the capacity to meet future needs?</li> </ul>	<ul style="list-style-type: none"> <li>• Delivery capacity.</li> <li>• Marginal cost of expanding capacity.</li> <li>• Adequate signaling to community of any plans for expanding capacity.</li> </ul>
<ul style="list-style-type: none"> <li>• How reliable is the water supply utility?</li> </ul>	<ul style="list-style-type: none"> <li>• Record of service disruptions.</li> <li>• Reserve capacity of existing infrastructure.</li> </ul>
<ul style="list-style-type: none"> <li>• What is the economic performance of the water supply?</li> <li>• How efficient (including eco-efficient) is the utility?</li> <li>• Does the utility address both supply and demand issues?</li> <li>• Does the tariff structure encourage cost-effective water conservation?</li> <li>• What are the needs and scope for promoting water demand management?</li> </ul>	<ul style="list-style-type: none"> <li>• Rate of return on water supply utility assets.</li> <li>• Production cost (including labour) per cubic meter of water produced.</li> <li>• Unaccounted-for (non-revenue) water (distribution losses, back-flushing).</li> <li>• Energy use for pumping and treatment per unit of supply.</li> <li>• Water use trends by sector (including per capita residential use).</li> <li>• Price structure: volumetric rates, increasing block tariffs, seasonal charges.</li> <li>• Ratio fixed/volumetric charges.</li> <li>• Share of total cost covered by water bills, amount of cross-subsidization from general rates.</li> </ul>

Source: Chapman and others (2003: 127).

To measure eco-efficiency, one indicator is the ratio between an environmental and a financial variable. It measures the environmental performance of an enterprise with respect to its financial performance. The problem with constructing eco-efficiency indicators is that there are no agreed rules or standards for recognition, measurement, and disclosure of environmental information, either within the same industry or across industries. Most importantly, there are no rules for consolidating environmental information for an enterprise or for a group of enterprises so that it can be used together and in line with the financial items of those enterprises (UNCTAD, 2004: 1). According to the *Manual for the Preparers and Users of Eco-efficiency Indicators* (UNCTAD, 2004), eco-efficiency indicators can be divided into five environmental performance categories: water use, energy requirement, global warming contribution, ozone depletion contribution, and waste. An example of sustainability indicators for urban water infrastructure is given in table 1.1.

Performance indicators relating to the eco-efficiency of infrastructure may involve the following:

- Private sector – such as level of participation and its impacts.
- Efficiency – in policy, technology, and resources.
- Rate of return – economic and social aspects.
- Services – including access, quality, and cost.
- Social – poverty reduction and income inequality.

Tables 1.1 and 1.2 give example of some indicators relating to eco-efficiency of infrastructure for different infrastructures and their status.

Table 1.2 Selected eco-efficiency indicators and their status

Country	Water supply access (%)	Sanitation access (%)	Electricity access (%)	Telephone access <sup>a</sup>	Internet access <sup>b</sup>	Road network (km/100 km <sup>2</sup> )	Paved road (%)	Rail network (km/100 km <sup>2</sup> )
Malaysia	93	-	97	62	34.4	20	76	0.49
Thailand	93	98	84	50	11.1	12	97	0.79
Philippines	85	83	79	31	4.4	68	22	0.15
China	75	39	99	42	6.3	19	91	0.64
Indonesia	78	55	55	13	3.8	20	58	0.25
Viet Nam	49	25	81	9	4.3	29	25	0.97
Cambodia	44	22	17	4	0.2	22	4	0.42
Lao People's Democratic Republic	58	30	41	3	0.3	14	15	-
Mongolia	60	30	90	19	5.8	3	8	0.15
Palau	79	100	50	42	-	-	-	-
Marshall Islands	-	-	100	9	2.6	35	-	-
Fiji	-	43	80	26	6.7	19	49	-
Micronesia	-	-	45	16	9.3	34	18	-
Samoa	99	99	95	13	2.2	28	80	-
Tonga	100	-	85	15	2.9	94	27	-
Vanuatu	88	100	26	7	3.6	9	24	-
Kiribati	-	48	40	6	2.3	92	-	-
Papua New Guinea	42	82	46	1	1.4	-	4	-
Solomon Islands	71	34	15	2	0.5	5	3	-
Timor Leste	-	-	22	-	-	25	41	-
Myanmar	72	64	5	1	0.1	-	-	-
Low & Middle Income	77	70	64	27	6.5	38	41	1.70

<sup>a</sup> telephone subscribers per 100 inhabitants

<sup>b</sup> number of users per 100 inhabitants

Note: Shaded values indicate above category average for low and middle income countries

Source: ADB, JBIC and WB (2005: 9).

Table 1.3 Selected additional eco-efficiency indicators and their status in some countries

Countries	Domestic water consumption (l/c/d)	Non-revenue water (% of water production)	Waste generation per capita (kg/c/d)	Waste recycling rate (% of total waste)	Motorization rate (private cars/1,000 persons)	Rail network (km/1,000 km <sup>2</sup> )
Bangladesh	47 (2005)		0.5 (1995)		0.5 (2002)	19 (2002)
India	139 (2005)		0.3-0.6 (2001)		7.2 (2002)	20 (2002)
Pakistan	65 (2005)		0.6-0.8 (2001)		9.2 (2001)	10 (2002)
Indonesia	86 (2005)	51 (Jakarta, 2001)	0.8-1.0 (2001)		15.6 (2002)	3 (2002)
Lao People's Democratic Republic		28 (Vientiane, 2001)	0.7 (1999)			
Malaysia	183 (2005)	43 (Kuala Lumpur, 2001)	0.8 (1995)		210.3 (2002)	7 (2002)
Philippines	176 (2005)	62 (Manila, 2001)	0.3-0.7 (2001)	12 (2002)	28.8 (2002)	3 (2002)
Singapore		5.2 (2006)	1.1 (1995)	48 (2004)	102.6 (2002)	253 (2002)
Thailand	78 (2005)	30.5 (Bangkok, 2006)	1.1 (1999)	11 (2002)	51.4 (2002)	8 (2002)
Viet Nam		38 (Ho Chi Minh City, 2001)	0.6 (1999)			9 (2002)
China	95 (2005)		1.0 (2005)		7 (2002)	8 (2002)
Japan	381 (2005)				334.2 (2003)	61 (2002)
Republic of Korea	221 (2005)		1.03 (2004)		171 (2001)	31 (2002)

Source: ADB (2004), United States Environmental Protection Agency (2004: 242, 263), World Resource Institute (2006), Zurbrugg (2003), ESCAP (2005), ESCAP (2003).

#### 1.4 FRAMEWORK AND PRIORITY ISSUES FOR SUSTAINABLE INFRASTRUCTURE DEVELOPMENT

One of the most fundamental issues in the delivery of infrastructure concerns the decisions on what types of infrastructure are required and how they should be provided. The policy framework influences the level of infrastructure provision and depends on policy objectives, the implementing institutions, level and type of resources, knowledge, information and communication systems, and the environment (Howes and Robinson, 2005: 33). Box 1.1 presents an example of policy framework elements for developing sustainable infrastructure. The process of improving infrastructure eco-efficiency requires the following: sustaining the economic growth rate of specific areas/sectors, meeting social requirements such as equity, arresting environmental degradation, and mobilizing the effective participation of stakeholders (Ti, 2006: 20).

The scope of an infrastructure policy framework should incorporate both growth and sustainability over the longer term. Policy makers should take into account externalities that have the potential to impact the achievement of goals, for example the process of developing the framework may include the following (Howes and Robinson, 2005: 290):

- Organization and systems analysis to define the nature of infrastructure and to provide the basis for performance prediction.
- Cost-benefit analysis of improvements to correct weaknesses in existing provision.
- Monitoring of the influence of externalities in terms of opportunities and threats.

### Box 1.1 Example of a policy framework for infrastructure

#### Key framework elements for a sustainability based approach to infrastructure

- Recognize that sustainable development is about a long-term (intergenerational and integrated (holistic) view.
- Work to advance all four dimensions of sustainability in making infrastructure policy and investment decisions.
- Next sectoral infrastructure policy and management within sectoral sustainable development strategies.
- Internalize externalities: comprehensively identify externalities associated with potential infrastructure provision, and integrate externalities into policy.
- 'Change attitudes': work to build awareness of sustainable development, as a relevant high-level goal (a 'quadruple bottom line') requiring behaviour change (e.g. monitoring and reporting) and other adjustments of social norms.

*Source:* Chapman and others (2003: 35).

The following are some of the concerns and suggestions from policy makers, academia, and NGOs regarding policy for promoting sustainable infrastructure development at the Seoul Initiative Policy Forum on Sustainable Infrastructure, held in September 2006:

- Infrastructure does not just mean roads, water, energy, and building cities, but rather all of their components too – people, time, money, and creative ideas. The most promising point for building a system or “infrastructure” of people, resources, energy, money, and institutions is that it helps promote sustainability better (Lee, 2006: 6, 9).
- The process of building sustainable infrastructure, much like discussion of sustainable development itself, needs clearer and more consistent standards and principles, including the development of a SID index (Lee, 2006: 11). Planners need to consider the long-term implications of the infrastructure development and to continue both political and technological innovation to provide more eco-efficient infrastructure in order to achieve green growth.
- For Indonesia, sustainable development in infrastructure needs a good and strategic coordination within infrastructure sub-sectors. Sustainable development is in the form of utilization of infrastructure and providing sufficient operation and maintenance budgets (Amron, 2006: 7).
- One of the biggest challenges today for India, and indeed the whole world, is to see how best urban development can take place with the least amount of negative impact on the environment, thus creating environmentally friendly, ecologically appropriate, and energy-saving sustainable human settlements (Jain, 2006: 14).

From international experiences, infrastructure issues cover three broad considerations (NZIER, 2004: 34):

- How to maintain current infrastructure so as to sustain the level of service it now provides?
- How to upgrade current infrastructure to accommodate the changing demands and the requirements of technology?
- How to provide new capacity to meet both increasing volume demand and new requirements?

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## 2. Sustainable water and waste infrastructure

### 2.1 CURRENT STATUS

#### 2.1.1 Water supply and wastewater management

Water is a critical resource for attaining sustainable economic and social development. As a result of population and economic growth, the gap between water availability and water demand has increased, bringing about a serious water crisis in many countries. It is reported that water resources in Asia make up 32 per cent of the world's total freshwater resources, which is the largest proportion of all regions. The region is home to approximately 60 per cent of the world's population, but water availability per capita is only about 4,000 m<sup>3</sup>/year, the least in the world and less than half of the world average (Shiklomanov, 2000, cited by IGES, 2005a: 55).

According to current trends, it is projected that 2.4 billion Asians will suffer from water stress by 2025, almost double the 1995 figure (IGES, 2005a: xiii). The increasing pressure on water resources leads to water scarcity and increased competition for water between agriculture, industries, and rapidly growing cities. Developing countries have made significant investments in water infrastructure and many are successfully addressing catastrophic water risks, but they have not yet achieved the sustainable infrastructure and institutional capacity to manage their water resources to optimize sustainable growth and provide universal and reliable water services (ESCAP, 2006a: 100).

Access to safe drinking water and adequate sanitation has been a global priority for decades. However, water supply and sanitation coverage in Asia in 2004 were only 82 per cent and 47 per cent, respectively, and also indeed, coverage for the region's urban residents actually decreased due to a population growth rate that outstripped the rate of development of urban water supply and sanitation (ESCAP, 2006a: 104).

Sewerage and wastewater treatment facilities are much less developed than water supply infrastructure. Moreover, even where such facilities exist, most of them do not operate properly because of financial and technical problems. However, adequately treated sewage is a valuable source of water for many applications. A number of countries have established water resource planning policies based on maximum reuse of urban wastewater, especially countries in arid areas.

#### 2.1.2 Solid waste management

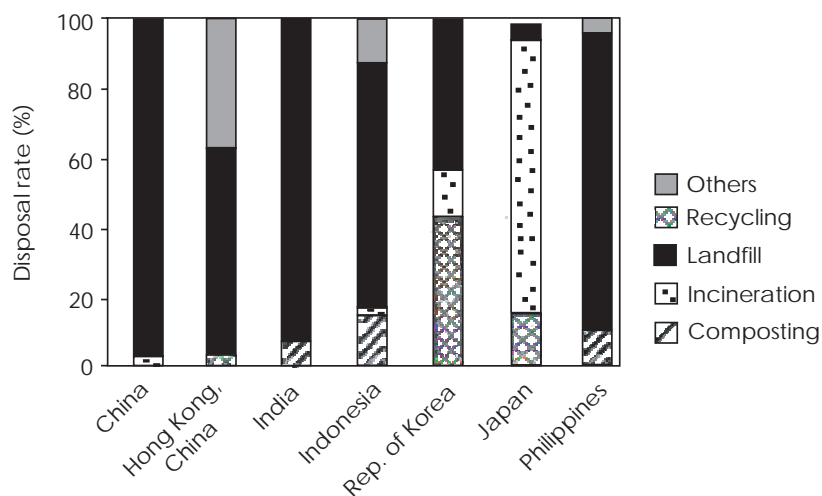
Waste quantities are inextricably linked to economic activity and resource consumption. In 1999, the waste generation rate in urban areas of Asia was about 760,000 tons per day, and this figure will increase to about 1.8 million tons per day by 2025 (World Bank, 1999: 1). The generation of solid waste differs according to economic status, population density, urban lifestyle, food habits, geographical conditions, and other socio-economic and cultural factors.

In most developing country cities, a significant portion of the population does not have access to waste collection services, and only a fraction of the generated waste is actually collected. In South Asia, 20-50 per cent of solid waste generated remains uncollected, even though more than half of the

local operation expenditures go towards waste collection (UNEP, 2001, cited by ARRPET, 2004: 18). Most of the Asian collection systems are relatively inefficient as the collection vehicles and containers are not fitted with compactors, necessitating transportation of loose waste and hence creating a constraint on the capacity of the collection system (Gardia, Cossu, *and others*, 2006: 43). Collection is normally door-to-door or using containers and communal bins. All medium and large cities would have administrative structures for providing collection services.

The main component of municipal solid waste (MSW) in Asia is organic matter. The average paper and plastic contents in municipal solid waste is lower than 15 per cent and varies according to the level of urbanization and formal/informal sector recycling activities (ARRPET, 2004: v). Landfilling is the major method of disposal in many Asian countries because it is usually inexpensive, whereas recycling is not common, except in the Republic of Korea and Japan. Typically, the kind of waste that lands in municipal or public dumpsites and landfills is totally mixed waste, including some hazardous materials.

Figure 2.1 Municipal solid waste management and disposal in Asian countries



Source: Terazono, Moriguchi, and others (2005: 486).

Minimizing the quantities of waste through source reduction, material recovery, reuse, and recycling is increasingly being recognized as the key of MSW management. The rate of waste recycling has increased dramatically in the Asia-Pacific region from 10 per cent in 1990 to 22 per cent in 1998 (ARRPET, 2004: 28). The informal sector plays an important role in the collection of recyclable materials (Terazono, *and others*, 2005: 485). However, it is not practiced widely and effectively.

Not only municipal waste but also hazardous waste generation is increasing along with urbanization and population growth. Some of the products used in modern society are too toxic to be disposed of without special treatment. According to Buron (2003b), the most acceptable method of disposal for hazardous wastes is through the use of secure landfills, as practiced in Malaysia, and through hazardous waste incinerators, as developed in countries such as Japan, Republic of Korea, Singapore, Malaysia, and Thailand. However, some countries in Asia frequently co-dispose of hazardous waste, including toxic wastes in sealed containers, with municipal solid waste in open

dumps. In recent years, the development of low-emission incinerators and the recognition that land disposal of hazardous waste leads to long-term pollution problems has resulted in combustion methods becoming the preferred mechanism for waste management.

### 2.1.3 Comparative analysis on status of infrastructure development in terms of eco-efficiency

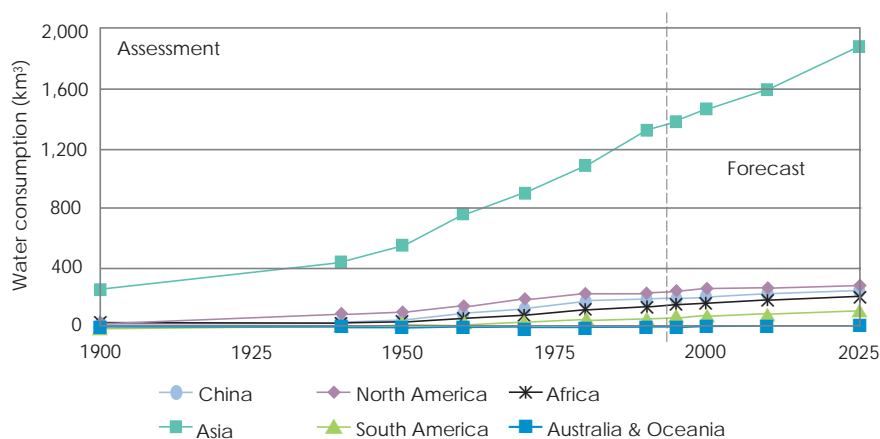
#### *Water and Wastewater*

Due to population growth, per capita water availability in 2025 is expected to be 10 to 15 per cent lower than current levels (ESCAP, 2006a: 98). On the other hand, total water consumption in Asia is much higher than in other regions, as shown in figure 2.2. The rate of increase in water withdrawals in Asia could be two or three times greater than the population growth rate, necessitating greater efficiency in the use of available supplies and water infrastructure, in order to reach the eco-efficiency target of at least by Factor 4 as explained in Chapter 1.

Economic constraints to achieving eco-efficiency in water infrastructure in Asia are partly attributable to very low tariffs and inappropriate fee systems with regard to utilities. Most cities cannot recover the operational costs, let alone generate the capital required for any new construction costs, of water and wastewater infrastructure. Figure 2.3 shows that most of the countries charge water tariffs at less than the unit cost of water production. Capital investment is mostly supported by government or international funding, whereas utilities attempt to recover the operation and maintenance cost from users. Once the cost of infrastructure use is lower than its actual cost, less eco-efficiency of the infrastructure can be expected. The government and international donors can play major role in financing for promoting sustainable infrastructure.

Most water supply systems have high rates of unaccounted-for water, (one of the indicators closely related to eco-efficiency in water infrastructure, with performance data mostly available), which are caused by illegal connections, leakage, or are the result of inadequate commercial operations. The main proportion of unaccounted-for water is water leakage, which generally results from leaking through the joints or fissures in old water pipes. Asia has a high rate of unaccounted-for water compared with countries in other regions, as shown in figure 2.4. This contributes to less eco-efficiency in terms of resources and financial losses as well as less output and poor service performance.

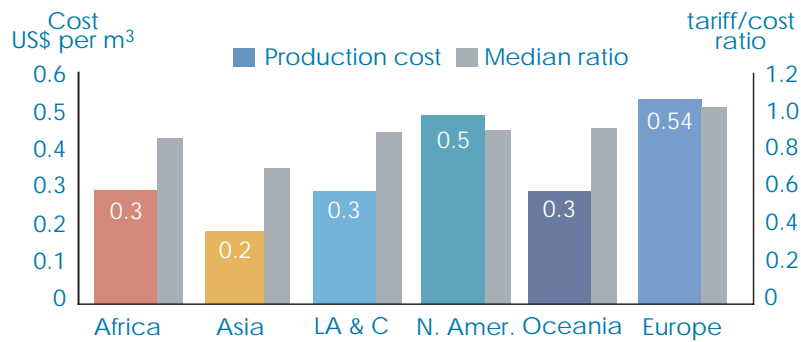
Figure 2.2 Water consumption by region (plus China)



Source: IGES (2005b: 57).

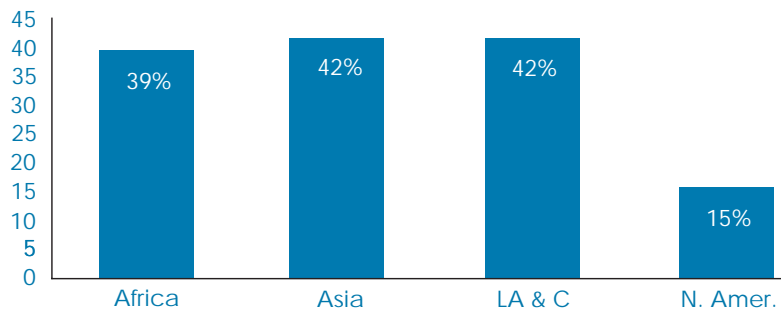


Figure 2.3 Unit production cost of urban water supply and the tariff/production cost ratio 1990-2000



Source: WHO and UNICEF (2000: 25).

Figure 2.4 Unaccounted-for water in large cities in Africa, Asia, Latin America and the Caribbean, and North America



Source: WHO and UNICEF (2000: 18).

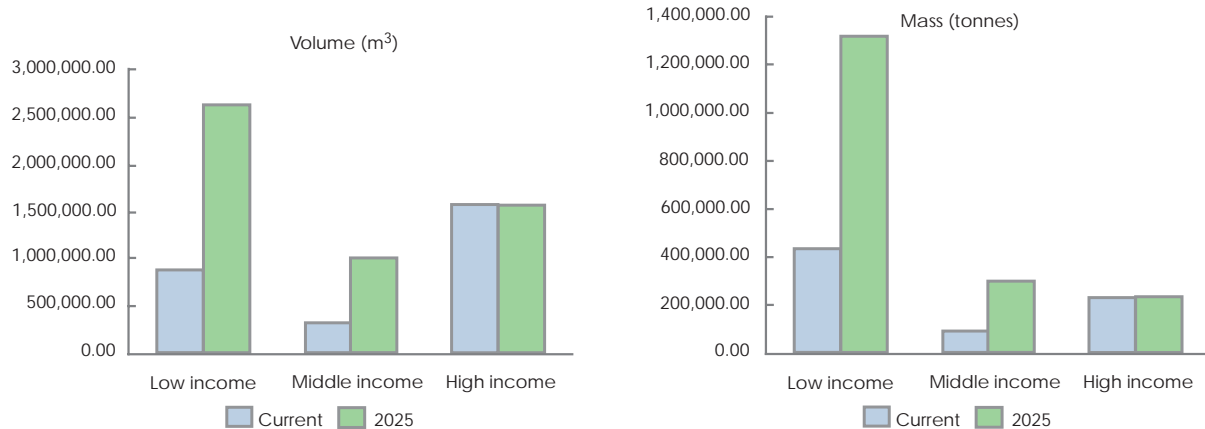
### Solid waste management

The rate of solid waste generation in most Asian countries is lower than that of developed countries. However, based on historical waste generation patterns, economic trends, and population predictions, solid waste generation in Asia is projected to increase greatly, requiring greater efficiency of solid waste management including its infrastructure and services. Low- and middle-income countries in particular will have to deal with enormous quantities of urban waste in the years to come, as shown in figure 2.5. Packaging waste, such as paper, plastic, and glass will become more predominant in the waste stream as the economies grow and the population becomes more urbanized. Compounding this is the fact that much of Asia's urban growth is occurring in very large cities, which exacerbates waste disposal and collection problems.

The expenditures of both developing and industrialized countries generally do not exceed 0.5 per cent of their per capita GNP on solid waste management (World Bank 1999: 20). The cost of solid waste management, which is generally borne by the public sector, is high and mainly includes collection and transport. However, there is a growing trend towards contracting or privatization as practiced in Singapore, Malaysia, Thailand, Philippines, and Indonesia (UNEP, 2004). Partnership between public and private sectors including with other stakeholders - such as NGOs - is therefore one of the

key strategies in financing and promoting sustainable infrastructure, by incorporating eco-efficiency indicators and targets, e.g., low unit cost of proper waste disposal facilities and more efficient waste collection process.

Figure 2.5 Waste generated by low, middle, and high income countries per day



Source: World Bank (1999: 11).

Many Asian countries have recently introduced laws on MSW. However, the major focus is on quality control, i.e., environmental protection, rather than on quantity control. It is a positive sign that the importance of the waste management hierarchy – that is, reduce, reuse, recycle (the “3Rs”), and disposal – is gradually being recognized; the challenge now is to put it into practice effectively in the many different contexts found in Asia (Terazono, *and others*, 2005: 477). The 3R approach can be considered as one of the policy or management tools in promoting eco-efficiency of waste management – especially concerning the control of waste generation rate.

## 2.2 CURRENT PRACTICES THAT PROMOTE SUSTAINABLE INFRASTRUCTURE DEVELOPMENT

Improving eco-efficiency is an important strategy for sustainability within infrastructure development. While there are a number of possible routes to improve eco-efficiency, the potential lies in initiatives that combine technical, economic, political, and social changes to improve quality of life with less material consumption and more beneficial material use. A summary of practices that promote sustainable infrastructure development relating to water and waste in Asian countries (including policy tools, eco-efficiency, or methods used) is provided in table 2.1.

Table 2.1 Current practices of eco-efficient infrastructure for water and waste

Cases	Location/ coverage	Partners (key and supporting)	Eco- efficiency aspects			Conditions/Factors/ Years	Policy tools/ eco-efficient mechanisms/ methods used	Sources/ references
			A	B	C			
<b>Water and Wastewater</b>								
Punjab community water supply and sanitation project	Pakistan	Local Authority ADB Community	●	●		Rural Water Supply and Sanitation Sector Project, provided simple, low-cost water supply and drainage facilities to 800,000 people. Project utilized a community-based, demand-driven approach where community members were involved in all stages of the project and trained on financial, technical, operational, and managerial aspects of the project at an early stage.	Stakeholder participation, community involvement	www.unescap.org/drpad/vc/conference/ex_pk_56_cwssp.htm
Phnom Penh water supply	Phnom Penh, Cambodia	PPWSA ADB	●	●	○	The year 1993 marked the beginning of the restoration of Phnom Penh's water infrastructure from insufficient organization and management. Through internal reforms in 1993, PPWSA transformed itself into an efficient, self-financed, autonomous organization. The result: PPWSA became financially and operationally autonomous, achieved full cost recovery.	Reforming of organization public awareness, community participation, user charge	www.adb.org/water/actions/CAM/PPWSA.asp
Rainwater harvesting in urban areas	Japan Republic of Korea Singapore	Local people community	●		○	Limited land and water resources. Collected rainwater from roofs in storage tanks for domestic, non-potable uses. As a result of savings in terms of water, energy costs, and deferred capital, rainwater harvesting and utilization is promoted to mitigate water shortages, control floods, and secure water for emergencies.	Environmentally appropriate technology, demand-side management approach	UNEP (2002)
Rainwater harvesting in rural areas	Bangladesh China Philippines Thailand	Local people community NGOs	●		○	Storing rainwater from rooftop run-off in jars is an appropriate and inexpensive means of obtaining high quality drinking water in rural areas as environmentally appropriate technology.	Environmentally appropriate technology, technical assistance	UNEP (2002)
Water conservation conscious city	Fukuoka, Japan	Fukuoka's citizens	○	●	○	A fast developing city, making efforts to achieve a stable level of supply by raising water conservation consciousness among the city residents.	Demand-side management approach – water saving	www.bestpractices.org
Private sector participation in bulk water supply	Johor Bahru, Malaysia	Johor Water Company Private sector	○	●	○	A lack of government funding lead to the PPP process (1991 to 1992) and a 20-year concession contract through build-own-operate transfer (BOOT) and rehabilitate-operate-transfer (ROT). The privatization of retail services can directly provide incentives for the concessionaire to take care of unaccounted-for water by reducing leakages. Appropriate tariffs by the retail concessionaire also provide incentive to consumers to conserve water.	Public-private partnership, effective bidding process for design, planning and management	www.iges.or.jp/kitakyushu

Table 2.1 Current practices of eco-efficient infrastructure for water and waste (continued)

Cases	Location/ coverage	Partners (key and supporting)	Eco- efficiency aspects			Conditions/Factors/ Years	Policy Tools/ eco-efficient mechanisms/ methods used	Sources/ references
			A	B	C			
Ground- water manage- ment	China Indonesia Japan Sri Lanka Thailand Viet Nam	National level IGES	●	●	○	Many Asian cities depend on groundwater and take advantage of the resource to facilitate economic activities. Shallow groundwater contamination is very common, mainly due to poor wastewater management. Therefore, it is imperative to have proper sanitary disposal systems or domestic wastewater treatment plants accompanying the urbanization process.	User charge and groundwater preservation charge, regulation	IGES (2006)
Wastewater reuse in aquaculture	Hanoi, Viet Nam	Hanoi People's Committee	●	○	●	Rapid population increases. Wastewater-fed aquaculture is a well-understood and well-established production system and has been developed mainly through farmer experiences accumulated since the early 1960s.	Community involvement, 3R approach	IETC and METC (2002)
Water reuse programme	Japan	Government Private sector	○	●	●	High income and density, and limited water resources. Focusing on water reuse for meeting urban water needs, municipal treatment works and reclaimed water systems were used together, as part of a dual system, providing more effective and economical treatment than individual reclamation facilities.	Demand-side management approach, cost effectiveness	Ogoshi, Suzuki and Asano (2001)
NEWater	Singapore	Guk	○	●	●	Limited water resources. Supplying high-quality reclaimed water to industries and commercial and office buildings for non-potable uses.	Demand-side management approach, cost competitiveness, public awareness	www.pub.gov.sg/NEWater_files/index.html
<b>Solid Waste</b>								
Volume- based waste fee system	Republic of Korea	Government	●	○	○	Facing excessive dumping of wastes. To reduce the amount of garbage from households by imposing garbage collection fees upon the amount of discharge.	Collection fees	Ministry of Environment, Republic of Korea (2002)
Central composting project in Colombo	Sri Lanka	Central Environmental Authority CMC BELT	●	●	●	Organic matter as a major portion of municipal solid waste. Colombo Municipal Council (CMC) opted for a large-scale MSW composting project. The contract has been signed between CMC and Burns Environmental Technology (BELT) for processing and final disposal for a period of 25 years.	Public private partnership	ARRPET (2004)

Table 2.1 Current practices of eco-efficient infrastructure for water and waste (continued)

Cases	Location/ coverage	Partners (key and supporting)	Eco- efficiency aspects			Conditions/Factors/ Years	Policy Tools/ eco-efficient mechanisms/ methods used	Sources/ references
			A	B	C			
Recycling in Mahara-gama	Sri Lanka	Ministry of Environment and Forest Authority Household	●	●	●	Initiated a source segregation scheme among 2,300 households for the separation of recyclable materials. It is effective in reducing the total quantity of waste collected for final disposal.	Resource recovery from waste stream	ARRPET (2004)
Alternate fuel programme (AFP)	Thailand	Ministry of Industry Industries	●	●	●	The cement industry received licenses to treat hazardous waste by completely substituting their fuel with wastes, providing a competitive solution for the disposal of hazardous waste since 2001.	Regulatory instrument, 3R approach	Buron (2003a)
General environmental conservation public company limited	Thailand	Ministry of Industry Estate Authority Private sector	●	●	●	GENCO was established following government policy to provide industrial waste treatment services in order to properly manage industrial wastes which create undesirable impacts on the environment and public health.	Private sector participation	www.genco.co.th
Waste recycling in private sector	Thailand	Wongpanit Company Limited	●	●	●	It provides professional services for systematic SWM, distributes printed materials, promotes waste separation and reclamation, and intensely campaigns for recycling awareness.	Private sector participation, 3R approach	www.wongpanit.com
Community based composting	Dhaka, Bangla-desh	NGO: Waste Concerns-PROSHIKA Local Communities Map Agro Ltd. (fertilizer company)	○	●	●	Huge and densely populated city facing solid waste problems. Limitation of funding, with inefficient collection and disposal of wastes. Used the slogan of "waste is not waste, waste is a resource" to motivate communities to compost organic waste and earn money.	Community-based approach	www.iges.or.jp/kitakyushu
Community related recycling initiative for SWM	Nonthaburi, Thailand	Local government Community	○	●	●	Rapidly growing city. Difficulties in establishing a new dumpsite because of comprehensive legislation. Strong political will in local governments is required to improve solid waste management.	Community based approach, user charges, incentive	www.iges.or.jp/kitakyushu

Note: A = Increasing service value; B = Resources use optimization; C = Minimization of environmental impact.  
(●=Direct; ○= Indirect)

### 2.3 REVIEW OF MANAGEMENT POLICIES AND INSTITUTIONAL FRAMEWORK

To ensure effectiveness and sustainability, increased investments must be underpinned by better policies and governance (Briceno-Garmendia, *and others*, 2004: 3). Policy goals and objectives must be accompanied by effective policy instruments to produce actual impacts. Building and supporting institutional arrangements for policy implementation remain vital tasks for Asian countries, and also the increased involvement of local stakeholders through appropriate institutional arrangements is considered desirable for enhancing the effectiveness of activities. Legislation and policies should establish national standards or guidelines for management. The legislation and policies should also promote a business framework that provides the basis for implementing a modern management system that is financially sustainable. To be effective, the legislation and policies must incorporate specific links to programmes that are to be adopted at the state/provincial/regional, municipal, community, and institutional levels.

National action programmes and policies are needed to manage water resources and improve water services that will sustain human and economic development in each country in the coming decades (ADB, 1996b: 1). Traditionally, governments' policies and strategies on water management have been aimed at the expansion of supply in order to meet the ever-increasing water demands of the domestic, agriculture, and industrial sectors. Increasingly policy frameworks are focused on an integrated approach to water resources management by placing emphasis on demand management, water-use efficiency, conservation and protection, institutional arrangements, legal regulatory and economic instruments, public information, and interagency cooperation (United Nations and ADB, 2000). Some countries in the region have created major national institutions with comprehensive responsibility for water resources assessment, planning and development, and other related functions (ESCAP, 1997, cited by United Nations and ADB, 2000). However, the failure of regulation frameworks in most of Asian developing countries is observed from a low priority of the wastewater sector, overlapping responsibilities and duties, poor enforcement of law and regulations, and lack of sector databases.

Most Asian countries have policies and acts/laws for waste management. National governments are responsible for establishing institutional and legal frameworks for waste management and ensuring that local governments have the necessary authority, powers, and capacities for effective management. The local governments are also expected to manage waste, especially municipal solid waste and some special wastes, such as those from slaughterhouses. However, the institutional framework for waste management in some countries is complex and without a clear definition of roles and responsibilities. There are overlaps or duplication of activities in some areas, but there are also grey areas where no activities take place because there is no particular agency identified as responsible (UNEP, 2004: 27). Table 2.2 summarizes the policies and institutional framework for water and waste infrastructure focusing on the application of eco-efficiency.

Table 2.2 Policies and institutional framework of eco-efficient infrastructure for water and waste

Policies/ institutional framework	Cities/ Countries	Sectors			Types				Brief description/ target	Sources/ references
		W	WW	SW	I	II	III	IV		
Rainwater harvesting regulation	Republic of Korea	●	○		/				- To enforce the installation of rainwater harvesting system in December 2004.	Han and Park (2005)
Groundwater resource management	Indonesia	●			/	/	/		- National and local legislation for groundwater conservation: regulation and charges for groundwater abstraction.	IGES (2006)
	Bangkok, Thailand	●			/	/			- Groundwater use regulation. - Extension of public water supply. - Charging for groundwater use.	IGES (2006)
	Taijin, China	●			/	/			- Regulation of groundwater abstraction. - Surface water transfer from other basins. - Charging for groundwater use.	IGES (2006)
	Osaka, Japan	●			/	/	/	/	- Strict control of groundwater abstraction. - Financial support for facilities and equipment for water saving.	IGES (2006)
	Sri Lanka	●						/	- "Agrowell Programme", encourages shallow groundwater irrigation to enable individual peasant farmers to irrigate their crops.	IGES (2006)
National water supply and sanitation board	Sri Lanka	●	●		/	/			- Support to decentralize the National Water Supply and Sanitation Board into five regional support centres.	IWA (2005)
Integrated policymaking to promote economic development and environmental protection	China	●	●		/	/	/		- To manage the urban environment as a business with recognition of conception of environmental efficiency, a favorable input-output cycle has been realized.	www.unescap.org/drrpad/vc/conference/ex_cn_14_a11.htm
Industrial efficiency and pollution control (IEPC) project in Bali, Central Java, West Java, and West Sumatra	Indonesia	●	●	●	/	/	/		- The establishment of the IEPC-project will tackle industrial pollution problem through the government's provision of investment loans to SMEs for efficient production and cleaner technology.	www.unescap.org/drrpad/vc/conference/ex_id_45_iep.htm
Promotion of saving and recycling of resources	Republic of Korea			●	/			/	- The Act on Promotion of Saving and Recycling of Resources covers both non-hazardous and hazardous containers and materials. A waste charge is intended to ensure that the manufacturer bears the cost of processing waste.	www.eiatrack.org/s/900
Encouraging comprehensive utilization of waste	China			●	/			/	- State's 10 <sup>th</sup> Plan, 2001-2005, included provisions to make laws on recycling and utilization of resources.	ARRPET (2004)
Recycling target, 8 <sup>th</sup> national economic and social development plan	Thailand			●		/	/		- Reduction of pollution from waste by recycling and proper treatment of waste, promotion of clean technology in industries, support NGO and public participation.	www.pcd.go.th

Note: W = Water, WW = Wastewater, SW = Solid Waste  
 I = Legislation, II = Institution, III = Capacity-building, IV = Plan/Programme.  
 ● = Direct, ○ = Indirect

## 2.4 REVIEW OF THE NATIONAL, REGIONAL, OR INTERNATIONAL EFFORTS AND/OR SYSTEMS TO PROMOTE SUSTAINABLE INFRASTRUCTURE DEVELOPMENT

The deterioration in the global environment has led to the creation of an international framework of measures, including the international agenda and concrete plans for implementation. Most regional or international efforts support sustainability for economic and environmental development, including sustainable infrastructure development, by providing knowledge, guidelines, leadership, and financial assistance. A summary of major regional and international initiatives on eco-efficient infrastructure for water and waste development is given in table 2.3.

Table 2.3 Initiatives on eco-efficient infrastructure for water and waste

Initiatives	Brief description/activities	Targets	Participating countries/ institutions	Sources
Asia Pacific Roundtable for Cleaner Production (APRCP)	The growing new economies within the Asia-Pacific region have raised concern about the environmental impacts generated from the industrialization and urbanization.	To provide leadership and support that will strengthen public-private partnership to stimulate the promotion and implementation of cleaner production strategies and technologies in the region.	Asia and Pacific countries	<a href="http://www.pcd.go.th">www.pcd.go.th</a>
Kitakyushu Initiative for a Clean Environment	The Kitakyushu Initiative for a Clean Environment aims to draw lessons from the city's practices and experiences and put them together as a menu of effective action that could be useful in other cities in the region.	To enhance the capacity of the local governments of the region by promoting integrated win-win approaches to urban environmental management and socio-economic development.	IGES, ESCAP and a total of 62 cities from 18 countries	<a href="http://www.iges.or.jp/kitakyushu/">www.iges.or.jp/kitakyushu/</a>
Environmental Conservation Initiative for Sustainable Development (EcoISD)	For water pollution countermeasures, JICA provides assistance for the installation of sewers and septic tanks, and many other water pollution prevention measures. For waste disposal, JICA helps developing countries to formulate public investment plans relating to the collection, transportation, intermediate and final disposal, and recycling of urban waste. It also supports technology transfers.	To support sustainable development in developing countries through cooperation in the environmental field under EcoISD as a comprehensive framework for international efforts.	JICA, China, Indonesia, and Thailand	<a href="http://www.jica.go.jp/english/global/envi/initiatives.html">www.jica.go.jp/english/global/envi/initiatives.html</a>
Water for the Poor Initiative	The Water for the Poor Initiative (2002-2005) provides US\$970 million by focusing on access to clean water and sanitation services, improved watershed management and increasing the productivity of water.	To improve sustainable management of freshwater and coastal resources and expand to achieve the MDGs.	United States Agency for International Development and 76 developing countries	<a href="http://www.usaid.gov/about_usaid/presidential_initiative/waterforpoor.html">www.usaid.gov/about_usaid/presidential_initiative/waterforpoor.html</a>
The European Union Water Initiative (EWI)	EWI, "water for life", designed to contribute to the achievement of the MDGs and WSSD targets for drinking water and sanitation, within the context of an integrated approach to water resource management.	To promote mobilization and partnerships between science, public, non-government and private actors in Europe and other regions with a view to achieve the water-related objectives of the MDGs.	The European Union and countries in Africa, Mediterranean, Latin America and Eastern Europe, Caucasus and Central Asia	<a href="http://ec.europa.eu/research/water-initiative/index_en.html">http://ec.europa.eu/research/water-initiative/index_en.html</a>



Table 2.3 Initiatives on eco-efficient infrastructure for water and waste (continued)

Initiatives	Brief description/activities	Targets	Participating countries/ institutions	Sources
Water for all	Water for all, as the water policy of the Asian Development Bank (ADB).	To conserve and protect water resources in the Asian region through participatory approaches.	ADB and Asian countries	ADB (2003)
OECD's Global Forum on Sustainable Development (GFSD)	GFSD discussed the financing dimension of water and sanitation infrastructure in December 2003.	To report experiences in order to add value to the debate on achieving the internationally-agreed water targets focused on urban water.	WB, United States Environmental Protection Agency, OECD member and non-member countries	<a href="http://www.un.org/esa/sustdev/csd/csd12/Background6.pdf">www.un.org/esa/sustdev/csd/csd12/Background6.pdf</a>
Private sector development and infrastructure network (PSI)	World Bank support to provide advisory services to its member countries.	To promote private initiatives for poverty reduction and support infrastructure development in poor countries.	World Bank	<a href="http://www.worldbank.org/html/extpb/2003/infrastructure.html">www.worldbank.org/html/extpb/2003/infrastructure.html</a>
Water for Asian cities	A water and sanitation initiative in Asian cities that aims address the need for pro-poor investments in this field by focusing on creating the enabling environment and building the necessary capacity.	To expand and improve water supply and sanitation services to the urban poor in Asia, and to build the capacity of Asian cities to secure and manage pro-poor investments.	ADB, United Nations Human Settlements Programme and Asian countries	<a href="http://www.adb.org/Water/WAC/WAC.asp">http://www.adb.org/Water/WAC/WAC.asp</a>
Seoul Initiative on Green Growth	The Seoul Initiative is to create synergies between economic growth and environmental sustainability, and to contribute to the achievement of an economically vibrant and environmentally sustainable future for Asia and the Pacific.	To improve environmental sustainability; enhance environmental performance; and promote environmental sustainability as an opportunity for economic growth and development.	47 countries in Asia-Pacific	<a href="http://www.singg.org">www.singg.org</a>
"Asia 2015: promoting growth, ending poverty" conference	Politicians, business leaders and aid agency workers gathered in London to find ways to end poverty in Asia.	To develop policies and strategies to manage environmental assets effectively and tackle the environmental costs of growth; maximize resource use efficiency, including energy.	ADB, WB, DFID and Asian countries	ADB, WB and DFID (2006)
Promoting improved access to clean water	ECO-Asia supports Provincial Waterworks Authority (PWA) of Thailand on a pilot project to develop guidelines to reduce unaccounted-for water, or non-revenue water, by building the capacity of PWA staff to conduct water audits to assess water losses resulting from both physical and commercial sources.	To promote improved access to clean water by strengthening operational efficiency of its waterworks.	ECO-Asia, United States Agency for International Development and Water Supply Authorities in Cambodia, Viet Nam, Indonesia, Philippines, Sri Lanka, India, and Thailand	<a href="http://usaid.eco-asia.org/tools/media/press_releases/2006/12212006.html">http://usaid.eco-asia.org/tools/media/press_releases/2006/12212006.html</a>

Table 2.3 Initiatives on eco-efficient infrastructure for water and waste (continued)

Initiatives	Brief description/activities	Targets	Participating countries/ institutions	Sources
World Water Forum	The World Water Forum is held every three years: "Local Actions for a Global Challenge" has already been established as an open, multi-stakeholder participatory process, which builds on the knowledge, experience and input of the global water community.	To raise global awareness on water issues.	World Water Council (WWC)	<a href="http://www.worldwatercouncil.org">www.worldwatercouncil.org</a>
3R Initiative Towards a Sound-Material-Cycle Society	Participating countries and organizations shared information on 3R-relevant activities carried out by them and discussions at the ministerial level and senior official level.	To promote the "3Rs" globally so as to build a sound-material-cycle society through the effective use of resources and materials.	Ministry of the Environment of Japan, IGES, and ADB	<a href="http://www.iges.or.jp/en/news/topic/0609_3r.html">www.iges.or.jp/en/news/topic/0609_3r.html</a>
3R Knowledge Hub	The 3R Knowledge Hub, a joint initiative, has three major functions: to generate 3R knowledge; to transfer and apply 3R knowledge; and to disseminate 3R knowledge to others in the region.	To strengthen capacity to generate innovative concepts and technologies. To promote networking among organizations, private sectors and research institutes dealing with 3R.	AIT, ADB, UNEP, ESCAP and Asian countries	<a href="http://www.ait.ac.th/aru/news/Jul06/art/a22.html">www.ait.ac.th/aru/news/Jul06/art/a22.html</a>
SEA-UEMA Project	Partnership between Canadian International Development Agency (CIDA) and Asian Institute of Technology (AIT) on the Urban Environmental Management Applications (SEA-UEMA) Project (2003-2008).	To improve urban environmental policies and good practices in the region, focusing on applications in three sub-sectors (water and sanitation, solid waste, and air pollution) with gender equality as a cross-cutting theme.	Eight countries in Southeast Asia	<a href="http://www.sea-uema.ait.ac.th">www.sea-uema.ait.ac.th</a>

## 2.5 CHALLENGES IN DEVELOPING SUSTAINABLE INFRASTRUCTURE

Many countries are challenged by trends in urbanization and industrialization, population increases, and the consequent rise in water demand and waste generation. Although each sector of infrastructure has special problems, there are common patterns—operational inefficiencies, inadequate maintenance, excessive dependence on fiscal resources, lack of responsiveness to users' needs, limited benefits to the poor, and insufficient environmental responsibility (World Bank, 1994: 10).

One of the major challenges in applying eco-efficiency approaches more broadly is that the success stories are originally based on business models rather than the public sector. These approaches often can not be easily replicated in the context of public sector sustainable infrastructure development, which have relatively long-term objectives, produce public goods, and are subject to intangible values and externalities. Nevertheless, eco-efficient infrastructure can be achieved by applying policies and strategies suited to both the country and local conditions, as explained in Chapter 5. The challenges (and opportunities) in developing sustainable infrastructure for water, wastewater, and solid waste are summarized in table 2.4.

Table 2.4 Challenges and opportunities in developing sustainable infrastructure

Challenges	Opportunities
<b>Water and Wastewater</b>	
<ul style="list-style-type: none"> <li>• Keeping pace with a net population growth of more than a billion people over the next 15 years.</li> <li>• Closing the coverage and service gap, with emphasis on sanitation and wastewater management.</li> <li>• Ensuring sustainability of existing and new services.</li> <li>• Improving the quality of services.</li> </ul>	<ul style="list-style-type: none"> <li>• Reducing unaccounted-for water.</li> <li>• Water pricing.</li> <li>• Water saving.</li> <li>• Groundwater efficiency.</li> <li>• Reuse and recycling of wastewater.</li> <li>• Environmental assessment—SEA, EIA.</li> <li>• Increasing service standard/level and service reliability.</li> <li>• Applying asset management in operation and maintenance of facilities.</li> <li>• Monitoring and evaluation of programmes/projects.</li> <li>• Enhance water information, consultation and partnership.</li> <li>• Raising education and public awareness.</li> </ul>
<b>Solid Waste</b>	
<ul style="list-style-type: none"> <li>• Difficulty in segregating waste at source.</li> <li>• Low awareness of all sectors.</li> <li>• Lack of sanitary disposal facilities and composting areas.</li> <li>• Limited resources including funds.</li> <li>• Difficulty for 100 per cent collection efficiency.</li> </ul>	<ul style="list-style-type: none"> <li>• Waste reduction/minimization.</li> <li>• Resource recovery, e.g. recycling, composting, waste to energy.</li> <li>• Financial sustainability including requirements for “user-pay”.</li> <li>• Public-private Partnership.</li> <li>• Promoting cleaner technologies/production.</li> <li>• Promoting sanitary landfill disposal, including use of guidelines and/or standards.</li> <li>• Raising education and public awareness.</li> </ul>

## 2.6 OPPORTUNITIES IN THE PROMOTION OF SUSTAINABLE INFRASTRUCTURE

The infrastructure for water supply, wastewater, and solid waste management can be considered as a type of environmental infrastructure requiring investment for protecting the environment and also for maintaining economic growth. Sustainability of infrastructure is required for proper asset management and planning. There are several opportunities for promoting eco-efficiency in planning and management of infrastructure development through the use of management tools. Examples include applying environmental assessments (e.g. strategic environmental assessment), applying asset management in operation and maintenance of facilities, and integrated monitoring and evaluation of projects. Also, utilities may use standard methodologies, such as benchmarking, to help assess conventional economic efficiency and to calibrate their own efficiency against that of others. In terms of economic aspects, public-private partnership is one opportunity to increase the economic efficiency of infrastructure. Furthermore, creating greater public understanding of the issues involved and instilling a conservation ethic will be necessary in providing more sustainable water and waste management. Specific opportunities in promoting eco-efficiency in water supply, wastewater, and solid waste management are presented in the following sections.

### 2.6.1 Water and wastewater

The water cycle includes: water sourcing, supply, wastewater collection, disposal, and reuse. These phases basically provide several opportunities to improve the eco-efficiency of water and wastewater infrastructure, as well as attaining a sustainable system. Key opportunities in promoting eco-efficiency in water and wastewater infrastructure are as follows.

### *Reducing unaccounted-for water*

No country in the world is free from water leakage, which is a major proportion of unaccounted-for water. Measures to prevent water leakage include: replacement of old pipes; optimization of water pressure; improvement of leakage detection skills; and procurement of leakage detectors (JICA, 2005: 99). The problem could be addressed through implementing policies such as increasing access to the water supply, especially among the poor. Another measure would be to conduct comprehensive audits of water and service levels, as Phnom Penh's water supply body has done.

### *Water pricing*

Water pricing is a market-based approach that can contribute to increased access to water and healthier systems, and which is more sustainable over the long term. Efficient and effective water pricing systems provide incentives for efficient water use and for water quality protection. They also generate funds for necessary infrastructure development and expansion, and provide a good basis for ensuring that water services can be provided to all citizens at an affordable price. The metering of water consumption is a prerequisite for the application of efficient water pricing policies. A successful example is Singapore's implementation of a water use tax and progressive tariff structure, where subsequent units of water are priced higher than previous units (for example, units 1-10 cost US\$1 each, units 11-20 are US\$2, units 21-30 are US\$3, and so on) (Tortajada, 2006: 232).

### *Water saving*

Increasing water saving is implemented by raising public awareness regarding water usage and encouraging public participation. The collection of rainwater from roofs, its storage, and subsequent use is a simple method for reducing the demand on both public water supplies and wastewater facilities. Rainwater harvesting systems provide a source of ongoing water supply, reduce reliance on other water sources, and, in many contexts, are cost effective (Kim, *and others*, 2003: 1).

### *Groundwater use efficiency*

Some countries rely heavily on groundwater, but it is not a reliable source in the long term and may not be adequate for current needs. For increased efficiency, the management requirements include technical capacity and the prevention or reduction of groundwater contamination. An example of a measure for more effective groundwater management is Bangkok's introduction of a charging system (IGES, 2006: 4).

### *Reuse and recycling of wastewater*

Eco-efficiency of water use can be achieved by increasing the efficiency of resource use and reducing the impact from wastewater. Reuse and recycling of wastewater is an important option to increase water use efficiency (Sa-nguanduan and Nitivattananon, 2006: 245) and hence promote eco-efficiency. An example of a water reuse application is shown in box 2.1.

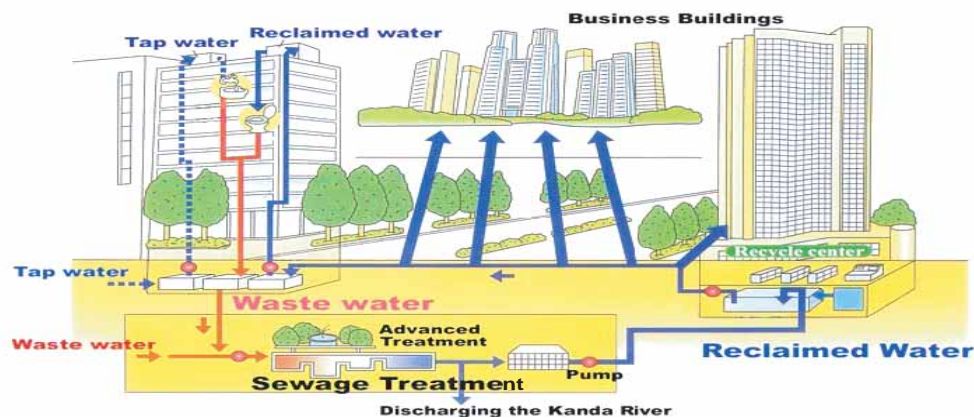
Another example is the "Ecosan" concept, the closed-loop solution for wastewater management, which increases eco-efficiency of wastewater based on the systematic recycling of nutrients and water as a hygienically safe, closed loop and holistic alternative to conventional solutions (Werner, *and others*, 2002: 67).

## 2.6.2 Solid waste

There is an obvious need to proactively manage the use of all natural resources and infrastructure to minimize economic and non-economic costs and to maximize returns. At the same time,

### Box 2.1 Wastewater reuse for urban applications in Japan

Tokyo is one of the leading cities successfully implementing wastewater reuse. For example, the city has developed dual water distribution systems—one for delivering drinking-quality water and one for delivering treated wastewater and stream augmentation—a process by which supplemental water is pumped to the headwater of a stream and allowed to flow through the system using gravity. In a water reuse project in the Shinjuku area of Tokyo, a dual distribution system has been adopted. Sand-filtered water from the Ochiai Municipal Wastewater Treatment Plant is chlorinated and used for toilet-flushing water in 25 high-rise business premises and for stream augmentation, as illustrated in the following figure. The system, which has been successfully operating since 1984, supplies treated wastewater up to a maximum of 8,000 m<sup>3</sup>/day (Tokyo Metropolitan Government, 2001).



Source: UNEP and GEC (2005: 19, 23-24).

effective management would also place greater effort towards using renewable resources, finding higher value alternatives, and establishing sustainable practices. In solid waste management, for example, extra economic benefits should be sought not from increasing solid waste disposal efforts in the region, but from promoting the 3R approach; developing higher-demand products and higher-value products; adding value through industry recycling; and developing new methods to reprocess waste materials efficiently.

#### 3R approach

The environmentally sound practices of “reduce, reuse, and recycle” or “3R” can be applied by minimizing waste generation through source reduction and separation, and by reusing, recycling, and recovering goods and materials. This not only responds to the problems of increasing waste generation, but may also provide significant gains from the reuse and recycling of waste. Promoting this approach requires establishing 3R-related policies along with environmentally sound recycling mechanisms; supporting and improving informal waste recycling; utilizing financial incentives such as government subsidies for recycling technologies; and harnessing market forces, including supporting recycling technologies and public awareness. Examples are practices in waste composting and waste to energy (more details are provided in table 2.1).

#### Solid waste fees

Waste fee systems impose a differentiated treatment cost as determined by the amount of waste generated by each resident. The system is significant in that it provides for an economic incentive that actualizes the Polluter-pays Principle, the User-pays Principle, and the principle of prevention

(not end-of-pipe solutions) in the field of waste. For example, the introduction of a volume-based waste fee system in the Republic of Korea increased the recycling rate from 15.4 per cent to 41.3 per cent, while the landfill rate dropped from 81.1 per cent to 47 per cent, from 1994 to 2000. This figure is equivalent to a total of US\$5.52 billion in social and economic savings (US\$3.66 billion from waste reduction and US\$1.86 billion from increased recycled goods), or US\$920 million per year (Ministry of Environment, Republic of Korea, 2002).

### *Public-private Partnership*

Public-private partnerships may be considered for solving solid waste problems. There is need to develop cooperation between government, non-governmental organizations (NGOs), community-based organizations (CBOs), and other private entities. An example of successful public-private partnership is in Sri Lanka. The partnership between Burns Environmental Technologies Private Ltd. (BETL) and Colombo's Municipal Council, under the support from the United States Asia Environmental Partnership (US-AEP), has eased the city's garbage disposal problems and is contributing to the regeneration of Sri Lanka's coconut and tea plantations by providing high quality, low-priced compost to renew agricultural land.

## 2.7 DEVELOPMENT OF ECO-EFFICIENT INFRASTRUCTURE

### 2.7.1 Key conditions considered in eco-efficient infrastructure development

Eco-efficient infrastructure developed in one country may not be appropriate for other countries. It requires careful consideration of the local conditions, and must be based on a sufficient and well-integrated analysis of technology options, financial implications, health-risk mitigation, and other factors. Key conditions for eco-efficient infrastructure development are described as follows:

#### *Economy: low-, middle-, and high-income countries*

Economic and financial analyses are normally needed to identify viable solutions and to access financial assistance when necessary. While many types of infrastructure have numerous benefits and long-term cost effectiveness, they may have a high initial cost. Alternatives to address this impediment, such as public assistance, incentives, and preferential private sector financing, must be explored. Japan's implementation of an eco-efficient solid waste management system provides one example. High-income countries like Japan have the technology, knowledge, and budget, but may be constrained in terms of land, especially in urban areas. Incineration is therefore an appropriate technology in this case; however, in other (developing) countries this technology is not well-accepted because of its cost constraint.

In recycling solid wastes, the composition of the waste depends on income. Low-income countries' major waste component is organic material, whereas high-income countries have a large proportion of paper in their waste. These differences lead to different strategies to develop an eco-efficient system for solid waste management. For instance, the use of composting in some low-income countries may be an effective strategy for recycling organic wastes, as can be seen in India, Indonesia, and Philippines.

#### *Physical/ topographical: arid areas, rainy areas, and areas with abundant water*

Physical and climate conditions are a main driver for infrastructure development, especially concerning water management. Physical conditions can drive the selection of technology and management alternatives. For example, Israel, an arid area faced with water scarcity, is successful in

reusing wastewater as a second water source, fulfilling 10 per cent of water demand (United States Environmental Protection Agency, 2004: 242). Whereas public awareness is crucial in the implementation of wastewater reuse, people in areas with limited water have greater awareness compared with areas with abundant water.

#### *Demographic: urban versus rural areas*

During a planning process, the appropriateness of infrastructure application needs to be carefully evaluated against the demand and supply of services. The functional purpose of the service needs to be evaluated together with the associated environmental impact and health risks. A population's needs must also be predicted according to future demand. In the context of urbanization, the growth of megacities is fast becoming a major source of demand for additional infrastructure, creating a sense of urgency in some policy circles.

In rural areas, people live in less-densely populated centres and rely heavily on natural resource-based production. Their demands for infrastructure are quite different from those of urban areas, including governance and financing arrangements and levels of service. In the case of wastewater infrastructure, evaluation of treatment options is useful in identifying necessary treatment and disposal technologies, as well as operational and maintenance requirements. Appropriate wastewater management in rural areas is normally an on-site system, such as septic tanks and land-based disposal.

#### 2.7.2 Recommendations on the development of eco-efficient infrastructure

The promotion of eco-efficiency of water, wastewater, and solid waste infrastructure should be based on the following:

- Increase in the efficiency of resources use.
- Applying cleaner technology.
- Use of 3R approach.
- Applying economic instruments.
- Use of appropriate public-private partnership.

Recommended strategies and actions to promote eco-efficient infrastructure in water, wastewater, and solid waste in Asian countries are outlined below. These should be considered in terms of priority and together with specific conditions of each country and/or local areas.

- Establishing clear policies and a master plan that can be implemented for water resources management.
- Restricting the use of water, including groundwater and the disposal of waste.
- Applying the Polluter-pays Principle to all waste generators.
- Providing composting, sanitary landfills, and integrated hazardous waste facilities.
- Promoting the use of waste as the energy renewal source.
- Public participation could be initiated with awareness campaigns in promoting a 3R programme.
- Providing organizational and legislation support for encouraging the involvement of private sectors, NGOs, and CBOs.
- Promoting public and private sector involvement in all stages of the management process.
- Monitoring and recording should be initiated on a continuous basis; for example, development and use of information systems for water quality monitoring.
- Enhancing management efficiency through capacity-building by training, workshops, etc.
- Encouraging research and development projects for cleaner technology application.

## 3. Sustainable transport infrastructure

### 3.1 DEVELOPMENT OF ECO-EFFICIENT TRANSPORT INFRASTRUCTURE IN LINE WITH THE ECONOMIC AND GEOGRAPHICAL SITUATIONS IN ASIAN COUNTRIES

Transport infrastructure has a very significant role in the socio-economic well-being for users. It contributes to the economic growth and development of any country, leading to poverty reduction. It also facilitates access to education and healthcare facilities for poor and/or rural populations. Insufficient infrastructure is considered a bottleneck for growth, requiring investments to alleviate the situation. Asian countries are seeking sustainable solutions for their transport systems, but the implementation of these solutions has often been deferred due to the complex interaction between many factors of transport, land use, stakeholders, and decision makers. Transport policy makers face various challenges while developing sustainable transport strategies (WCTRS and ITPS, 2004), which are discussed below.

#### 3.1.1 Economic efficiency

This requires the maximization of benefits that users can gain from the transport system, after taking into account the resource costs of building and operating the transport system. Travel time and cost are key elements in reducing the benefits of travel, and economic efficiency is concerned with reducing these costs, whether they arise through congestion, unreliability, or inadequate services. It is possible for an efficiency analysis to include the external costs of pollution and accidents.

Budget constraints for the implementation of sustainable transportation also pose a big challenge in Asia. Some eco-efficient transport infrastructure development like Bus Rapid Transit (BRT) and heavy or light rail are very capital intensive. At the same time their success and failure is very much dependent on proper planning and studies, which in themselves require significant funding. Therefore many developing countries are hesitant to implement them.

#### 3.1.2 Environmental / ecological efficiency

This involves reducing a number of adverse impacts of the transport and land use system: the global, regional and local pollutants; noise and vibrations; and other environmental impacts such as visual intrusion, the fragmentation and severance of settlements and biodiversity, urban sprawl, and loss of cultural heritage and natural habitats. Apart from the many economic benefits of transport infrastructure in Asia, its rapid growth, quality, spatial pattern, and modal shift have created an alarming situation from an environmental standpoint. The poor quality of transport infrastructure not only continues to stand against the realization of Asian countries' full economic potential, but also appears to be a main cause of many of the environmental problems. The concentration of populations and economic bases in large cities in the face of inadequate investment in transport infrastructure has led to crowding and poor energy efficiency in the transport sector. The dramatic rise in road transport has led to an unbalanced situation between private cars and public transport, which is relentlessly degrading the region's environment (Saeed and Acharya, 1995).

The International Energy Agency (IEA) has projected that the transport sector will be the primary user of energy by the year 2020. That same year, the world energy consumption will have grown by 66 per cent, due in great part to the developing countries. In the case of transport, petroleum accounts for more than 95 per cent of its energy needs (IEA, 2006). As a result of motorization, the demand for oil cannot be sustained and the energy cost for developing countries can become a real burden when oil is bought with foreign currencies.



### 3.2 CURRENT STATUS

Asia's urban population, especially in the developing countries, is increasing at a very fast rate. Table 3.1 shows the population and the growth rate of some largest cities of the world. This has caused a tremendous increase in demand for passenger and freight transport, leading to transportation-related problems.

Table 3.1 Population and growth rates of a selection of the largest cities of the world

City	Population (millions)			Growth rate (percentage)		
	1980	2005	2015	1980-1995	1995-2005	2005-2015
Tokyo	28.5	35.3	36.2	1.1	0.51	0.24
Mumbai	8.7	18.3	22.6	3.3	2.65	2.11
Delhi	5.6	15.3	20.9	4.1	4.27	3.15
Calcutta	9.0	14.3	16.8	1.9	1.83	1.62
Jakarta	6.0	13.2	17.5	2.9	3.72	2.86
Shanghai	11.7	12.7	12.7	0.7	-0.35	0.03
Dhaka	3.3	12.6	17.9	9.2	4.33	3.61
Karachi	5.0	11.8	16.2	3.5	3.39	3.20
Osaka-Kobe	10.0	11.3	11.4	0.7	0.21	0.10
Beijing	9.0	10.8	11.1	1.2	0.02	0.23
Metro Manila	6.0	10.7	12.6	3.1	1.28	1.67

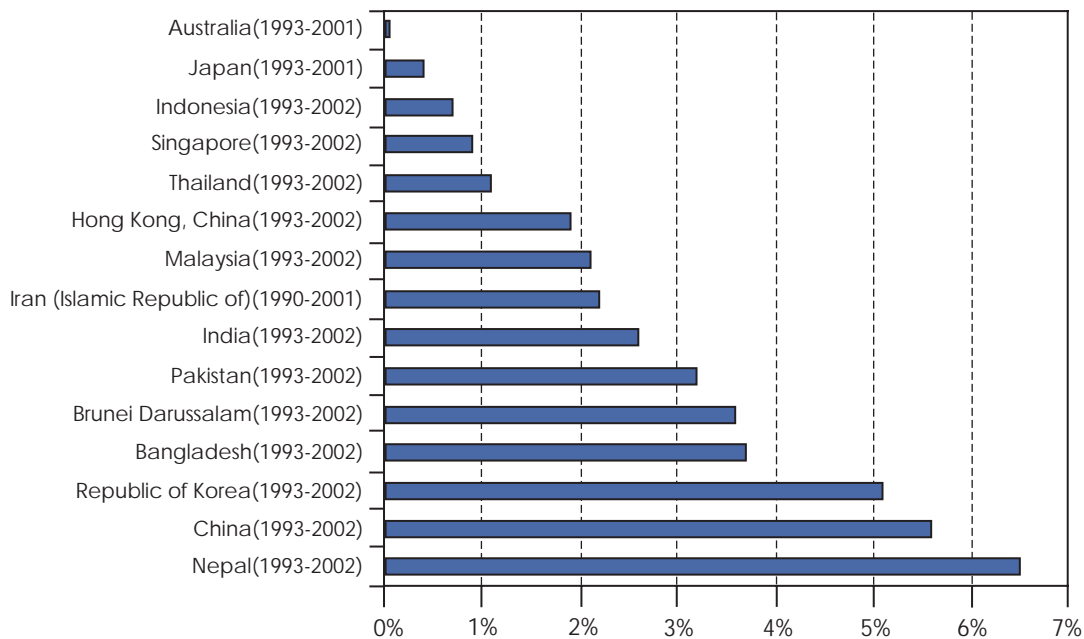
Source: ESCAP (2005: 29).

The development of transportation has greatly contributed towards the development of tourism, trade, and commerce leading to economic development in the Asian region. It has also helped greatly in the process of poverty alleviation both in the rural and urban areas. Transportation development has contributed significantly towards enhancing the quality of life of the Asian people. On the other hand, the development of transport infrastructure such as roads and railways has some negative impacts; for instance, increases in environmental pollution in the form of air and noise pollution. However, many initiatives have been undertaken to overcome this. The current status of transport infrastructure development in Asia is described in the following sections.

#### 3.2.1 Road infrastructure

The growth and development of road infrastructure from 1993 to 2002 for many Asian countries is shown in figure 3.1. It shows that Nepal has the highest growth rate for road infrastructure. However, the story is different when it comes to the absolute figures. For example, India has a growth rate of 2.6 per cent, but in absolute terms this accounted for 700,000 km of road development between 1993 and 2002 (ESCAP, 2005: 5). South Asia accounts for 26 per cent of the total lending of the World Bank transport infrastructure development from 2002 to 2004, of which 80 per cent was allocated for highway development.

Figure 3.1 Road network growth in selected countries and areas, 1993-2002



Source: ESCAP (2005b: 67).

The road network in China has grown from 900,000 km in 1981 to 1,920,000 km in 2001. This figure represents quantitative growth in terms of kilometers, but the quality of roads has also increased. India's hierarchical network of roads aggregates to 3.3 million km, which is the second-largest in the world. In Japan, the total road length is 1,180,342 km in 2003, while in Pakistan, the total road length amounts to 2,580,000 km with a road density of 0.32 km/km<sup>2</sup>. Other Asian countries also follow the same trend (ESCAP, 2006a).

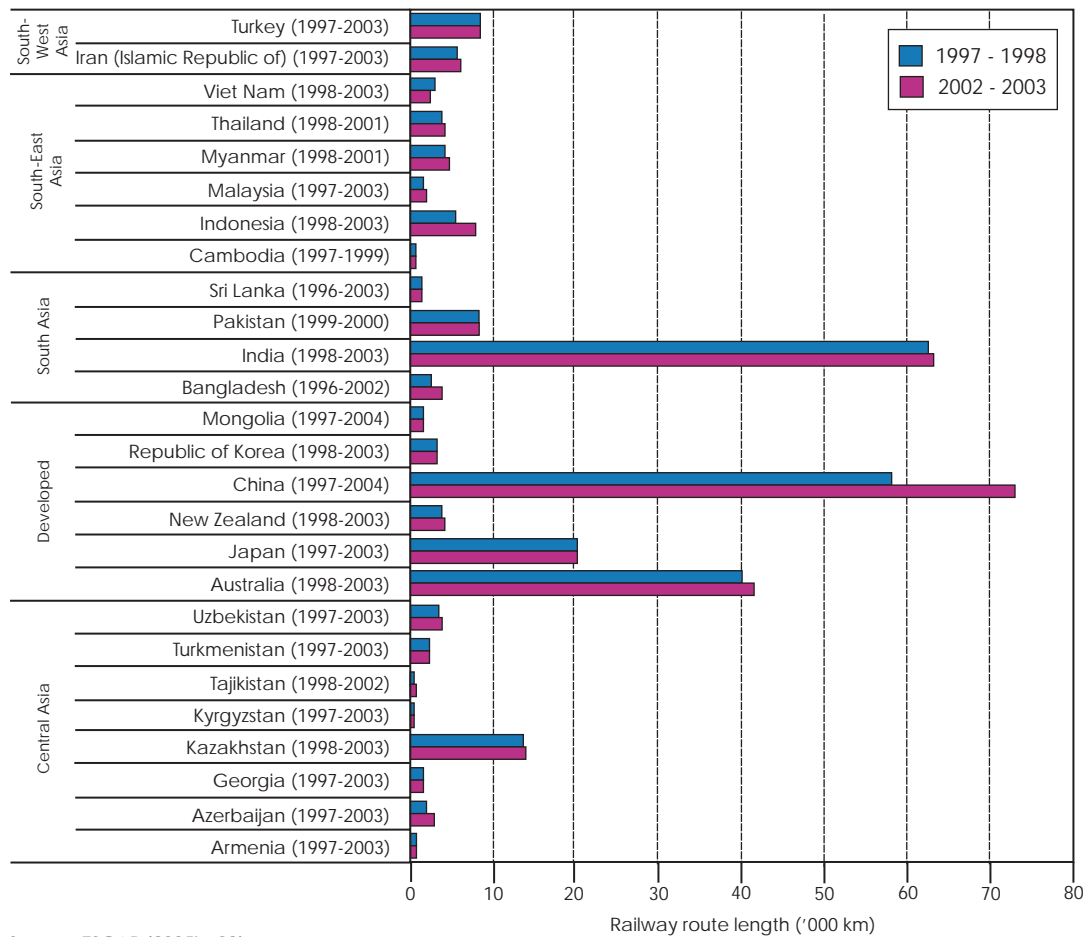
### 3.2.2 Railway infrastructure

Figure 3.2 compares growth in the overall rail route length for a selection of ESCAP countries. As a result, China's rail network increased 14,800 km between 1997 and 2004, surpassing India as the country with the largest rail network in the ESCAP region. The Chinese and Indonesian rail networks show average annual expansion rates of 14.8 per cent and 8.4 per cent, respectively. On the other hand, India's rail network grew at only 0.21 per cent, although its coverage is already quite extensive. In contrast to the impressive growth seen in China and Indonesia, a number of Asian countries experienced little or no expansion of their overall rail network. Looking at density, Singapore's is highest (253 m/km<sup>2</sup>), then Japan (61 m/km<sup>2</sup>), the Republic of Korea (31 m/km<sup>2</sup>), and India (20 m/km<sup>2</sup>) (UITP, 2001). Other Asian countries have less than 10 m/km<sup>2</sup>.

### 3.2.3 Urban transport infrastructure

Urban areas are the pivot of economic activities for all countries and it contributes significantly towards the national economy. This brings a large population concentration at city centres. For instance, it was estimated that Bangkok contributes 37.4 per cent towards Thai economic activities and it also has 10.9 per cent of the Thai population (ESCAP, 2005: 129).

Figure 3.2 Trends in railway route length in the ESCAP region, 1997-2003



Source: ESCAP (2005b: 82).

Asian cities are characterized by high speed motorization. Car ownership in Thailand grew from 46 per thousand people in 1990 to 359 per thousand in 2001. During this period, car ownership grew by 300,000 cars per annum in Bangkok (ESCAP, 2005: 129). There is an increasing trend of two-wheelers in many Asian large cities, which has aggravated the problem of pollution because two-stroke engines are common in two-wheelers. However, many cities have made significant moves towards phasing out two-stroke engines in favor of more environmentally friendly four-stroke engines.

Although many Asian countries have sufficient transport infrastructure, it is often not adequately maintained. This leads to deterioration of the quality of infrastructure and requires significant resources for rehabilitation of the asset. The transport infrastructure in Asian countries can also be unsafe for users, as evidenced by the loss of 430,000 lives and more than 2 million injured on roads in 2003 in Asia and the Pacific (ESCAP, 2006a: 35). Traffic congestion leading to huge economic and environmental losses is another feature.

Public transportation such as railways and buses are more sustainable and eco-efficient transport modes. Some of the large Asian cities like Hong Kong, China; Singapore; and Tokyo have modal shares of public transportation in excess of 70 per cent, but the situation varies for different cities. With the aim of reducing congestion and pollution, many Asian cities have started paying serious consideration towards the development of public transportation. Tokyo; Hong Kong, China;

and Seoul developed urban rail networks quite some time ago. Some other cities like Bangkok, Chengdu (China), New Delhi, Jakarta, and Manila, have urban rail development projects that were developed in the last few years (ESCAP, 2005: 132-134).

Bus Rapid Transit (BRT) is a bus system that emphasizes dedicated infrastructure of minimal interaction with general road traffic, much like rail systems bypass road traffic, through which it is possible to fill the niche between rail and conventional buses. It is considered as a cheaper investment in public transport and to operate than rail. Jakarta and Beijing operate BRTs, and many other cities have plans to implement the system. In comparing urban rail transport and bus rapid transit, each has their own advantages and disadvantages, such as high capacity and good punctuality for rail, and low investment cost for buses. Many Asian cities are trying to have integrated public transportation systems in order to maximize the advantages by using Intelligent Transport System (ITS).

Asian cities also have many para-transit systems like vans, jeepney, tuk tuk, three-wheelers, etc., and non-motorized mode of transport like rickshaw. The non-motorized modes, such as walking and cycling, are also eco-efficient. To some extent, the use of rickshaws in some Asian cities like Shanghai (78 per cent) and Ho Chi Minh City (44 per cent) are significant (Worldwatch Institute, 2007: 68). However, the political priorities sometimes influence its promotion.

In general, higher-density Asian cities are characterized by more public transportation use; however, there are some exceptions like Bangkok, which has the highest car use in spite of having very high density. Here, cars, motorcycles, and three-wheelers fill the roads, leading to declines in the average speed of public transportation modes.

In many Asian cities, eco-efficient intermodal transport, which takes into account different modes of transportation for a single trip, has so far not been properly developed. The policies and their implementation in many countries should be made accordingly so as to facilitate and utilize integration of several transportation modes.

### 3.3 COMPARATIVE ANALYSIS OF EACH MODE OF TRANSPORT IN TERMS OF ECO-EFFICIENCY

Each mode of transport has its own eco-efficiency. Eco-efficiency is a management philosophy which focuses on business opportunities and allows concerned parties to become more environmentally responsible and more profitable. It fosters innovation and therefore growth and competitiveness. Thus eco-efficiency is the sum of economic and ecological efficiency.

#### 3.3.1 Fuel efficiency and fuel economy

Fuel efficiency and fuel economy are terms that explain the cost component of eco-efficiency for transportation infrastructure. Fuel efficiency is the term given to the level of efficiency in converting energy contained in a carrier fuel to kinetic energy or work. In reference to the concepts in traffic engineering, output can be measured in terms of passenger-kilometers or ton-kilometers. Fuel economy is usually expressed in one of the following two ways: (1) the amount of fuel used per unit of distance, e.g. liters/100 km; and (2) the distance traveled per unit volume of fuel used, e.g. km/liters. The efficiency becomes very important not only due to the huge cost of large-scale consumption of fossil fuels but also due to the limited nature of the available resource.

Figure 3.3 Energy consumption by transport mode in Asian cities

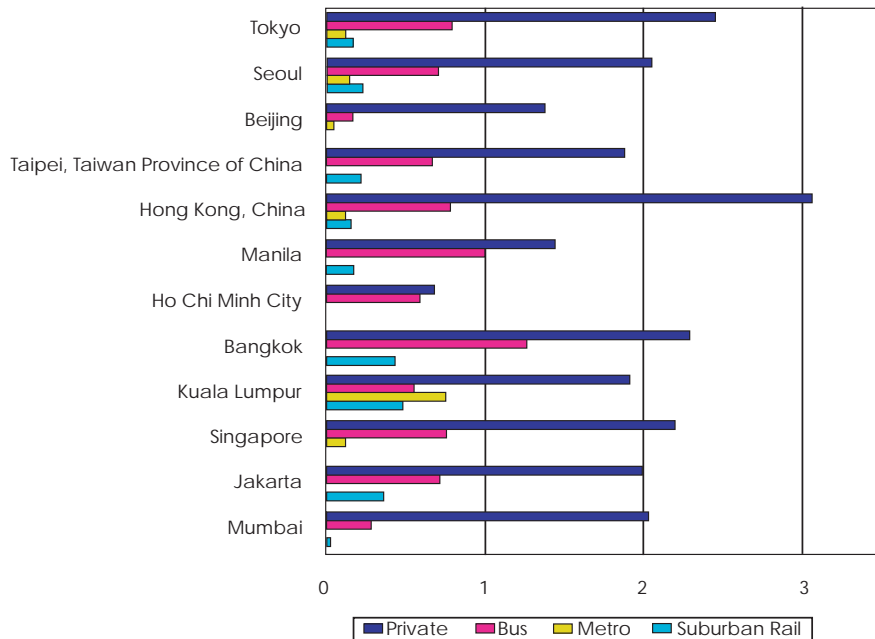


Figure 3.3 shows the energy consumption per passenger-kilometer by transportation mode in selected large Asian cities. Private cars have the highest energy consumption in all cities, but in Ho Chi Minh City, private cars and buses have almost the same values. Among public transport, buses are the least fuel-efficient mode. Although metros and suburban railways are not so fuel efficient in Kuala Lumpur due to low occupancy, trains generally are the most fuel-efficient urban transport mode. Thus, when its share of public transport is high, its energy efficiency is higher.

The easiest way to improve fuel efficiency is to increase vehicle occupancy. Passenger/private car trips currently constitute the most widely used mode of transport in many Asian cities and they have very low occupancy. High occupancy vehicles use fewer trips for carrying the same number of passengers and are thus more efficient. Public transport has a high potential for serving passenger trips at low energy consumption. With high enough load factors, public transport consumes less energy per passenger-kilometer than private transport. However, without sufficient ridership, public transport might be less energy efficient than private vehicles.

### Box 3.1 Electric versus internal combustion engines

There are two common methods of propulsion for vehicles, namely the use of electric motors and internal combustion engines. Electric motor propulsion is powered by energy fed from overhead electric wires, third rails, series of batteries, or prime movers that generate electricity, such as diesel electric locomotives and hybrid vehicles. In the case of internal combustion engines, the system may use fuels including gasoline, diesel, propane, and natural gas. The internal combustion engines used in standard automobiles may be spark ignition petrol or gasoline engines, or compressed ignition diesel engines. Petrol engines are either four-cycle or two-cycle engines. Two-cycle engines pollute more than four-cycle engines. In diesel engines, air is compressed to reach a high temperature and then fuel is injected under high pressure, which is subsequently heated and becomes vaporized to mix with air and undergo combustion. Diesel engines are better than petrol engines in their thermal efficiency, CO<sub>2</sub> emissions, and efficient use of fossil fuel. However, they emit large volumes of nitrogen oxides and particles that pollute the air, especially in the absence of new technologies like particulate filters.

Source: World Conferences on Transport Research Society and Institute for Transport Policy Studies, 2004.

### 3.3.2 Pollution of public versus private transport

The mode of transport used determines the nature of pollution, and the most significant problem associated with transportation is air pollution. Moreover, various forms of transport also cause noise pollution, land degradation, and water pollution. Table 3.2 shows the emissions from public versus private transport in the United States, which has a much higher rate of private transport. Transportation is also a major producer of greenhouse gases, e.g. carbon dioxide and methane, which leads to climate change as described below. This is either due to direct or indirect use of fossil fuels in the production of other forms of energy. Combustion of gasoline produces nitrogen oxides, carbon monoxide, and volatile organic compounds (VOC), which help in the formation of ozone at ground level. Nitrogen dioxide (NO<sub>2</sub>) reacts with water to cause acid rain. These gases have serious adverse impacts on human health as well. Diesel fuels also produce the same type of pollution; in addition to the above they also produce particulate matters. Modes of transportation using electricity are not pollution-free, as the production of electricity produces pollution at the power plants rather than where transportation takes place. Of course, hydroelectric generation does not produce air pollution, but electricity generation using combustion does. Still, the pollution produced is relatively less than that produced by vehicles used for transportation. This is especially true where high-efficiency external combustion engines and effective anti-pollution devices are installed.

Table 3.2 Emissions by public versus private transportation in the United States, 1999

Mode of travel	VOC	CO	NO <sub>x</sub>	CO <sub>2</sub>
Public transport	6,319	38,079	29,838	9,120,489
Private vehicles	76,748	783,006	57,002	16,526,345
Environmental savings	70,431	744,927	27,164	7,405,856

Unit: metric tons  
Source: UITP (2003b: 26).

The transport sector is one of the major contributors to greenhouse gases. According to an estimate of ESCAP (2005: 33), the transport sector contributes 15 per cent of total global emissions of CO<sub>2</sub>. It is noted that the transport sector's energy use includes not only fuel but also operations, as shown in table 3.3. Transport also contributes to global nitrous oxide (N<sub>2</sub>O) and methane (CH<sub>4</sub>) emissions, and motor vehicle air conditioners are major producers of hydrofluorocarbons (HFCs). While transport is the major producer of greenhouse gases, private vehicles account for more than half of all carbon dioxide emissions. There has been a rapid growth in private car ownership, especially in the developing and emerging countries, and at the same time occupancy rates in private vehicles is declining, increasing the demand for cars. This is bound to increase the emission level of carbon dioxide and other pollutants.

Cities that embrace public transit modes require less space for car traffic (roads) and parking, resulting in more space that can be used for more productive purposes. This is due to the fact that a freeway carries 2,500 people per hour; a bus lane carries 5,000–8,000; light rail transit (LRT) or BRT can carry 10,000–20,000; and heavy rail transit can carry 50,000 people per hour. In contrast, most car-dependent cities require five to eight parking spaces for every car (Worldwatch Institute, 2007: 83).

Table 3.3 Energy use by urban transport mode in Australia

Mode	Operation	Fuel	Total
Bicycle	0.5	0.3	0.8
Light Rail	0.7	1.4	2.1
Bus	0.7	2.1	2.8
Heavy Rail	0.9	1.9	2.8
Car, Petrol	1.4	3.0	4.4
Car, Diesel	1.4	3.3	4.7

Unit: Mega joules/passenger-km  
Source: Lenzen (1999: 277).

Table 3.4 Current practices of eco-efficiency transport infrastructure

Cases	Problems	Eco-efficiency aspects			Conditions/Factors/ Years	Sources
		A	B	C		
Nagoya and Japan	<ul style="list-style-type: none"> <li>High density of population.</li> <li>Too much use of personalized vehicles.</li> <li>Air and noise pollution.</li> </ul>	●	●	●	<ul style="list-style-type: none"> <li>Development of suburban railways and subways in 1960s.</li> <li>Regular testing and inspection of vehicles, key-route bus system allows buses to move on exclusive central lanes during 1970s-1990.</li> <li>Introduction of park-and-ride facility, guideway bus system, promotion of fuel economy, introduction of vehicle taxes, subsidies for low emission and consumption vehicles in 2000s.</li> </ul>	WCTRS and ITPS (2004)
Manila	<ul style="list-style-type: none"> <li>Large-scale use of second hand diesel vehicles as means of public transport.</li> <li>Air pollution.</li> </ul>	●		●	<ul style="list-style-type: none"> <li>Philippines clean air act in 1999.</li> <li>Awareness by NGOs, institutions, government and private sector participation.</li> <li>Introduction of light rail transits (LRT3, LRT1) and South Luzon expressways.</li> <li>Introduction of cycle routes.</li> <li>Private emission test centres established.</li> </ul>	WCTRS and ITPS (2004)
Seoul	<ul style="list-style-type: none"> <li>High population density.</li> <li>Low car speed and quality of bus service.</li> <li>Rapid increase in personalized vehicles.</li> </ul>	●	●	●	<ul style="list-style-type: none"> <li>Innovative bus reforms e.g. exclusive bus lanes in 2004.</li> <li>Different color buses used for buses serving different functions. The zone of the bus operation and origin and destination were marked clearly. Red Zone at bus stops.</li> </ul>	WCTRS and ITPS (2004) and Pucher, and others (2005)
Singapore	<ul style="list-style-type: none"> <li>Population increase.</li> <li>Vehicular population increase.</li> </ul>	●	●	○	<ul style="list-style-type: none"> <li>High import duties, registration fees, fuel tax, and annual tax for personal cars.</li> <li>Vehicle quota system.</li> <li>Electronic road pricing (ERP) in 1998 as a means of dynamic road pricing.</li> <li>MRT in 1987 and LRT replacing bus feeder to MRT.</li> </ul>	WCTRS and ITPS (2004)

Note: A = Increasing service value; B = Resources use Optimization; C = Minimization of environmental impact.  
(●=direct; ○=indirect)

### 3.4 SOCIAL COST AND ENVIRONMENTAL IMPACT OF TRAFFIC CONGESTION

Road congestion is one of most serious problems in transport infrastructure. The World Bank (2001: 10) reported that the average speed of downtown weekday traffic was 8 kph (kilometers per hour) or less in Seoul and Shanghai; 10 kph or less in Bangkok and Manila; and 15 kph or less in Kuala Lumpur. The Victoria Transport Policy Institute (VTPI) defines traffic congestion cost as the incremental delays, driver stress, vehicle costs, crash risks, and pollution resulting from interference between vehicles in the traffic stream, particularly as a roadway system approaches its capacity. Table 3.5 shows the cost of road traffic congestion as a percentage of GDP.

Table 3.5 Cost of road traffic congestion

Country/City	Year	Annual cost (US\$)	per cent of regional or national income
Bangkok	1996	272 million	2.1 per cent of GNP
	-	-	6 per cent of GDP
Jakarta	1996	68 million	0.9 per cent of GNP
Kuala Lumpur	1996	68 million	1.8 per cent of GNP
Manila	1996	51 million	0.7 per cent of GNP
Australia	-	12.8 billion (A\$)	-
Europe	1995	-	2 per cent of GDP
France	2001	5 billion	0.5 per cent of GDP
The United Kingdom	2001	30 billion	3 per cent of GDP
	-	-	1.25 per cent of GDP
Japan	2001	100 billion	2 per cent of GDP
	-	-	0.79 per cent of GDP
The United States	-	-	0.65 per cent of GDP
Republic of Korea	-	-	4.4 per cent of GDP

Source: UITP (2003a), Chung (2006), Lucas (2002), and WCTRS and ITPS (2004).

Each vehicle on a congested road system both imposes and bears congestion costs. Traffic congestion is a non-linear function of traffic volume. The VTPI (2005) shows that a 5–10 per cent reduction of traffic volume on a congested highway leads to a 10–30 per cent reduction in congestion. Larger and heavier vehicles cause more congestion than smaller and lighter vehicles as they need more space and are slower to accelerate.

According to the VTPI (2005), congestion is a significant cost and externality in terms of economic efficiency and also to some extent in terms of equity. This is due to congestion imposed per passenger mile (or kilometer) by different modes. Though it is an externality for individual road users, it is internal to the road users as a group. Thus while calculating total cost, it is not justified to add congestion and user costs together. The congestion costs of individuals are counted under travel time and vehicle operation costs. In order to avoid double counting, congestion costs are taken out when all costs are added up (see box 3.2).

Several policy tools could be implemented to help solve and alleviate the problem of traffic congestion and air pollution in both developing and developed countries. A list of measures to solve traffic congestion is listed in table 3.6. Goodwin's study (2004) of the economic cost of road congestion in the United Kingdom concluded that congestion costs decrease by 40–50 per cent when road charging



is combined with complementary measures such as priority lanes and signaling, switching to other modes of transport, walking and cycling, and land use patterns discouraging unnecessary travel.

### Box 3.2 Estimating congestion costs

Congestion externalities include pure congestion cost in the form of wasted time and fuel cost, as well as air pollution, noise, global warming, and safety risks. The marginal cost is the summation of the average generalized cost and the additional costs imposed on existing users known as the “congestion cost”. Thus the marginal private cost along with congestion cost makes up the marginal social cost. It is possible to monetize environmental and social impacts by using techniques such as hedonic methods, contingent valuation methods (CVM), travel cost method, damage costs, etc. Some economic approaches for estimating congestion include the following:

- Calculation of marginal delays,
- Estimating the willingness to pay for road use, and
- Estimating the unit cost of expenditures on a congestion reduction project.

The engineering approach involves estimating the peak period vehicle distance such as vehicle-mileage as the first step. This is followed by a calculation of vehicle travel delay multiplied by the vehicle distance. Finally an average passenger-speed based on vehicle occupancy is calculated.

Koopmas (2004) estimated the congestion cost in the Netherlands by dividing the congestion costs into two components: namely, observed costs and unobserved costs. The observed costs can be measured directly on the road network but the unobserved costs relate to the travel behavior that has been modified as a reaction to the congestion. He emphasized that in most traditional methods, the observed costs were included as congestion cost, unobserved costs such as changes in route, change in mode of transport, change in time of travel, etc. can be very important.

Table 3.6 Optional policy measures to solve traffic congestion

Traffic Constraining Techniques	<ul style="list-style-type: none"> <li>• Automobile-restricted zones in central business districts</li> <li>• Area licensing</li> <li>• Urban road charging</li> <li>• High occupancy lanes</li> <li>• Pedestrians/bus streets</li> <li>• Company travel plan</li> <li>• Vehicle taxes</li> </ul>
Public Transport Improvement Techniques	<ul style="list-style-type: none"> <li>• Transit priorities</li> <li>• Contra-flow bus lanes</li> <li>• Fare reform</li> <li>• Fleet management</li> <li>• Transit incentive</li> <li>• Integration among urban modes</li> <li>• Ride sharing systems</li> <li>• Operation management systems</li> <li>• New transit systems like LRT, BRT</li> </ul>
Peak-period Dispersion Techniques	<ul style="list-style-type: none"> <li>• Flexible and/or staggered work hours</li> <li>• Shortened work weeks</li> </ul>
Parking Control Techniques	<ul style="list-style-type: none"> <li>• Remote parking such as “park-and-ride”</li> <li>• Parking taxes and exclusive parking charges</li> <li>• Parking meter management</li> </ul>
Land-use Control Techniques	<ul style="list-style-type: none"> <li>• Development densities and pattern</li> <li>• Value capture taxes</li> <li>• Developer contributions for financing infrastructure</li> <li>• New towns</li> </ul>

### 3.5 REVIEW OF MANAGEMENT POLICIES AND INSTITUTIONAL FRAMEWORK FOR TRANSPORT INFRASTRUCTURE IN ASIA

The policies and institutional frameworks for transportation development in Asian cities for achieving eco-efficiency and development of sustainable transport can be broadly categorized into three types: (1) Development of safe, efficient, economical, and convenient public transport system; (2) Promotion of non-motorized means of transport; and (3) Reduction in emission from automobiles.

Due to the inherent eco-efficient quality of the rail-based Mass Rapid Transit (MRT), it has gained wide acceptance for not only countries like Japan, Singapore, and Republic of Korea but also from developing countries like China, India, Philippines, Thailand, and Bangladesh. Many countries have already implemented MRTs in their major cities or are now in the planning stage. Bus Rapid Transit (BRT) is another means of public transport to achieve eco-efficiency in transportation. Japan, China, and Indonesia have already implemented the scheme in selected cities. Intelligent Transport System (ITS) tools such as Advanced Travelers Management Systems (ATMS), Advanced Travelers Information System (ATIS), Advanced Vehicle Control System (AVCS), Advanced Public Transportation System (APTS), and Commercial Vehicle Operations (CVO) are very much useful in achieving eco-efficiency and have already been implemented in Japan, Republic of Korea, and Singapore. Due to the huge reduction in price of ITS technologies and lower investment cost in implementing them at the planning stages, it is now possible to utilize ITS technologies cost effectively in the developing Asian countries.

#### Box 3.3 Singapore - Asian eco-efficient transport city

Various cities in Asia have implemented different strategies to reduce the social impacts of transport. Of these, Singapore has most fully practiced eco-efficient policies (Fwa, 2004a and 2004b). The city's transportation planning has been executed as part of the overall land development master plan, considering economic and social impacts, as well as traffic operational impacts. The policy measures which were adopted for sustainable transportation include car ownership restrictions and car usage restriction, such as import duties, vehicle registration fees, fuel and road taxes, and compulsory vehicle inspection fees. In addition, the Vehicle Quota System (VQS) was introduced in 1980, which requires a Certificate of Entitlement (COE) under the open bid system. The quota is for a fixed number of cars set by the transport authority every month at a 3 per cent growth rate. The Electronic Road Pricing (ERP) system restricts cars on the main arterial roads. As part of the ERP, the Congestion Pricing System pilot project rates the entire road network's congestion using a global positioning system. Other measures include a car-sharing scheme, and today five car-sharing vendors provide their services 24 hours a day.

A key factor in Singapore's smooth implementation of car and usage restrictions has been the commitment and involvement of the government and transport authorities in establishing an efficient, integrated land public transport system. It has set service quality and safety standards, ensuring that fare structures are affordable (for passengers) and profitable (for operators). To maintain a high standard of bus service in Singapore, the Public Transport Council issued a set of guidelines that requires bus companies to comply with a 22-point standard, including the following: (a) Every commuter must have a bus service within 400 m of his/her home to connect with public transport services; (b) At least 95 per cent of all journeys should involve no more than one transfer, excluding rides on feeder buses; and (c) 70 per cent of trunk services and all residential feeder services should have service intervals of less than 10 minutes during peak hours.

The promotion of non-motorized means of transport, such as walking and cycling, is also part of the policy framework for sustainable transportation development. Many countries like Japan, Singapore, and Philippines have incorporated it successfully. This includes development of land-use policies in such a way to encourage the minimum use of transport and to provide infrastructure such as cycle tracks, pedestrian facilities, etc.

The emission reduction is boosted by legislation that sets up the permissible limits of pollution that any vehicle use can cause. Many testing centres have been established to identify the vehicles flouting the environmental regulations of the country. Most of the countries have set up their own norms. However, countries like Japan, Republic of Korea, and Singapore are stricter in their implementation and in punishing violations. The introduction of eco-efficient technologies and their promotion also depend on the policies adopted and the institutional framework.

#### Box 3.4 Innovative bus reform in Nagoya

Bus lanes usually follow the edges of roads, with no physical division from the rest of the roadway. A bus's progress is therefore often impeded by private vehicles. The "key route bus system", successfully implemented in Nagoya, Japan, has achieved increased speed and carrying capacity through the use of reserved lanes or reserved stretches of elevated roadways that avoid congestion points (WCTRS and ITPS, 2004: 353-355). The system has its own exclusive area in the central portion of a main road as shown in photo A below. Operations began in 1985, with just one key route of 10.4 km. The normal running speed on this route rose 40 per cent, and there was also a substantial improvement in keeping on schedule. The speed and high frequency of the service led in turn to higher satisfaction among users, and passenger numbers increased by about 20 per cent. About 3 per cent of all users had switched from traveling by private car, implying an estimated daily decrease of 950 car journeys, which represents a significant reduction in the load placed on the environment.

In another system, a bus runs along its own reserved roadway ("trackway"), guided by side rails as shown in photo B. Construction costs are moderate, which gives a cost advantage for this type of infrastructure investment compared with either conventional reserved bus lanes or rail-based mass transit systems. Capacity is normally 3,000-10,000 passengers an hour. It can achieve running speeds and punctuality similar to those of railways. In Nagoya, the guideway bus was inaugurated in 2001, with a single route of 11.3 km, and the normal running speed is 31 kph—2.5 times as fast as an ordinary bus service, and 1.5 times as fast as the key route bus. The number of passengers on the route increased 1.6 times. A large proportion of the gain can be attributed to users switching from the parallel railway line, but it is also estimated that some 10 per cent have switched from using private cars.



A. Key route bus system

B. Guideway bus system

Table 3.7 Policies and institutional framework of transport infrastructure in Asia

Policies/ Institutional Framework	Countries	Types				Brief Description	Sources
		I	II	III	IV		
Development of public transport facility	China, India, Indonesia, Bangladesh, Pakistan, Philippines, Thailand, Japan, Singapore, Republic of Korea	●	●	●	●	Rail-based MRT development.	ESCAP (2005)
	China Japan Indonesia Republic of Korea	●	●	●	●	Bus rapid transit (BRT) development.	
	Japan Republic of Korea Singapore	●	●	●	●	Use of information technology such as ITS tools.	
Promotion of non-motorized transport	Japan Singapore Philippines			●	●	Development of cycle tracks, promotion of walking.	WCTRS and ITPS (2004)
Emission reduction	Japan Singapore Republic of Korea China	●	●			Legislation, establishment of testing facilities, and enforcement of environmental regulations.	WCTRS and ITPS (2004)
	India Thailand Philippines	●	●			Introduction of new and efficient technology and its promotion.	

Note: I = Legislation, II = Institution, III = Capacity-building, IV = Plan/Programme.

● = Direct, ○ = Indirect

### 3.6 REGIONAL INITIATIVES TO SUPPORT SUSTAINABLE TRANSPORT

Across Asia, many of the individual national or local initiatives in the development of sustainable transportation infrastructure could be replicated in neighboring countries. Some of the lessons and mechanisms developed through these initiatives have been shared and further developed in regional projects, such as those outlined below.

The Partnership for Sustainable Urban Transport in Asia (PSUTA) was a pilot programme prepared jointly by the Clean Air Initiative for Asian Cities (CAI-Asia) and EMBARQ, the World Resources Institute's Center for Transportation and the Environment. PSUTA reviewed existing experiences and capacities on sustainable transport in Asia, drew up a set of key indicators for three cities in Asia (Hanoi, Viet Nam; Pune, India; and Xian, China), and developed a strategic framework that cities throughout the region can use to develop medium-term sustainable transport strategies. The objective of PSUTA was to propagate awareness on sustainable transportation and to encourage cities and governments to intensify efforts to improve sustainable transportation systems. It also aims to build relationships with both international and regional organizations (CAI-Asia, 2006).

PSUTA was completed in December 2005, and CAI-Asia has now launched the Sustainable Urban Mobility in Asia (SUMA) project as a follow up in 30 cities. SUMA assists Asian cities and countries to make progress towards reduction in air pollution and achieving sustainable urban transportation goals. It is based on the integration of air quality management and sustainable urban transportation into economic and social strategies, policies, and programmes. The focus of SUMA is on improving air quality, improving road safety, and reducing transportation contribution towards climate change (CAI-Asia, 2005).

Another project, the Sustainable Urban Transport Project (SUTP), established in 2003, is a partnership between the German Agency for Technical Cooperation (GTZ), ESCAP, CITYNET, and the Bangkok Metropolitan Administration (BMA). SUTP supports developing Asian cities in achieving their sustainable transport goals through the dissemination of information about international experienced and through targeted work with particular cities. The project aims to promote environmentally sustainable and economically efficient modes of transport, such as public transport, walking, and non-motorized transport. The topic of fuel and vehicle technologies is also crucial to any sustainable urban transport policy framework. The issue of modal shifts is also closely related to issues of equity (the lower income majority rely more on public and non-motorized transport), traffic congestion, efficiency of short trips, and general urban livability. Their main products are the Sourcebook on Sustainable Urban Transport for Policy Makers as well as workshops and training courses on sustainable transport (SUTP, 2006).

The United Nations Centre for Regional Development's (UNCRD) Environmentally Sustainable Transport (EST) Project is a collaborative effort between United Nations Centre for Regional Development and the Ministry of Environment, Japan. The main objective is to integrate the concept of environmentally sustainable transport into the overall planning process by identifying and addressing issues, critical challenges, and strategic measures in the environment and transport sector in 10 ASEAN countries, plus China, Japan, Republic of Korea, and Mongolia. The project also aims to set in motion a regional mechanism through the establishment of a regional EST forum to share best practices, policy instruments, and to promote collaborative and participatory efforts towards harmonization of vehicle inspections and maintenance, roadside air quality monitoring, fuel quality standards, exhaust gas emission monitoring, road safety and maintenance, traffic noise management, and proper management of exported/imported used vehicles. This concept is centered on transportation systems and activities that meet social, economic, and environmental objectives (United Nations Centre for Regional Development, 2004).

### 3.7 FINDING REGIONAL SOLUTIONS FOR SUSTAINABLE TRANSPORT INFRASTRUCTURE DEVELOPMENT

The challenges for sustainable transportation are sometimes inherent in the policies adopted for its formulation and implementation. At times the policies of sustainable transport development for a city may be strongly influenced by adjacent, regional, or even national authorities, and there can be friction between them in cases of inconsistent policies. As many of the programmes of sustainable transport development involve many parties who may have different perceptions of the transportation problems and thus different solution methodologies, this also creates institutional problems. To overcome this type of problem, an integrated approach at strategic, operational, political, and organizational levels is needed.

In addition, transportation infrastructure in Asia should increasingly be viewed as common regional assets. Developing sustainable infrastructure provides opportunities for countries to improve the way they provide such facilities and services to their constituents. As such, creating the institutional and organizational conditions that oblige suppliers of infrastructure services to be more efficient and more responsive to the needs of the users should be carefully planned and implemented. Development in Asia does not occur in isolation in individual countries. Instead, policies in one country can have significant impacts on its neighbors, and there is potential for simultaneous growth resulting from effective economic development strategies for the entire region. Therefore, the development of sustainable infrastructure is expected to have impacts over large areas transcending international borders.

The measures and activities to improve eco-efficiencies in transport infrastructure should be based on the following principles: (1) Increase in the use of public transit; (2) Encouragement of walking, cycling, and use of non-motorized modes of transport; (3) Restricting the use of automobiles; (4) Development of land use plans that minimizes the need for travel; and (5) Improvement of road networks. Although the economic situations in Asia are varied, rapid urban development, unplanned land use, and motorization are occurring in most developing countries, leading to a lack of sufficient investment time and/or political will to construct the road and rail infrastructure. This brings serious road congestion and the low service quality of public transport. Geographically, many countries (except those in northern Asia) are warm and tropical. Therefore, motorcycles and para-transit, non-motorized modes are popular in Southeast Asia and South Asia, respectively.

Based on the above principles and situations in Asia, some measures in line with the economic and geographical situation in Asia are recommended as follows:

- Investment in new rail lines and new bus systems such as BRT to increase ridership to provide a faster and more comfortable public transport mode, and to reduce the demand for car use.
- Facilities to promote bicycle or motorcycle lanes, bicycle or motorcycle parking, and their integration with public transit.
- Development of the methodology to estimate traffic congestion cost to include not only time delays and oil consumption, but also environmental and social costs.
- Improvement in the quality of service of public transport by using new technologies of ITS, such as integrated ticketing systems, real time information systems, and the introduction of high quality buses.
- Urban traffic control to use computer systems for controlling traffic signals throughout a road network.
- Road pricing or other car pricing schemes to charge an additional fee to enter a city centre.

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## 4. The role of stakeholders in promoting sustainable infrastructure

### 4.1 THE ROLE OF THE PRIVATE SECTOR IN PROMOTING SUSTAINABLE INFRASTRUCTURE DEVELOPMENT

Providing the necessary infrastructure has been the primary responsibility of the public sector (Faulkner, 1997: 159). This is because of the natural monopoly features that preclude market competition, as well as the social and environmental externalities and other public good aspects that result in social benefits exceeding private benefits (Panayotou, 1997: 46). While this may be the case, public sector monopolies in infrastructure have often been plagued by inefficiency (World Bank, 2003: 3). Information gathered from the World Bank's Public-Private Infrastructure Advisory Facility (PPIAF) showed that in most developing countries the public sector still contributes a substantial amount in the delivery of basic infrastructure services; however, numerous challenges remain:

- 1.2 billion people in the developing world have no access to electricity;
- 1 billion lack access to clean water;
- 1.2 billion lack adequate sanitation; and
- Technical inefficiencies in roads, railways, power, and water lead to US\$55 billion in losses each year (Muir, 2002: 1).

Given these conditions, governments seek various means to solve these inefficiencies, through finding new sources of financing, new technology, and management. Most often, tapping the private sector for resources has been the recourse of the public sector.

#### 4.1.1 Improved infrastructure management by the private sector

The private sector has the financial, technological, and management resources as well as a proven track record of providing lower production costs, delivering services more efficiently, maintaining capital equipment at a higher standard, making decisions faster than public bureaucracies, introducing new technologies, and offering consumers greater choice (Faulkner, 1997: 159-160 and Muir, 2002: 4).

The role of the private sector lies in (1) improved management and higher efficiency; and (2) increased access to private capital for maintenance and expansion (Panayotou, 1997: 51). The private sector plays an increasing role in all infrastructure sectors, including power, natural gas, transport (railways, roads, ports, and airports), waste treatment, water supply, and sanitation. Recent privatizations in Asia include water supply, roads, and traffic management in the Philippines, and the urban rail system development and waste management in Thailand. Likewise, private participation has been able to improve efficiency through the introduction of incentives to reduce wasteful costs and collect revenues. In fact, private management introduces new entrepreneurial skills and new technology, which is not easily or efficiently attained by public agencies (Rondinelli and Kasarda, 1993: 157). The price of services have also declined where private operators have achieved efficiency gains (such as reducing unaccounted-for water), and efficiency has improved for both public and private providers when the operators are subject to competition (Ingram, 1995: 71).

Increasing private sector participation would increase the financing available and improve efficiency (Commonwealth Secretariat, 2004: 13) in infrastructure provision. As shown in table 4.1,



there are several options for private participation in the promotion and delivery of sustainable infrastructure, starting with minimal service contracts on the left and ending with full divestiture on the right.

Table 4.1 Allocation of key responsibilities for private participation options

	Increasing private participation →						
	Service contract	Management contract	Affermage	Lease	Concession	BOT-type	Divestiture
<b>Asset ownership</b>	Public	Public	Public	Public	Public	Private/public	Private
<b>Capital investment</b>	Public	Public	Public	Public	Private	Private	Private
<b>Commercial risk</b>	Public	Public	Shared	Shared	Private	Private	Private
<b>Operations/maintenance</b>	Private/public	Private	Private	Private	Private	Private	Private
<b>Contract duration</b>	1-2 years	3-5 years	8-15 years	8-15 years	25-30 years	20-30 years	Indefinite

Source: Commonwealth Secretariat (2004: 13).

Moreover, privatization is widely viewed as an opportunity for governments to improve efficiency and to promote competition, good management and improved access to product and capital markets. Finally, private enterprises, especially those in the informal sector, can play a large “gap-filling” role; they can and do provide services for poor households that are not served by local governments (Rondinelli and Kasarda, 1993: 157). What is less recognized is that many of these improvements may also generate environmental benefits (Lovei and Gentry, 2002: 10). Many of the economic improvements associated with privatization can be linked with potential environmental benefits. Lovei and Gentry (2002: 11) noted the following benefits:

- More efficient use of resources;
- Increased access to capital and greater investment in cleaner technologies;
- Increased exposure to advanced environmental management techniques and access to markets for environmentally friendly goods and services; and
- Regulatory freedom.

A number of cases have shown that private sector projects have sometimes adopted higher environmental standards than what prevails in that sector generally, and that such financing has contributed to opening up markets for environmentally friendly goods. Moreover, increasing investments to meet ISO 9000 and ISO 14000 certifications among private organizations allows them to conform their processes and systems to both quality and environmental standards, which puts them in a better position against their competitors. For instance, a water supply company in Malaysia has become the first water supply organization in the country to received multi-site certifications for the treatment and supply of water with the ISO 9001:2000 series. This certification induced them to use their resources more efficiently and has boosted the quality and performance of their services (see box 4.1).

Table 4.2 Environmental implications of various privatization methods

Privatization method	Improvement in efficiency and management	New capital	Technology transfer	Access to foreign markets	Expected positive environmental impact
Management contract, lease	XXX		X	X	XX
Concession	XXX	X	X	X	XX
Direct sale	XXX	XXX	XXX	XXX	XXX
Public offering	X	XXX		X	X
Joint venture	XXX	XX	XXX	XXX	XXX
Voucher privatization	X				X
Management buyout	X				X

Note: Strength of environmental implications is indicated as follows: XXX – great effect; XX – moderate effect; X – slight effect; blank – no effect  
Source: Lovei and Gentry (2002: 13).

Other methods of privatization have different implications for generating environmental incentives and for promoting sustainable infrastructure. Table 4.2 summarizes some of the expected environmental implications including impacts from private sector participation.

#### 4.1.2 The promises and challenges of the private sector participation in developing sustainable infrastructure

While the private sector is primarily motivated to maximize their profit, encouraging the private sector to focus on more environmentally responsible activities is a major challenge. In this case, the enforcement of environmental laws and regulations remains a major weak point in the environmental protection systems of many developing and transition economy countries. Some regulations are unrealistically strict and impossible to meet; others are outdated. At the same time, enforcement agencies often lack the resources and political support necessary to do their jobs properly. These factors can be an obstacle to effective private sector participation and to adequate local protection of the environment. They can also make it difficult for countries to meet international environmental obligations. Given this stance, more resources are needed in the enforcement of regulations especially external assistance. In addition, the whole system of regulation, monitoring, and compliance has to be changed, with greater use of informal methods and greater involvement of civil society.

Productivity in the provision of goods and facilities, as well as economic gains, could be achieved by facilitating the adoption of innovative and measurable eco-efficient practices and technologies (Canada Environment, 2006). The challenges for the public sector in promoting eco-efficiency and the private sector's involvement in sustainable infrastructure include:

- Demonstrating measurable economic and environmental benefits of eco-efficiency to industry and other institutions;
- Upgrading the knowledge base in terms of the latest environmental tools and management systems, including eco-efficiency, and related areas such as life cycle assessment and eco-design;
- Examining the potential barriers to eco-efficiency; and
- Exploring incentives (e.g. pilots) to encourage the introduction of new eco-efficient technologies.

The financial incentives from governments to the private sector to invest in clean technology still have a significant role to play. Otherwise, the private sector has no incentive to adopt clean technology unless it is to comply with local or international regulations, or to create a green image. Subsidies to clean technology via capital allowances and tax breaks are also consistent with the general proposition that incremental costs of clean technology might be partly met from public funds (Pearce, 1997: 78). Likewise a culture of constant innovation and research into new technologies and management approaches that support the best management practices, including conservation, efficiency and reuse, along with a system to ensure transparency and public participation should be implemented so the private sector remains accountable to their stakeholders and the general public.

Public-private sector partnerships in infrastructure services provide several opportunities. Among these includes the adoption of eco-efficient activities in most aspects of infrastructure service provision. Implementing eco-efficiency is first and foremost about identifying opportunities for eco-efficiency, such as those listed below. A summary of some practices, policies, initiatives, and efforts among stakeholders is given in table 4.3.

- Re-engineering processes to reduce consumption of resources, reduce pollution, and avoid risks, while saving costs;
- Cooperating with other companies to revalorize their by-products;
- Product redesigning and innovation; and
- Working with other stakeholders to rethink their market (WBCSD, 2000: 5).

Sustainable management approaches, including asset management and environmental management systems (EMS), that proactively ensure the long-term viability of each component of the system while simultaneously ensuring compliance with local, national, and international environmental regulations should be strengthened through public-private partnerships. EMSs can ensure that risks and opportunities are identified and managed systematically and efficiently, and they offer organizations the tools and instruments to effectively manage and communicate their environmental performance and achievements (WBCSD, 2000: 5 and Five Winds International, 1999: 6). Further sustainability will only be achieved by businesses working together with governments and external stakeholders such as suppliers, customers, neighbors, and NGOs sharing the responsibility (WBCSD, 2000: 13).

In general, the challenges facing developing countries is to find the proper balance between public- and private-sector responsibilities for providing services and the infrastructure needed to promote economic growth and the sustainable use of resources, which will ultimately lead to a better quality of life among the people.

Table 4.3 Examples of stakeholder participation in promoting sustainable infrastructure development

Cases Location and Sources	Eco-efficiency aspects			Types		Outputs/Outcomes/Impacts	Policy Tools/ Eco-efficient Mechanisms/ Methods Used
	A	B	C	I	II		
<b>Water Supply</b>							
<b>Macau water concession</b>	•	•	○	I		Within three years of signing the concession contract, Macau, China's water quality was brought up to the European Union standard. This was done through the assistance between New World and Lyonnaise des Eaux which brought together a successful combination of capital, local knowledge, global best practice technology, and expertise in water management and treatment. Since 1986 leakage has ranged between 13.8 per cent and 11 per cent. Unaccounted-for-water from leakages has also declined.	Private sector participation through concession  Economic and regulatory instruments (Tariff regulation)
Macau, China ADB (2000)							
<b>Johor Bahru water concession</b>	•	•	○	I		The bulk water supply capacity had increased by 75 per cent within 30 months of signing. By 1996, capacity had more than doubled. Although the Johor Water Company's water tariffs have not changed since 1991, the bulk water costs associated with supplying retail water have increased in nominal terms. Water supply in Johor Bahru was undertaken through joint ventures with three private companies tasked to undertake operation, rehabilitation, and management of the utility in three phases.	Private sector participation through BOT  Demand-side management
Malaysia ADB (2000)							
<b>Transportation</b>							
<b>Local participation in road construction</b>	•	•	○	I		The management of the local road programme is done voluntarily by the road committee (composed of government officials, contractors and local people living along the road corridor) formed for each road site. The people participating in the construction of the local roads programme were willing to work extra hours as part of their local contribution which contributed to the cost-effectiveness of the programme.	Local participatory approach  Cost-effectiveness approach
Dhading District, Nepal ESCAP (1994)							
<b>Urban rail concessions</b>	•	○	○	II		Using private sector organizations to finance, develop, implement and operate these projects has provided space for government to focus on its other priorities. In part it is because the private sector has shown considerable energy in identifying projects that governments had not done (BTS, STAR, Monorail, and Manila MRT3 were all identified by the private sector). And in large part it is because the public finances would probably not have financed the cost of the projects, when faced with other priorities.	Private sector participation through concessions  Asset management
Bangkok, Kuala Lumpur, Manila Halcrow Group Limited (2004)							
<b>Solid Waste Management</b>							
<b>Community-based initiatives in controlling solid waste</b>	•	•	•	I		Established partnership with a local NGO and initiated a small-scale, community-based organic waste recycling project for composting the municipal solid waste. Environmental pollution such as air, water and soil pollution has significantly reduced in the area. This is a partnership between a government agency that provided the land, an NGO who operates with the community and a private company that markets the compost. Stakeholder involvement in this initiative include development of a small-scale community-based organic waste recycling project to compost municipal solid waste and involving public participation	Community mobilization and capacity-building  Social cost-benefit analysis  Utilize low-cost, labour-intensive and locally available technology
Dhaka, Bangladesh ESCAP (2003)							

Table 4.3 Examples of stakeholder participation in promoting sustainable infrastructure development (*continued*)

Cases Location and Sources	Eco-efficiency aspects			Types		Outputs/Outcomes/Impacts	Policy Tools/ Eco-efficient Mechanisms/ Methods Used
	A	B	C	I	II		
						through community-based organizations (CBOs) to collect garbage on a house-to-house basis where garbage bins are not a feasible option.	
<b>Private sector participation in solid waste management</b>  Kathmandu, Nepal ESCAP (2003)	●	○	●		I	Stakeholder involvement in the management of solid waste include: (1) holding of meetings among sweepers; (2) private sector was briefed on financial cost benefits and the profits they could make if programme was carefully launched; (3) general public was briefed regarding Kathmandu Metropolitan City's (KMC) financial situation and that the fee they paid would be utilized to improve the environment of KMC. Approximately 50 per cent of people surveyed said the service provided by the private sectors was better (and the ward is cleaner) than before.	Community participation  Transparency in process and decision-making
<b>Orangi pilot project</b>  Karachi City, Pakistan IGES and ESCAP (2004)	●	○	●		I	The Orangi town, famous for being the largest informal settlement in Asia, developed a community project which is self-funded, self-administered and self-maintained. It relies on the resources and skills of the local urban poor using local materials and labour in building extremely low-cost underground sewers. Since 1980's, around 92,000 families have benefited from this scheme in about 6,000 lanes or nearly 90 per cent of the entire settlements. The project uses social preparation among the community, NGO and government to promote community organization and self-management by providing social and technical guidance in order to exploit local resources and cooperative self-action.	Social preparation in the community  Social cost-benefit analysis
<b>City-wide waste management</b>  Nagoya, Japan < <a href="http://geic.hq.unu.edu/ENV/files/InnComm%20Report/case%20study%207%20Japan.pdf">http://geic.hq.unu.edu/ENV/files/InnComm%20Report/case%20study%207%20Japan.pdf</a> > Accessed on 1 March 2007	●	●	●		I	The joint vision and determination of the local government, community-based organizations and citizens to implement the waste management system contributed to its success. Extensive efforts were made by all in forming partnerships and initiating their own innovative activities for waste management. There was a 23 per cent reduction in non-recyclable solid waste generated by the city, and the amount buried in landfills decreased by half within two years.	Utilization of local knowledge and indigenous systems  Mixed (bottom-up and top-down) management  Extensive education campaign

Note: A = Increase service value, B = Optimization of the use of resources, C = Minimization of environmental impact

I = Initiatives / Practices, II = Policies / Institutional Framework,

● = Direct, ○ = Indirect

#### 4.2 THE ROLE OF INTERNATIONAL COMMUNITY IN PROMOTING SUSTAINABLE INFRASTRUCTURE DEVELOPMENT

The international community also has an important role in promoting sustainable infrastructure development. While the initiatives implemented by bilateral and multilateral aid institutions presented below may not be exhaustive, this section tries to provide some their undertaking in relation to sustainable infrastructure development in Asia. The international community can share its regional and global experiences to encourage Asian countries to commit to a programme of sustainable development. They also have the capacity to provide innovative development models and encourage the passage of legislations demonstrating government and private sector commitments to support sustainable activities. Likewise, the international community can help developing countries share experiences and find mechanisms to optimize the private sector's contribution not only to infrastructure but to sustainable development in general.

Development banks have been important in terms of incorporating sustainability aspects in the financing and development of essential infrastructure systems. Most multilateral financial institutions' core mission is to support infrastructure and financial sector projects in its developing member countries by providing long-term financial assistance and sound advice on regulation, governance and competitive solicitation (Sagar, 2006: 3). Multilateral financial institutions also aim to promoting private sector development, sound financial systems, and infrastructure development which are part of their overall strategy to promote sustainable growth, reduce poverty, and integrate countries into the global economy. In terms of operations, multilateral financial institutions incorporate environmental aspects in infrastructure development activities, including investing in projects that improve environmental conditions and mitigating negative environmental impact of infrastructure projects. These agencies work with the public and private sectors and communities to enhance the capacity of sectoral infrastructure institutions to provide sustainable infrastructure and services.

The United Nations organizations likewise can play a catalytic role in encouraging and supporting developing countries on sustainable infrastructure. The United Nations can play a key role in helping to enhance the skills of the public sector as an overseer and regulator of private sector participation in infrastructure and public service provision (Panayotou, 1997: 64). For instance, United Nations Development Programme initiated efforts to create the framework for partnerships with the World Business Council for Sustainable Development (WBCSD) and the private sector. As such, a public-private partnership model called Sustainable Project Management (SPM) was set up in 1994. Today, SPM is involved in more than 20 projects worldwide that focus on eco-efficiency, technology cooperation, and capacity-building (Faulkner, 1997: 159).

Bilateral development agencies have also been instrumental in promoting sustainable infrastructure in Asia. For example, in 2002, Japan announced its Environmental Conservation Initiative for Sustainable Development (EcoISD) as a comprehensive framework for international efforts to support sustainable development in developing countries through cooperation in the environmental field.

#### 4.3 ENHANCING THE ROLE OF THE PUBLIC SECTOR IN PROMOTING SUSTAINABLE INFRASTRUCTURE

The role of the public sector in supporting private sector investments for infrastructure is essential. Central and local governments have the key function in planning, facilitating, and coordinating

investment decisions in infrastructure. The reason that infrastructure industries have remained in the public sector for so long is that they have components that are natural monopolies; e.g., the costs are lower with only one provider and the services are often essential (water, power and transport) (ADB, 2000: 5). Another common argument for retaining these industries within the public sector was that they must provide common (or universal) access to their services and that subsidies are required.

While this may be the case, it turns out that public ownership and management is neither necessary, nor the best way to ensure universal access. It is noted that one way of mobilizing private sector resources for sustainable development investment is by removing barriers. Another is to enter into public-private sector partnerships, co-financing arrangements, and joint ventures (Panayotou, 1997: 58). They are considered especially relevant for local governments that lack the capacity and funds to meet their responsibilities for infrastructure provision (e.g. piped water networks, sewers, drains, roads and paths) and services (e.g. solid waste collection and management) (Commonwealth Secretariat, 2004: 11). As such, governments should allow the private sector to provide infrastructure services to the maximum extent possible, with governments concentrating on planning, policy and regulation, and with the private sector on efficiently investing capital and improving the efficiency and quality of such services (ADB, 2000: 6).

The public sector's role of providing risk security in attracting private investment should be emphasized (Pearce, 1997: 73). Central to the problem of infrastructure provision is the question of opportunity costs and risks attributed to the lumpiness and long gestation period of these infrastructures (Vickerman, 2003: 3). Governments should build up capacity to negotiate and deal with the private sector. Commercial risks should be assigned to the private sector and other risks should be assigned to the party best able to mitigate them (ADB, 2000: 9). Direct foreign investment will remain an important source of funds for the development of the infrastructure sectors. For instance, private sector funding of infrastructure usually brings the risk of foreign currency mismatches in the financing package. In the absence of the necessary capital market reforms, it is hard to see how private sector provision of infrastructure can proceed on the scale required to meet future demand (ADB, 2000: 8-9). The development of domestic long-term capital markets will be critical for private sector investment in infrastructure, but these markets must have much better regulation as well. Moreover, investment risks cannot begin to be reduced unless there is greater political stability in recipient countries (Pearce, 1997: 72).

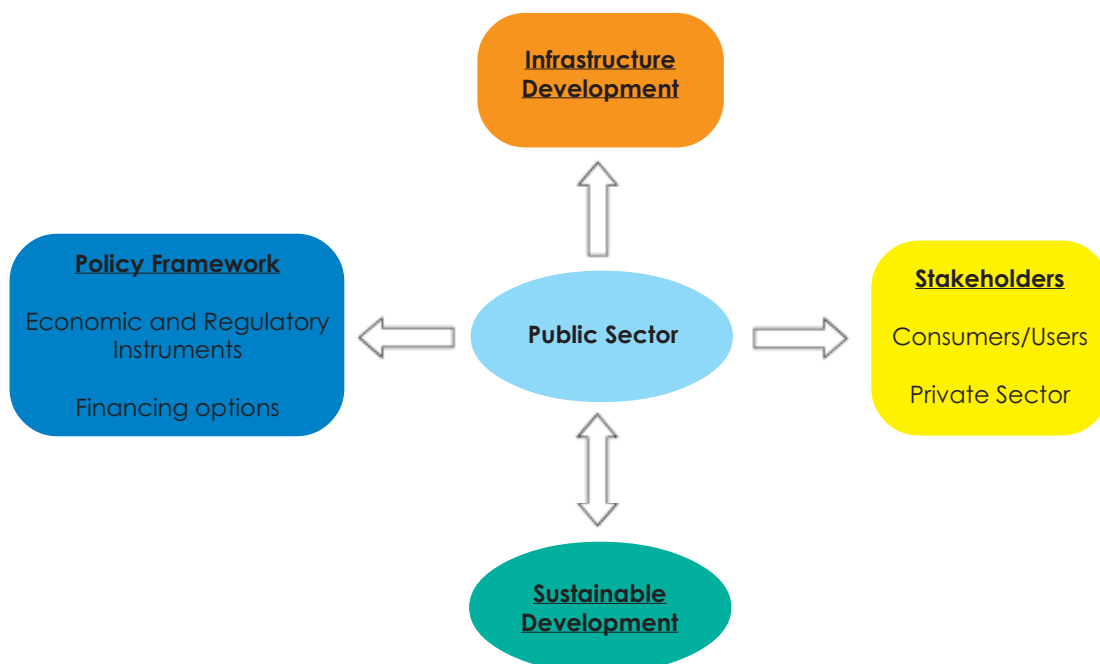
In order to attract private capital and managerial talent, a series of economic, financial, legal, and institutional reforms is necessary (Panayotou, 1997: 59 and Fitch Ratings, 2004: 3-4). The public sector should also develop more effective contracts which will reduce the implicit problem of asymmetric information and provide the right incentives for the private sector (Vickerman, 2003: 7). A set of government strategies for promoting private sector participation in infrastructure and public service provision could be presented in figure 4.1. Thus the key factors that could be highlighted are clear government commitment, legal and regulatory capacity, stakeholder involvement, intelligent transaction design, cost-recovery tariffs, the right option, and a systematic approach to undertake successful public-private partnerships in infrastructure provision (Kumar and Prasad, 2004: 37). Rondinelli and Kasarda (1993: 158-159) further noted that for government to achieve the benefits of public-private partnerships, some or all of the following actions must be taken:

- Governments should consider removing the restrictions and regulations that inhibit private companies and informal sector enterprises from operating effectively in urban areas and provide or encourage low-cost credit programmes that allow small enterprises to expand.
- Governments may offer opportunities for private enterprises to develop their management capabilities by contracting for services that are not effectively provided by public agencies.
- Governments may have to provide, at least initially, incentives and assurances to protect current civil service employees.
- Assistance or subsidies to private operators for providing unprofitable services for the poor would increase access.
- Governments may take measures to reform state-owned enterprises before private investors are willing to purchase shares or take over their operations.
- Legal reforms must precede privatization in countries where laws or regulations have been intolerant of or hostile to the private sector.
- Improvements in the implementation of privatization policy require a redefinition of the roles of government and public employees.

While reforms have to be undertaken by the government to ensure private sector participation, investing in the “sustainable” part of infrastructure should also be an important consideration in their decision making. One important area where government could intervene is through creating incentives and/or positive mechanisms for the private sector to invest in an environmentally sensitive manner. Pearce (1997: 82) suggested three aspects for governments to consider:

- Boost opportunities for investment in environmental assets through “market creation”.
- Change the relative prices of clean and dirty technology so that the former is far more attractive through the use of market-based instruments.
- Look for financing structures that help fund the incremental cost of clean technology where it remains more expensive than conventional technology.

Figure 4.1 Role of public sector in sustainable infrastructure development





Ensuring access to infrastructure services for the poor is an important policy issue. Broad subsidies should be rationalized in a way to ensure availability and affordability of these services and facilities to the marginalized sectors. Governments, for example, can contribute by formulating economic and industrial policies which encourage eco-efficiency as well as reduce energy and resource use throughout the economy. The public sector should also have the responsibility of ensuring that infrastructure promotes environmentally sustainable development and to minimize the adverse consequences of infrastructure expansion (Ingram, 1995: 73). Environmental concerns, including public safety, can be met by a variety of instruments: participation in the initial planning and public discussion of proposed investments; carefully designed subsidies for certain environmental improvements; and regulatory measures, particularly those that give service providers and users economic incentives favoring good environmental outcomes. Likewise, the enforcement of Environmental Impact Assessment (EIA) for both the private and public sectors in undertaking infrastructure projects will help maintain and promote consideration of the environment.

Boxes 4.1 and 4.2 provide examples of successful public-private sector partnership in promoting sustainable infrastructure development and efficiency.

#### Box 4.1 Public water supply provision in Malaysia

Perbadanan Bekalan Air Pulau Pinang Sdn Bhd (PBAPP), which is involved in the business activities of the water suppliers in the state of Pulau Pinang, Malaysia, was granted a license by the state government to operate as the water supplier. They adopted a holistic approach towards handling the water supply in Penang, i.e. they handled the sourcing of raw water, treatment, distribution, and billing the consumers. This approach involved increasing access to water using appropriate technology at affordable prices while ensuring high revenue efficiency. The critical factor for successful stakeholder participation involved a management team that is committed to administrative excellence, public service, and creating an efficient water management system. Some of the efficiency indicators include the following:

- Workforce to population ratio: 1:1,410 (2005)
- Total water supplied: 196 billion liters (1999) to 241 billion liters (2005)
- Coverage: 100 per cent urban supply and 99 per cent rural supply
- Percentage of non-revenue water: 20 per cent (national average: 38.9 per cent)

Source: <<http://www.pba.com.my>> Accessed on 1 December 2006.

#### Box 4.2 Vehicle fuel efficiency standards in China

China implemented its first fuel efficiency standard, the Fuel Consumption Limits for Light Duty Passenger Vehicles, on 2 September 2004. The main goal of this regulation was to help limit the national oil consumption to less than 400 million metric tons per year. The government decided in 2002 to establish a framework including government cooperation, research teams, and international support to develop vehicle fuel efficiency standards and regulations. The components of the vehicle fuel efficiency standard were (1) the development of weight-class based maximum fuel consumption standard; (2) an overall per-distance fuel consumption reduction of 15 per cent; and (3) a more stringent standard for heavier vehicle classes to prevent a shift to heavier vehicles and to encourage the use of economic compact cars.

- Savings of 13 million tons of fuel in 2020 and 31 million tons in 2030. A further reduction of 25 per cent in vehicle fuel consumption to 5.6 l/100 km by 2012 for light-duty passenger cars and a fuel consumption level of about 4.8 l/100 km by around 2016.
- If this were implemented, additional 19 million tons oil would be saved in 2020 and 60 million tons in 2030.

Source: ADB (2006: 20).

#### 4.4 THE ROLE OF CIVIL SOCIETY AND NGOs IN PROMOTING SUSTAINABLE INFRASTRUCTURE

Civil society can play an important role in the accountability of infrastructure institutions through consumer participation or through coordinating with the government in regulation. For instance, when consumers or users are in control through paying the full cost of infrastructure service delivery, there are several benefits (McIntosh, 2003: 122):

- Corruption is minimized;
- More accountability for finances;
- More efficiency in infrastructure service delivery;
- More transparency regarding information;
- More staff responsibility;
- More equitable service;
- Consumer society will likely be formed;
- Service levels will be reviewed;
- Performance benchmarking is encouraged; and
- Pressure to improve service.

Likewise, civil society has a vital role to play in ensuring that the interests of the poor, those not connected, and the ill-served are safeguarded and that their voices are heard in public and private sector debates (McIntosh, 2003: 122). NGOs can provide small-scale infrastructure services/facilities; act as watchdogs against red-tape and corruption; and play as advocates in ensuring for more sustainable infrastructure policies and services (ADB, JBIC and WB, 2005: ii). While NGOs and other civil society organizations are often viewed as “anti-developmental”, their role as advocates of sustainable development is often overlooked (Lee, 2006: 10-11).

The success of a community-based programme depends largely on identifying and addressing community needs while the sustainability of the project hinges on involving the community in the cost-recovery/cost-sharing process. It is important that community-based projects to have demonstrable effects. NGOs can play an important role in initiating, demonstrating new concepts, providing technical know-how and providing training to others (ESCAP, 2003b: 5). Lee (2006) further pointed out several ways in which NGOs can work together with other stakeholders in terms of promoting sustainable infrastructure:

- Provide education and raise awareness about the concept of sustainable development;
- Engage in government policy and people’s participation in sustainability; and
- Participate in the process of building sustainable infrastructure, especially in dealing with conflict-resolution.

#### 4.5 PROPOSED GUIDELINES AND STRATEGIES

There is still the need for the public sector to redouble their efforts to get the right fundamentals, particularly with the participation of the private sector and NGOs. The following guidelines and strategies should be considered among stakeholders in financing and promoting sustainable infrastructure development:

##### *Governments*

- Governments and policy makers could look at other areas such as market structure, contract design, transparency, subsidies, regulations, and the use of appropriate technologies in relation to other stakeholders to achieve sustainable infrastructure development.

- Likewise, the public sector could also look at good practices undertaken by the private sector in dealing with the delivery of infrastructure services. Capacity-building and technical support activities should also be integrated to enhance public-private sector partnerships and public sector-civil society relations. Sustainable private financing of infrastructure requires enhancing the credibility of governments' reform and regulatory commitments. This can occur by institutional and legal development, as well as by more transparent procedures for project selection, appraisal, implementation, and the awarding of concessions.
- Improve the environmental management capabilities of local authorities in terms of legislative power, human resources, financial and technical capability, etc.
- Encourage private sector investment for pollution control and environmental improvement in conformity with the "polluter-pays principle".
- Governments' roles could be shifted gradually from being the principal financier and operator of infrastructure and service provision to being the overseer and regulator. This calls for governments to hold the private sector accountable but allow it the freedom and flexibility to figure out the most efficient way to provide a service of specified quantity and quality.

#### *Private sector*

- Ensure proper combination of end-of-pipe and cleaner production technologies, which could be more efficient for achieving sustainable development goals, and encourage their transfer.
- Promote the development of environmentally sound technologies for sustainable infrastructure development.
- The gradual increase of user fees to cost recovery levels is essential for financial sustainability, but the increases should be at a realistic pace and with explicit measures to deal with social issues. A first target should be for user fees to cover operation and maintenance costs, gradually increasing to recover capital investments, and ultimately reflecting environmental costs as well (OECD, 2004: 18).

#### *International community*

- Ensure financial support for international cooperation initiatives of local and national authorities.
- Link local and national initiatives with international cooperation schemes of nations (for example, official development assistance).
- Encourage participation of the private sector.
- Although domestic resources will be the dominant source of finance, overseas aid will also continue to play an important catalytic and demonstration role, especially in the developing countries. More attention should be given to using foreign assistance for creating local, sustainable financial mechanisms rather than for direct financing of investment projects (OECD, 2004: 18).

#### *Civil society and NGOs*

- One way of involving civil society and NGOs is to hold stakeholder consultations as a basis for formulating government policy and major actions. Such initiative would lead to increased participation in decision making and promoting sustainability of infrastructure activities. Monitoring of the infrastructure implementation and operation is also important.
- Research is an important effort to increase awareness and understanding among the various stakeholders in terms of advocating sustainable infrastructure. This has good potential for the involvement and role of academic and research institutions.

*Multi-stakeholder cooperation*

- Promote dialogue, consultations, and consensus-building between local authorities, citizens, local organizations, and private enterprise.
- Increase awareness of businesses and households.
- Promote information exchange among all stakeholders.

Enhancing manpower capacity among the sectors would improve productivity and efficiency in providing sustainable infrastructure services to the people. Among the things to be considered include applying eco-efficient materials to be used in construction and maintenance of infrastructure; applying successful business models in organizations providing services; and, identification of public-private sector roles in different development stages (such as planning, construction, and operation) to optimally promote eco-efficiency of infrastructure.

At the sectoral level, the following strategies could be emphasized among key stakeholders in promoting sustainable infrastructure:

- Develop policy measures for the establishment of eco-recycling socio-economic systems or mechanisms to improve non-motorized transport.
- Critical review of technology and the development of knowledge centres for solid waste management and water resource management.
- Awareness and capacity-building among governments, private sector groups, and civil society in adopting efficient management and utilization of resources.

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# 5. Policy framework and future directions

## 5.1 KEY ISSUES FOR ASIA

Infrastructure supports growth and sustainable development by providing services as inputs to other productive processes and as outputs going direct to final demand consumption. Infrastructure can deliver major benefits in economic growth, poverty alleviation, and environmental sustainability – but only when it provides services that respond to effective demand and does so efficiently, especially from ecological points of view.

Key issues in the current situation of sustainable infrastructure development in Asia include the following:

- The development of infrastructure in the past has not seriously considered a systems or holistic approach, but rather relied upon specific methods such as cost-benefit analysis or typical impact assessment, as can be seen from most end-of-pipe solutions.
- There is a need to utilize existing infrastructure to better manage the supply side, while there is lack of the focus on demand-side management in a number of sectors including transportation, water supply, and energy.
- There is serious lack of comprehensive statistical data and valuable information to understand the current level of eco-efficient infrastructure development (including environmental impacts for the whole lifetime of the infrastructure) and future development plans.
- Provision of infrastructure services by the public sector alone would not be as efficient and effective, as well as sustainable without the involvement and partnership of other stakeholders including the private sector.
- There is a need for institutional integration among different stakeholders and sectors both horizontally and vertically including public-private partnership, e.g., between the environmental and transport sectors; between road and rail infrastructure in transport management plans; between water supply and wastewater agencies; and between private and public transport.
- Although currently there are no standardized eco-efficient indicators for infrastructure development, some existing indicators with available data - such as water loss rate, solid waste generation rate, and energy use rate in transportation - may be used as the basis for upcoming activities while developing more comprehensive set of indicator for sustainable infrastructure.

The following summarizes major issues and challenges in sustainable infrastructure development:

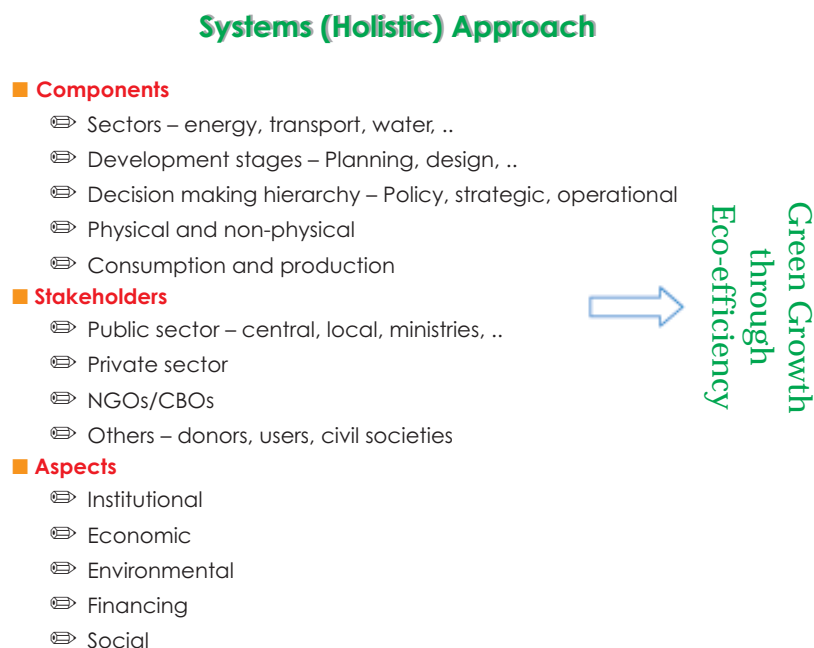
- Environmental infrastructure has resulted in low economic efficiency because it is difficult to take into account or estimate the benefits clearly and apply the user charge directly. This is a major challenge in developing eco-efficient infrastructure in this sector.
- Increases in the population and economic growth are another challenge in terms of how to maintain the efficiency under this condition and resource constraint.
- The development of technology and enhancement of public awareness can provide the opportunities to improve efficiency of the environmental infrastructure.
- Different stakeholders and financing can play major roles in the sustainable infrastructure development. Enhancing capacity of both the public and private sectors would improve productivity and efficiency in providing sustainable infrastructure services to the people.
- Involving civil society and NGOs in decision-making would promote better and more sustainable policies and programmes.

## 5.2 GUIDING PRINCIPLES

Sustainable infrastructure development requires a systems approach in identifying the relationships between various elements within the system and integrating them. The main concepts of using systems (or holistic) approach of guiding principles for policy framework in promoting sustainable infrastructure development is presented in figure 5.1.

In the traditional approach, the responsibility of the construction party terminates when design and construction works are completed. The facilities are then transferred to the owners often without a detailed knowledge of how best to integrate soft and hard facilities management to obtain the best in use performance which is the main goal of infrastructure development. The holistic approach incorporates design, financing, construction, and post-construction asset services over a predetermined concessionary period in exchange for rent, the benefit of user charges, or a combination of both. Hence, greater emphasis is placed on the operational performance and efficiency that has engendered a shift to a “service focused” approach. These changes reflect the need for greater integration of the project stages during infrastructure development. In addition, integration is required among different system components, including sectors (water, transport, etc.) and decision-making levels, several stakeholders, and management aspects.

Figure 5.1 Use of a systems approach in promoting sustainable infrastructure



In promoting eco-efficiency of infrastructure, the following principles should be considered:

- Use resources efficiently to obtain greater value from fewer resources and to reduce waste/ impacts by considering long-term impacts with measurable performance (NZIER, 2004).
- Minimize externalities when considering market failures, including life cycle costs and the social benefits of policy tools, such as tolled roads.
- Use both mandatory and voluntary systems for assessing and reducing environmental impacts, including raising awareness of policy makers and the public.
- Promote the use of indicators to measure environmental sustainability for infrastructure development focusing on existing indicators that can be used or modified.

- Promote appropriate technology for eco-efficient infrastructure in the region focusing on local and renewal energy, climate responsive design for building, and waste management and treatment.
- Promote effective multi-stakeholder partnerships involving key actors.
- Use innovative financing and procurement methods such as cost sharing and partnering.
- Promote demand side management or a service-focused approach, keeping in mind the end user's needs.

### 5.3 POLICY TOOLS FOR PROMOTING SUSTAINABLE INFRASTRUCTURE DEVELOPMENT

#### 5.3.1 Role of government policymaking

Policymaking and especially the effects of policymaking cannot be treated as static and unchanging. It calls for an active role by the government to enact policies and legislation, particularly in the area of environmental protection and sustainable development, to achieve effectiveness, equity, and efficiency among various stakeholders. De Greene (1993: 9) noted that policymakers tend to seek economic and technological solutions to societal and environmental problems. This is the case in Asian governments where policies such as emission charges and other forms of taxes are imposed on activities that pose environmental problems.

In order to be more proactive in developing infrastructure that is sustainable, NZIER (2004: 9) cited that government policies should generally under the following actions:

- Set rules within which activities take place across the community, striking a balance between being responsive to perceived problems and avoiding excessive changes that create uncertainty and disincentives for investments in the future.
- Correct inefficiencies that arise from market failures, such as anti-competitive behavior arising from monopoly or market dominance, and externalities.
- Provide public goods that private suppliers cannot supply in sufficient quantities because free-rider issues prevent them from recovering their full costs, and merit goods that the state considers more beneficial than is evident in private consumption choices.
- Address equity and income distribution concerns.

Infrastructure policy requires a demand orientation in the evaluation and operation of infrastructure investment, with performance indicators reflecting quality of service and user satisfaction, not just measures of assets and finance, implying that sustainable policy framework needs information to monitor and analyze (NZIER, 2004: iv) including:

- Trends in population, economic activity, and other influence on the demand for infrastructure services.
- Infrastructure capital stock, not just current state and quality but also rates of depreciation, renewal, and upgrade.
- Supplementary indicators of externality effects falling on the natural environment or on society.
- Macro- and micro-policies and their role in ensuring an open and competitive economy allowing efficient resource allocation.

An example of emerging issues affecting policy guidelines in different sectors is given in box 5.1.



### Box 5.1 Example of emerging issues in different sectors of infrastructure development

#### In transport:

- Decarbonization
- Urban agglomeration and quality of life
- Dematerialization and immaterialization

#### In energy:

- Scale reduction and “infrastructure energy”
- Energy security
- Decarbonization

#### In water:

- Decentralization
- Scale reduction
- Integration of urban water management
- Impact of environmental factors

*Source:* Chapman and others (2003: 51).

The pressures to replace goods with services (immaterialization) or reduce the material and energy intensity of economic activity (dematerialization) are likely to increase with growing concerns over waste volumes, energy and materials usage, and a desire to increase eco-efficiency in Europe and countries in Asia such as Japan.

### 5.3.2 Opportunities for improving government policymaking for sustainable infrastructure

Governments at both the national and local levels develop policies, plans, and programmes of action which directly or indirectly affect water resources management. These include policies and plans for land use (particularly at the local level), environmental protection and conservation, economic development (in such areas as energy, agricultural, industrial developments), and trade. In most countries, water is dealt with by many ministries, for example, agriculture, transport and navigation, power, industry and environment, but there may be little coordination between them, and their focus is likely to be more on development issues, as suggested above, rather than on water resource management.

Decentralization which is progressing in a greater extent from the institutional view point in many Asian countries, together with some on-going research at regional universities and institutions, has provided good opportunities for the policies to promote relatively centralized water system design and application. This may be in the form of national governments to financially support local authorities on the investment of the municipal water infrastructure.

There are also policy areas where a regional focus would support integration – fiscal reform, regulatory reform, labour market reform, competition policy, and the commercial legal environment. In Japan, as a result of the introduction of the “green” car tax preference, there has been a rapid shift among consumers to cars with lower fuel consumption, and this in turn spurs competition in technology development among the manufacturers, leading to a positive chain reaction (Kato, 2004: 355-356). This case shows that it is possible to control the load imposed on the environment by traffic once the mechanisms linking the multiple parties have been properly grasped and effective policies

have been discerned. Such case would provide an area for policymakers from other countries to integrate their policies towards implementing environmentally sustainable practices and technologies. Another example is the volume-based waste fee system undertaken in the Republic of Korea.

“Debt for nature use” policies could also provide innovative models of financial support for sustainable development. These are mechanisms of debt payback in the form of commitments to allocate financial resources for environmental protection and sustainable development (Karazhanova, 2006: 4). These mechanisms could include the implementation of marketable quotas, green taxes, and provision of green products. For instance, Russian Federation has signed an agreement on debt payoff in the amount of USD\$520,000 and development of environmental protection projects for the Baltic Sea as a result of implementing infrastructure projects in 2001.

### 5.3.3 Policy tools

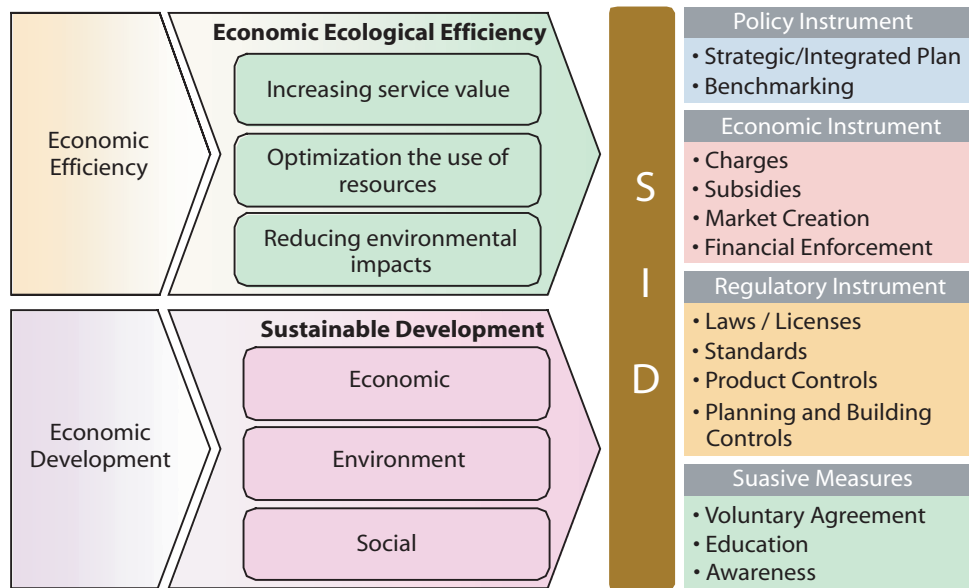
Optional policy tools are related to economic efficiency and (sustainable) economic development, with a long list of policy tools in the areas of policy, economic, regulatory, and suasive instruments and/or measures. Figure 5.2 presents optional policy tools that may be selected and applied in promoting the sustainable infrastructure development.

According to Rothengatter (2004: 416-417), a way to foster eco-efficiency is to integrate policies and strategies into a market regime in such a way that individual responsibility is encouraged and the ecological control of the government is reduced. An eco-market economy needs a set of constitutional and regulatory conditions to guarantee its long-term sustainability. The essential mark of an ecological market regime would be that the reduction of environmental damage is to be seen as a market-adapted individual strategy, which pays off for individual decision makers. For example, a sketch of an international framework for ecological market economies is as follows:

- Development of better environmental technology and appropriate policy instruments to promote it.
- Development of technology for infrastructures.
- Restructuring of the taxation and charging systems.
- Introduction of tradable emission certificates for technology developers.
- A framework for an ecological market economy.
- Fostering of international solidarity.

Anchoring on this framework, developing better environmental technologies and policies in infrastructure are more successful if indigenous knowledge, systems, and resources in the community are utilized. Such cases have been applied in most Asian countries where resources and funding are limited. For instance, there have been successful initiatives undertaken by the Orangi Pilot Project in Pakistan, road construction in Nepal, and waste management in Nagoya, Japan; these lessons and practices could be replicated to other countries. Moreover, the active participation of Asian countries in the Seoul Initiative on Green Growth, the Kitakyushu Initiative for a Clean Environment, and other subregional initiatives such as the Southeast Asia Urban Environmental Management Applications Project and CAI-Asia, is an indication of their commitment to sustainable development and fosters sharing of best practices.

Figure 5.2 Optional policy tools in promoting sustainable infrastructure development



The following tools, which are related to eco-efficiency, can be tentatively selected and potentially used in the development and management of sustainable infrastructure:

- Macro level, relating to national or regional strategic planning
  - Integrated policy analysis
  - Multi-criteria analysis (MCA)
  - Social cost-benefit analysis (SCBA)
  - Economic instruments
  - Strategic environmental assessment (SEA)
- Micro level, focusing on municipal, local, investment, or implementing planning, including for design, construction and operation stages
  - Systems analysis and integration
  - Asset management (AM)
  - Life cycle assessment (LCA)
  - Logical framework analysis (LFA)
  - Material input per unit of service (MPIS)
  - Material flux analysis (MFA)
  - Risk assessment and management
- Others, flexible to be applied at different levels
  - Eco-efficiency indicators
  - Demand-side management (DSM)
  - Public-private partnership (PPP)

The effective use of economic instruments should have the basic support from regulatory and other instruments. For example, according to a study by Thanaprayochsak, *and others* (2006: 20), if there are no regulatory instruments, it will create many violators. And regulatory instruments can be the measure of giving the penalty.

Asset management is another example of a process of guiding the acquisition, use, and disposal of assets, to make the most of their service delivery potential and manage the related risks and costs over the full life of the assets (Leong, 2004: 18). This concept can be used as a tool in promoting consideration of life-cycle cost and assessment to integrate both economic and environmental aspects in the infrastructure development system, particularly at the programme or project levels of infrastructure development. Asset management is important in the development of large infrastructure projects where environmental impacts are most likely to be significant. This tool is utilized, for instance among urban rail concessions in the cities of Bangkok, Kuala Lumpur, and Manila to incorporate the economic assessment of trade-offs among alternative investment options and uses this information to help make cost-effective investment decisions.

#### 5.3.4 Monitoring and evaluating performance

Another policy tool that could be used in promoting sustainable infrastructure development is through the use of benchmarking systems. The benchmarking system is a long-term and continuous process of searching for the best practices within a sector; selection of appropriate indicators comparing the performance; analyzing the advantages and disadvantages; and improving the performance to meet the best one. This system could help address the problem of deficient information of cost and performance for governments and other concerned stakeholders (Zhong and Chen, 2005). In the case of China's application in the wastewater sector, it has been considered as one of effective instruments for cost control and performance supervision (Zhong and Chen, 2005: 6). An example of technology verification and benchmarking is given in box 5.2.

#### Box 5.2 Eco-efficiency – measuring, verifying and reporting performance

A vast amount of information already exists regarding the most efficient applications of technologies and management practices. Often, the missing element is a comprehensive performance benchmarking and verification platform to assist decision-makers in determining which eco-efficiency options are most appropriate in meeting their needs. Some of the key issues of concern to stakeholders include:

- Measuring, tracking and getting credit for more efficient resource use
- Optimizing the intrinsic strengths of existing infrastructure
- Ensuring energy and resource security, resiliency and reliability
- Demonstrating effective implementation of appropriate eco-efficiency applications
- Integrating renewable and decentralized options with conventional systems.

An essential part of ensuring that credible performance information is available to support sound decision-making and transparent reporting of results is to build on existing technical and institutional capacity. Governments can lead by example and ensure that procurement policies and procedures reflect conservation and eco-efficiency objectives. Increasingly, stakeholders are demanding clear, transparent performance reporting to assist them in making sound decisions in the selection and implementation of sustainable eco-efficiency and conservation alternatives. The challenge in meeting stakeholder expectations requires both demand-side and supply-side initiatives. Demand-side management technologies and practices represent the foundation of effective resource conservation. Similarly, the effective application of eco-efficient supply-side alternatives offers the opportunity to match specific technology solutions to their most appropriate uses.

Source: ETV Canada, <<http://www.etvcanada.ca>> Accessed on 16 March 2007.

#### 5.4 APPLYING ECO-EFFICIENCY IN DEVELOPMENT STAGES

Applying eco-efficiency in different development stages is a key aspect of the systems approach for sustainable infrastructure development (Howes and Robinson, 2005: 18). Policy tools can then be used for particular stages. Table 5.1 provides examples of policy tools to suit each of the development stages. There is also a need for greater integration of planning, design and construction, operational, recycling, and disposal stages and how to view infrastructure as a system to facilitate the delivery of services rather than as an end-product.

Table 5.1 Selected policy and management tools for different stages of sustainable infrastructure development

Policy tools	Planning	Design	Construction	Operation	Disposal/ Recycling
MCA	Y				
SCBA	Y				Y
AM	Y	Y		Y	Y
LCA	Y	Y		Y	Y
DSM	Y			Y	
SEA/EIA	Y	Y			
PPP	Y			Y	
Risk assessment		Y	Y		Y
Indicators	Y				Y
LFA	Y		Y	Y	
Cost effectiveness		Y			Y

These development stages are generally sequential but there are often overlaps between them. Implementing infrastructure projects requires inputs from key agencies in the public sector and other stakeholders including the private sector, ranging from policy planning and appraisal to the operation of facilities, and finally disposal and recycling.

The planning stage involves establishing the needs and objectives of the project, identifying an appropriate location, and assessing its feasibility. There are three main aspects to consider at this stage: information about the project, information relating to the location of the project, and the potential consequence of the project in terms of costs and benefits. Due to the large range of activities and objectives, several tools can possibly be used in order to take into consideration of environmental concerns.

The design stage involves developing solutions to reflect the planning parameters and constraints. Detailed design decisions are made or fine-tuned based on the shape and dimensions of the facilities, aesthetics, the regulations, and how it will be constructed. Some specific tools may be used for this detailed planning stage. Possible incorporation of environmental costs and benefits can be made through either AM, LCA, or EIA. Risk assessment and cost effectiveness are generally used when detailed information is available from the design stage to ensure incorporation of environmental concerns before the construction of infrastructure facilities.

There are different technical and management processes required in infrastructure construction. Standard construction projects require programmed organizations relying heavily on routine and standard procedures to manage the construction process. Risk assessment can be potentially used for this stage, following the design stage to validate environmental concerns. The LFA should be appropriate to be used for planning and monitoring during this construction (as well as operation) stage.

The operation stage is according to the relevant benchmarks, operational targets, and expectation of the users of the facility. Given the construction of an infrastructure facility is not an end itself, it is now increasingly recognized that the services derived at the operational stage need to be sustainable over the whole life cycle of the project and need to address issues relating to the conservation of non-replaceable resources. Some of the tools with similar purpose of use as in the planning are also recommended for this operation stage, such as AM, LCA, DSM, and PPP.

The disposal and recycling stage is when the project has reached the end of its intended life. Consideration should be given to how facilities could be reused, how any component, material or part of the facility could be recycled and the associated cost. The information from this stage is mostly intangible, requiring some specific tools to be used to assess for incorporating environmental concerns during this stage.

## 5.5 APPLYING ECO-EFFICIENCY FOR DECISION MAKING AND STAKEHOLDERS

There are three levels in the decision-making hierarchy of infrastructure development (Howes and Robinson, 2005: 66) which require different applications of eco-efficiency at the policy, strategic, and operational levels. There are also interactions within levels (horizontal interactions) and between levels (vertical interactions). The decision-making hierarchy provides an insight into the effect of various policy objectives on improving strategic outcomes for solving operational problems. The following provide some background, applications of specific tools, and actions at each decision level in order for promoting sustainable infrastructure.

### *Policy level*

Factors such as socio-economic, sectoral, institutional and environmental considerations influence the development of infrastructure development strategy. The institutional framework plays major role at this policy level requiring well coordination among concerned agencies which is one of main concerns expressed by policy makers in Asia. This is a long-term period, mostly for national or regional purposes, requiring critical system or method for tackling problems:

- Use of eco-efficiency indicators with targets.
- Applying innovative financing methods including PPP.
- Developing and use of regulatory framework to enable different stakeholders including private sector to participate.

### *Strategic level*

The levels of infrastructure and resource provision are influenced by factors, such as economic and institutional policies. Soft systems or methods are used to tackle problems at this medium-term period. Major issues at this stage are lack of decision support tools that can practically incorporate environmental concerns into the strategic decision. Some of the actions to promote sustainable infrastructure at this level include:

- Use of stakeholder partnership, and systems analysis and integration.

- Applying demand-side management and life cycle assessment for improving the efficiency of infrastructure plan and implementation.
- Applying qualitative methods and indicators for assessing environmental concerns and resources used.

### *Operational level*

The level of infrastructure depends on the strategy for transforming infrastructure plans and projects into facilities, and their maintenance. The delivery or improvement of particular types of infrastructure services could be hampered by a number of operational problems such as design and construction options, cost overruns, and incomplete infrastructure projects due to lack of resources or lack of maintenance of existing stocks. This short-term problems require hard system or method to tackle. More quantitative methods can be used, such as:

- Use of DSM and service-focused approach.
- Developing mechanisms for long-term evaluation of the infrastructure systems.
- Applying optimization methods for allocation of resources and incorporating environmental impacts into the design and implementation of the infrastructure.

The roles of key actors are important to be identified and chosen in order to ensure participation of relevant stakeholders which are keys to the success of the application. The first three actors (national governments, local governments, and donors) directly determine the policy agenda, while the last three (NGOs/CBOs, the private sector, and users) influence the agenda (Fox, 1994: 54-56). International organizations, the United Nations agencies, and international NGOs, can act as facilitators to support dialogues or provide new analyses on issues that benefit from a wide range of perspectives.

### *National governments*

- Developing a framework for assigning service delivery responsibilities to national and local governments including other key stakeholders.
- Development of a regulatory framework that supports institutional reform for sustainable infrastructure as an integral component of change.
- Development of policies to encourage consideration of long-term costs, effects, and benefits, including demand and public awareness of infrastructure development and evaluation.

### *Local governments*

- In the best position to recognize and achieve service demands.
- Where possible, contract with private firms to produce efficient components of effective infrastructure and services.
- For the services under responsibilities of local governments, user fees can be applied to directly finance service delivery.
- Particularly under the government decentralization, improved environmental management capacities of local authorities in terms of legislative power, human resources, financial, and technical aspects for local infrastructure such as water supply and solid waste management.

### *International community including donors*

- Can support research, data and the development of guidelines for achieving eco-efficient infrastructure development in the region.

- Can identify ways to cooperate with and finance strong stakeholders for particular sectors and components of infrastructure.
- May require the incorporation of environmental concerns including impacts into national policies and infrastructure development programmes.
- Support the incorporation of environmental concerns into national policies and implementation.
- Support capacity-building and sharing of best practices on sustainable infrastructure development.

#### *NGOs/ CBOs*

- NGOs and community-based organizations (CBOs) can act as catalysts for more effective service delivery with more attention to the local environment.
- NGOs can raise the resources necessary to participate in self-help or cooperative projects.
- NGOs/civil society can have a strong voice in bringing environmental concerns into the public awareness, as well as supporting new mechanisms for community participation in policymaking and implementation of environmentally friendly practices.
- NGOs can act as facilitators by bringing together governments, private companies, and communities in a participatory approach to understand the issues related to the development and management of infrastructure and incorporate environment-friendly practices.

#### *Private sector*

- Promoting the development of eco-technology and environmental-related industry.
- Partnering with public and other stakeholders to utilize strength of private sector in infrastructure development.
- Applying the success of eco-efficiency typically from business for similar conditions in the infrastructure development including support for research in modifying good practices to fit the public sector.

#### *End users*

- Play major role in the performance of infrastructure operation and maintenance including cost recovery and demand for the services.
- Can get involved through consultations and decision making in the earliest stages of and throughout infrastructure development.
- Can assist in resource mobilization, monitoring, and evaluation including planning for sustainable infrastructure development.

## 5.6 POLICY DIRECTIONS AND RECOMMENDATIONS

Table 5.2 provides a summary of policy directions, possible actions, and tools that can promote sustainable infrastructure in Asia. Governments, international organizations and other stakeholders can draw on each other's knowledge and expertise in implementing these actions.

Priority actions to promote sustainable infrastructure in the Asia include the following:

- (1) Develop guidelines for achieving eco-efficient infrastructure development in the region using existing information as much as possible, considering potential policy tools (such as economic incentives, life-cycle cost saving, and strategic environmental assessment) and strategies that are appropriate to different sectors, development stages, and economic and geographical conditions.



Table 5.2 Policy directions and possible actions

Areas	Guidelines and Policy Direction	Possible Actions and Tools
Capacity-building and awareness	➤ Promote application of systems or holistic approach in infrastructure development.	<ul style="list-style-type: none"> <li>• Integrate infrastructure development plan using eco-efficient indicators.</li> <li>• Apply Asset Management and Multi-criteria Analysis.</li> </ul>
	➤ Consider development and use of national strategic infrastructure development plan.	<ul style="list-style-type: none"> <li>• Develop national sustainable infrastructure plan.</li> <li>• Use of Life Cycle Assessment and Strategic Environmental Assessment.</li> </ul>
	➤ Disseminate the information on the importance and good practices of eco-efficiency in infrastructure development.	<ul style="list-style-type: none"> <li>• Involve decision makers, planners, academics, etc.</li> <li>• Implement pilot projects based on good practices.</li> </ul>
	➤ Establish a network for capacity-building of sustainable infrastructure development in the region.	<ul style="list-style-type: none"> <li>• Research covering good practices, indicators, and criteria.</li> <li>• Training focusing on planning, design, and evaluation.</li> </ul>
	➤ Develop guidelines for achieving eco-efficient infrastructure development in the region.	<ul style="list-style-type: none"> <li>• Use of policy tools and strategies that are appropriate to different sectors and conditions.</li> </ul>
Specific infrastructure sectors	➤ Propose methodologies to improve eco-efficient infrastructure.	<ul style="list-style-type: none"> <li>• Benchmarking and/or verification programme.</li> <li>• Use of available data and develop required data base.</li> </ul>
	➤ Develop eco-efficient infrastructure according to economic, physical/topographical, and demographic conditions.	<ul style="list-style-type: none"> <li>• Develop and implement pilot projects based on good practices.</li> <li>• Target exchange programme.</li> </ul>
	➤ Integrate development sectors such as transport and land use systems.	<ul style="list-style-type: none"> <li>• Apply at city or subregional level.</li> </ul>
	➤ Improve the quality of infrastructure services.	<ul style="list-style-type: none"> <li>• Use of technologies and improved management.</li> <li>• Applying eco-efficient materials to be used in construction and maintenance of infrastructure.</li> <li>• Applying successful business models in service providing organizations.</li> </ul>
	➤ Improve implementation, monitoring and evaluation of infrastructure projects.	<ul style="list-style-type: none"> <li>• Use of Environmental Assessment (EA) and Environmental Management System (EMS).</li> </ul>
	➤ Increase the use of public transport and low energy-consumption vehicles.	<ul style="list-style-type: none"> <li>• Investment of new rail lines and new bus system such as BRT.</li> <li>• Provision of facilities to promote non-motorized vehicles and integration with transit.</li> </ul>
	➤ Develop methodology to estimate traffic congestion, environmental and social costs.	<ul style="list-style-type: none"> <li>• Apply social cost-benefit analysis.</li> <li>• Develop and maintain required databases.</li> </ul>
Stakeholder participation	➤ Governments and policy makers look at areas in relation to other stakeholders to achieve sustainable infrastructure development.	<ul style="list-style-type: none"> <li>• Use of innovative financing and economic instruments.</li> <li>• Country and regional workshops to share good practices.</li> </ul>
	➤ Integrate capacity-building and technical support activities to enhance partnerships among sectors and stakeholders.	<ul style="list-style-type: none"> <li>• Apply good practices from the private sector.</li> <li>• Target counterpart exchanges.</li> </ul>

Table 5.2 Policy directions and possible actions (*continued*)

Areas	Guidelines and Policy Direction	Possible Actions and Tools
	➤ Involve civil society in formulating government policies and major actions.	<ul style="list-style-type: none"> <li>• Use of community and participation techniques.</li> <li>• Information library and websites.</li> </ul>
	➤ Education and awareness on adopting sustainable management practices.	<ul style="list-style-type: none"> <li>• Information, education and communication (IEC) campaign.</li> <li>• Publication of good practices and research results.</li> </ul>
	➤ Promote dialogue, consultation and consensus-building among stakeholders.	<ul style="list-style-type: none"> <li>• Participation of stakeholders including local authorities, citizens, local organizations, NGOs and private enterprises.</li> </ul>
	➤ Improve environmental management capacities of local authorities.	<ul style="list-style-type: none"> <li>• Capacity-building and human resources development.</li> <li>• Enhancing technical and financial capacities.</li> </ul>
	➤ Governments can be prepared to gradually shift their role from principle financier and operator to overseer and regulator.	<ul style="list-style-type: none"> <li>• Use of public-private partnership.</li> <li>• Development of regulatory framework and guidelines.</li> </ul>
	➤ Promote the development of eco-technology and environmental industry.	<ul style="list-style-type: none"> <li>• Consider the use of economic instruments.</li> <li>• Provide research funds.</li> </ul>

- (2) Continue to utilize and strengthen the Seoul Initiative Network on Green Growth for capacity-building of sustainable infrastructure development, considering needs of members and development of activities, such as the following:
  - research for environmental costs and benefits, and appropriate indicators for eco-efficient infrastructure
  - compilation of good practices in eco-efficient infrastructure in the region
  - training for planning and design including evaluation of infrastructure using eco-efficiency principles, and
  - developing/implementing pilot or demonstration projects
- (3) Disseminate/publish information on the importance and good practices of eco-efficiency in sustainable infrastructure development among decision-makers, planners, academics, and related stakeholders.
- (4) Integrate capacity-building and technical support activities to enhance partnerships among sectors and stakeholders. Drawing on the knowledge and expertise at the United Nations agencies, international financial institutions, regional institutes, and others can support these efforts. Among the activities to be considered include applying successful business models in service providing organizations, and identification of public-private sector roles in different development stages (planning, design, etc.).
- (5) Enhancing manpower capacity among the sectors would improve productivity, quality, and efficiency in providing sustainable infrastructure services to the people, for example, promoting use of eco-efficient materials to be used in construction and maintenance of infrastructure.

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# PART II:

## PROCEEDINGS OF THE SEOUL INITIATIVE POLICY FORUM ON SUSTAINABLE INFRASTRUCTURE

*SEOUL, REPUBLIC OF KOREA  
6-8 SEPTEMBER 2006*

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# Sustainable infrastructure: Doing more with less by applying eco-efficiency principles

*David Ness*

*Adjunct Research Fellow, University of South Australia*

*Office of Major Projects and Infrastructure, SA Department for Transport,  
Energy and Infrastructure, Australia*

## 1. INTRODUCTION

This paper explores the application of eco-efficiency principles to transport, energy, and water infrastructure. It seeks to highlight some means by which more may be achieved with less consumption of resources, focusing on the materials, energy, water, and land associated with the construction and maintenance of physical infrastructure such as highways, power plants and transmission lines, water supply, and draining and sewage systems.

A case is made for more consideration of these eco-efficiency factors during infrastructure decisions, based on a belief that these factors are frequently neglected at present. Some examples of innovations are also outlined.

In providing infrastructure for developing countries, the resource and capital intensive models used in the west – involving large, centralized plant and extensive distribution systems – may not be appropriate. The answer may lie in localized, small-scale infrastructure solutions that empower the local community, especially for rural settings as opposed to urban centres where much infrastructure may already be in place.

The paper seeks to raise awareness of the emerging field of eco-efficiency of infrastructure, present some basic concepts and principles, and to highlight the need for further research and the production of guidelines.

## 2. THE PRINCIPLES

### 2.1 Eco-efficiency

The underlying principle of eco-efficiency involves increasing the service intensity of goods and services while reducing material and energy intensity (WBCSD, 2000). This approach has, to date, been mainly applied to product manufacture, but may offer far greater sustainability benefits when applied to physical infrastructure or even economies as a whole. This means providing increased transport, energy, and water services but with less consumption of material and other resources, thereby enabling “green growth” and socio-economic development, especially in developing countries. Infrastructure is a key element for realizing sustainable economic growth and achieving the United Nations Millennium Development Goals – in particular, MDG 1 (eradication of extreme poverty) and MDG 7 (environmental sustainability).

Eco-efficiency also involves collaboration, integration, and sharing, enabling more to be done with less through synergies. The application of systems thinking (Checkland, 1981; Metcalfe, pers. com. 2006) is seen as helpful in advancing such connectivity and networking approaches. Material and energy flows of stocks, and life cycle thinking, are also important considerations in the eco-efficiency of infrastructure, as is the concept of the 3Rs: Reduce, Reuse, and Recycle (see ESCAP, 2006: 13).

## 2.2 A systems approach

It is important that physical infrastructure is seen as part of a wider system related to the provision of services that are essential for growth and poverty alleviation. For example, highways form part of a wider access and mobility system that may include the need for journeys (e.g. location of work and home), feeder roads, land uses, noise barriers, personal vehicles, public transport, freight, fuel, refuelling stations, traffic control, and the like. These reflect the elements of a theoretical system, including purpose, components that are also systems (sub-systems), connections between the components, a boundary between the system and the outside “environment”, and resources (see Checkland, 1981). In other words, eco-efficiency of transport infrastructure needs to be seen in the context of the wider transport or mobility system. In this regard, the OECD *Report on Eco-Efficiency in Transport* (1998) is a useful reference.

Taking a wider systems approach can lead to synergies, major innovations, and a better use of resources that we expend in infrastructure. Any gains from insular thinking (e.g. viewing highways as just road corridors) are likely to be restricted to that component of the transport system. On the other hand, a collaborative approach is likely to open up wider opportunities through the connections. Most importantly, “systems thinking” enables us to focus on the purpose or required service (e.g. socially inclusive urban environments) and how all the elements may work together towards achieving this end.

Salon *and others* (1998: 5) have encapsulated this idea:

*For a new mobility system to function more effectively than single stand alone alternatives, the alternatives must be coordinated so as to capture synergies, especially with respect to the user. These synergies will generally take the form of lower cost or greater convenience for the traveller (as well as lower overall social costs).*

## 2.3 Achieving the shift

The approach taken in this paper is therefore one of, firstly, reducing the demand for large capital-intensive infrastructure, such as the use of low technologies to provide infrastructure at a local level and empowering local communities. Secondly, it involves rationalizing the supply, such as via shared or multiple uses, to reduce the need for massive material and other resource consumption associated with construction and maintenance—that is, to do more with less. In this regard, the application of strategic asset management principles can lead to a greater and “leaner” alignment of infrastructure assets to community needs, and their more effective use (see APCC, 2001; IPWEA, 2006). If we are successful in this, we reduce the demand for assets, reduce our drain on world resources, save money, and achieve “green growth”.

### 3. NEW APPROACHES TO COMMUNITY INFRASTRUCTURE

#### 3.1 Reducing demand

Managing demand can reduce the need for supply of infrastructure, achieving ends by means other than the construction of physical assets. An example is the “dematerialization” of freight transport in Kassel, Germany, as outlined by the OECD (1998). City Logistik Kassel united ten delivery firms into a partnership that agreed to coordinate and bundle deliveries at a dedicated trans-shipment facility for distribution by a neutral carrier. The partnership expected to save costs by increasing vehicle utilization, rationalizing delivery routes, and better scheduling of deliveries, accompanied by environmental gains. This is an example of achieving the same degree of access with less movement by reducing the need to travel. It also exemplifies system thinking, where a better and more sustainable result was achieved through ensuring that all the parts of the delivery system were coordinated and worked together – shared responsibility, as advocated by World Business Council for Sustainable Development (WBCSD, 2000: 28).

Similarly, a cheaper and more sustainable solution to a city water crisis, rather than building more dam infrastructure, may be to switch water from agriculture (where water is used for low-value exports) to high-value residential use (see Burns, 2006).

#### 3.2 Central versus decentralized and distributed systems

Developed countries are accustomed to considering infrastructure in terms of massive central power plants, sewage treatment and water filtration plants, multi-lane highways, and vast public building complexes. But the opportunity cost of large capital investments may be better allocated to smaller distributed systems at the local community level. Local management of sewage treatment, stormwater, energy production, and the like may reduce the demand for large central plants. This approach seems especially relevant for developing countries and presents an opportunity for involvement of the urban poor, both in the development and management of such systems and in their use. It is also likely to be more cost- and eco-efficient to generate power, provide water supply, and deal with “waste” close to the community they service.

Distributed systems are emerging on the back of new high technologies, especially in terms of power generation. As with mobile phones, there is an opportunity for developing countries to “leapfrog” outmoded technologies and avoid the need for extensive transmission lines and the waste of energy that may occur en route.

According to UNEP (2003: 1-2):

*In some communities, large distribution grids and remote treatment and generation facilities are giving way to a network of distributed or ‘on-site’ management systems, with shared elements integrated into the fabric of the built environment. More diverse land use and building types can complement these on-site infrastructure systems, creating self-reliant, mixed developments...In these communities, each new housing development is seen simultaneously as a centre of employment, communications and food production, as well as a facility for power generation, water treatment, stormwater management and waste management.*

However, UNEP acknowledges that this type of sustainable integration is more difficult to apply in older communities. The performance of existing systems must be carefully evaluated and forecast in order to allocate resources between maintenance, refurbishment, or replacement. Many

developing countries already have the advantage of extensive public transport services and land use patterns that suit public transport, cycling, and walking – it would be most unfortunate for these to be lost, just before their value is recognized. However, the economies of sunk costs do not apply where there is a lack of existing infrastructure; hence technologies that are not financially competitive in developed countries may be so in developing countries.

As UNEP has recognized, the life cycle impacts of energy and material flows need to be assessed for very diverse technologies and for a range of scales and locations. This will require comprehensive models in order to combine the flows from different stocks (i.e. roads, pipes, wires, etc.) to allow meaningful comparison between integrated and less integrated systems (UNEP, 2003).

### 3.3 Some examples of involvement of local communities in infrastructure provision

#### *Waterworks and roads*

There are many examples, though, where local communities are empowered to manage infrastructure provision. One such example is the Sarvodaya Shramadana Movement in Sri Lanka, providing sustainable local communities with economic self-reliance through collaboratively digging wells, building waterworks and roads, planting trees, providing micro-credit, and generally sharing of resources (APFED, 2004: 107). This improves environmental conditions while providing jobs for poor communities.

#### *Renewable energy for electrification*

Another example of such a local system is the APACE “Village First Electrification Programme” (VFEP), which began in the Solomon Islands but now includes Papua New Guinea, Bougainville, and Vanuatu. This is based upon micro-hydro technology, which recognizes that electricity via renewable energy is a prerequisite for basic services and economic development (APFED, 2004: 472; Bryce, 2006). Similar approaches have been pursued in Rajasthan, India, through a project on “Enhancing Access through Off-Grid Electrification”. This recognizes that the present approach to rural electrification is environmentally and financially unsustainable. The alternative approach through off-grid electrification, pursued to a modest degree, has established the resource availability and technical viability of renewable energy-based technologies (APFED, 2004: 164).

The structure and composition of many electricity markets around the world is moving away from the centralized power generation and distribution that characterized the industry for much of the 20<sup>th</sup> century (Carder, 2003). Solar photovoltaic (PV) panels enable more distributed power generation, converting sunlight into electricity, with no moving parts. It is the most cost-effective energy choice for many off-grid applications, for example in remote areas. Where solar PV is grid-connected, the electricity that is generated does not need special storage. It is used on site initially and, when the solar panel generates more than is being used, it feeds electricity into the grid. Systems are modular and easy to install, so they are very suitable for urban environments (Australian Conservation Foundation, 2006).

Another more basic, remarkably simple, and highly innovative scheme, involving Solaris Technology of South Australia, is the use of low cost “solar lanterns”, to provide access to electric light for households in rural areas not serviced by mains or diesel power. This is being implemented in rural Southeast Asia and the Pacific, and involves the Energy and Resources Institute (TERI), which is located in India. The provision of light by high-reliability portable solar lanterns has many added benefits including: increasing effectiveness of literacy programmes; allowing rural dwellers to

participate in educational programmes; increasing household income from home-based production; and opportunities for local business in servicing the lanterns (APFED, 2004: 387). This is another example of “systems thinking”, where the solar lantern is considered not just as a lighting source, but as part of a wider education and development system.

### *Sewage systems*

Cities that do not have the infrastructure to dispose of sewage and organic wastes for reuse (as in food production) have other options. Some authorities have developed sewage farms using reed beds. Kuwait City pipes sewage water into groves of trees on the city outskirts, thus creating a green belt in the desert sand (Girardet, 1992: 188-9).

The main point is that such on-site and decentralized schemes reduce the pressure on urban and regional infrastructure, and are likely to constitute a better use of scarce resources than highly capital- and resource-intensive centralized schemes. In addition to achieving more with less, such systems may lead to added and possibly unforeseen benefits, such as ensuring that communities are less vulnerable to terrorism.

There is a case for such schemes to be subsidized by the general community and utilities, through a redistribution of funds, as they reduce the need for costly plants, such as power stations.

### 3.4 Extending the Christie Walk EcoCity Model

Adelaide’s Christie Walk EcoCity Project will be the first inner-city housing project in Australia to have on-site sewage treatment and to be able to provide treated effluent for irrigation of publicly owned parklands. Other features include photovoltaic panels that provide power to the grid and hot water to all dwellings, a roof garden, community produce garden, and underground stormwater tanks. Christie Walk is a grassroots project involving the local community – the first privately funded housing co-operative to undertake green development. It recently received international recognition when it was awarded a silver prize through the Asia Pacific Forum for Environment and Development (APFED) in the Ryutaro Hashimoto Awards (Ecopolis Architects, 2006), and may serve as a model for much wider application in the Asia-Pacific when modified and adapted to suit particular circumstances.

Similarly, Weizsacher *and others* (1997: 132-6) have outlined alternative forms of suburban development in the United States – including low-scale farming and forestry, and pedestrian friendly narrow roads doubling as walkways with natural draining swales instead of costly underground concrete drains – which have saved US\$800 per house. Even Shanghai, with its booming growth and associated problems, has pursued a policy of self-sufficiency in vegetables.

There are examples of apartments with much-reduced car parking provisions, where a car or mobility service is provided as part of the tenancy package leading to more efficient use of vehicles and reduced parking and transport infrastructure (Scheurer, 2001).

### 3.5 Local transportation systems

Transport needs can be reduced while also reducing need for large transport networks, and with added socio-economic benefits. For example, diesel operated three-wheelers were introduced to the Kathmandu Valley, Nepal, in the late 1980s to early 1990s. It became a popular transportation

option but with associated pollution problems. Through the support of organizations such as the Global Resources Institute, the diesel three-wheelers are being converted to use electricity, which has given rise to an electric vehicle industry consisting of vehicle owners, electricity charging station operators, and a new business involving the manufacture of electric vehicles. All are components of an electric vehicle system (see APFED, 2004: 116; Dhakal, 2002). Imagine if the vehicles were rented and shared as part of a sustainable product service system, taken back, and reused, with increased eco-efficiency. This is an area for further investigation, but the words of Salon *and others* (1998: 6) – while referring to developed countries – point to the way forward for developing countries:

*Strong synergies and large incentives are needed to accomplish a major transportation transformation...Partnerships between new mobility businesses, such as local car-sharing organizations, bicycle retailers, and local bus and train operators, need to be fostered. These partnerships will create a strong new mobility core business community and will facilitate the intermodalism necessary for a new mobility system to thrive.*

#### 4. SHARED OR MULTIPLE USE AND “LEAN” APPROACHES

##### 4.1 Multi-function land use

Shared or multiple uses of land and infrastructure lead to greater eco-efficiency, or “doing more with less”, as the resources can be put to multiple purposes. According to Beecham (pers.com. 2006), “*the future lies in multi-function land use*”, involving habitat connections, flood storage, water-sensitive urban design, and social amenities – all in the same corridors. While this concept requires further exploration, it points to exciting, innovative, and creative solutions.

##### 4.2 Transport corridors for rainwater harvesting and reuse, and solar collectors

There are emerging examples of transport corridors serving more than one purpose, which demonstrate prudent and efficient use of resources.

Beecham (2003) has outlined how biofiltration systems may have multiple land use functions. In this regard, permeable pavements can be designed for both enhanced water quality treatment and integrated rainwater tank storage (below the pavement surface). This allows transportation corridors to be utilized as large rainwater harvesting and reuse facilities, without requiring the construction of separate facilities. Research is continuing at the University of South Australia, under the theme of “water-sensitive urban design”, on enhancing the structural strength and water quality treatment capabilities of these novel systems.

Noise barriers along highways can also double as solar collectors, and there are a number of examples of trials and demonstration projects in Europe, Japan, and elsewhere. The possibility of direct heating of neighbouring buildings has even been explored, again demonstrating wider systems thinking (Carder, 2003). At a more micro-technological level, Holdsworth (2002) has described the “ModieSlab” system, consisting of a road surface incorporating a number of systems and serving a number of purposes, i.e. noise reduction, drainage, and solar collection.

##### 4.3 “Power Parks” with shared transmission lines

On being informed that a coal mine would be running out of its capacity in the next generation, Adelaide “Thinker in Residence” and renowned climate change expert Stephen Schneider (2006) asked during a public lecture:

*So what is going to replace it? And this is the key: will the technology that replaces it be a repeat of the same, or will it be greener? I have suggested - this is a difficult one - that we consider power parks. They would have shared infrastructure. If you had a lot of units in the same place then you'd only have one set of transmission lines. It would be a high visibility centre for low emitting technologies to strut their stuff. It could be hot rocks, it could be hot tower solar, it could be deep earth sequestration...It could also have a proximity to big users, in particular mining. You'd be able to have green power available on shorter transmission lines...*

This is an example of wider system thinking – rather than thinking of power generation sources individually, we can think of them holistically and this opens up opportunities for innovation, sharing, and integration.

#### 4.4 Lean infrastructure solutions

One example of a lean infrastructure solution is the use of uni-directional highways where traffic flow is controlled. This is akin to the scenic “Enoden” railway system near Kamakura, south of Tokyo, where local commuter-friendly trains use a common track by means of passing loops and synchronization controls. Another novel approach developed by the University of Hannover, which involves quadrupling the capacity of existing railways, has been described by Weizsacher *and others* (1997: 121-3). In brief, the idea is to increase the frequency of trains by developing new electronic control techniques for safely minimizing the safety distance between trains. Again, this demonstrates how more services can be derived from the same infrastructure, with both economic and environmental benefits.

#### 4.5 Closing the loop and new sustainable service models

We also need to switch our thinking in relation to infrastructure in order to create closed-loop urban environments where various elements feed off each other – reflecting industrial ecology principles and applying the concept of eco-industrial parks at a wider urban scale. For example, sewage systems may be thought of as “fertilizer factories” rather than systems for the disposal of noxious household and factory discharges (Girardet, 1992: 185).

The Aichi Expo 2005 in Japan featured a demonstration project involving a regional power grid with various new energy systems that generate environmentally friendly recycled electricity and heat. This system utilized organic waste, construction wood waste, waste plastic bottles, and photovoltaic power generation or other natural energies and demonstrated innovative system thinking (NEDO, 2005). The relevance and application of such sophisticated, high technology to developing countries is an area requiring further consideration.

Infrastructure solutions at a local community level, such as the three-wheeled electric vehicles in Kathmandu, or solar photovoltaic (PV) panels (both described earlier in this paper), present the opportunity for exciting new business models such as sustainable product-service systems (see Halen *and others*, 2005). Such innovations, reflecting the notion of a service and flow economy, may enable increased resource efficiency coupled with social and economic benefits (ESCAP, 2006: 19). For example, solar PVs may be provided as part of a service by the producer (i.e. for rental rather than sale), and be designed for take back, disassembly, reuse, and recycling (that is, greater product stewardship). This eco-efficiency principle is already being used in the product field and is being introduced by the Technical University of Delft and others to developing countries. Imagine if such systems were facilitated by micro-credit schemes and “eco-currencies” (APFED, 2004: 88) and were able to increase employment for local communities, as in labour-intensive disassembly.



## 5. ECONOMIC AND FINANCIAL ASPECTS

As highlighted by ESCAP (2006: 30), *“the optimum cost-effective way of increasing resource productivity is through economic instruments that steadily and predictably increase the real prices of resource use over the long-term.”* Such instruments, including eco-tax reform, congestion taxes, emissions-permits trading, and the like, may have application to infrastructure provision.

In the context of this paper and its emphasis on decentralized provision of community infrastructure, micro-credit and community-based finance are seen by many as the only forms of capital available to the large majority of people in rural areas of the region. According to APFED (2004: 84-5):

*For many of the basic needs such as access to modern and environmentally less harmful fuels as well as electricity, micro-credit is becoming a promising form of local finance in places where necessary institutional support has been established.*

## 6. MEASURING IMPROVEMENTS

Eco-efficiency relates service value (e.g. welfare) to environmental influence (WBCSD, 2000), with Factors 4 and 10 being eco-efficiency targets for the economy at large in developing and developed countries respectively. In this regard, concepts and tools such as “material intensity per unit of service” (MIPS) and material flow analysis (MFA) offer much potential (Schmidt-Bleek, 1999). There are more specific concepts that stem from MIPS, such as “transport intensity”, or the amount of transport infrastructure associated with a particular service (OECD, 1998: 63). Such tools for relating resource consumption to services may enable eco-efficiency to receive far greater attention in infrastructure decisions, leading to a paradigm shift in thinking and practice.

## 7. CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

This introductory paper highlights the need for a substantial shift in the approach to infrastructure provision in developing countries, focusing on transport, energy, and water, leading to more eco-efficient and socially inclusive urban environments. This changed approach should involve greater consideration of more decentralized provision of services and infrastructure, reducing demand on capital-intensive centralized systems, and enabling a redistribution of funds to more empowered local communities. This approach may offer new possibilities for the urban poor to participate in the economic activities of society.

As part of further work to promote sustainable infrastructure development, it is suggested that the principles be described in guidelines. Recognizing that not all of these principles are applicable universally, it is further suggested that the principles be categorized according to various circumstances, accompanied by a knowledge base of good practices. Comprehensive modeling tools are also required to enable comparison of alternative methods of infrastructure provision, e.g. centralized versus decentralized models of development. These would be relevant to developed as well as developing countries.

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## DEDICATION

A few years ago, Augus Simanjuntak from Medan, North Sumatra, spent a few days in my office as part of a training programme for Indonesian local administrators run through the University of South Australia. At the time, I was having Windows 2000 installed on my computer. But Augus had nothing like that, not even basic computing or internet. An educational administrator, he described the poor condition of the education infrastructure, such as schools without walls, with chairs falling apart, earth floors, and of course, no internet access. Finally, Augus managed to gain internet access by traveling more than 50 km over rough roads. But then the earthquake and tsunami of 2004 came. Sadly, I have lost that precious contact with Augus, and fear that he may have lost his life. This paper is dedicated to Augus and others like him, who hold aloft the “solar lantern” of hope for equitable and sustainable development in the Asia-Pacific.

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# Sustainable infrastructure: What is it? Why is it important?

Rolf André Bohne

Department of Civil and Transport Engineering

The Norwegian University for Science and Technology

Norway

## 1. INTRODUCTION

This paper seeks to outline what sustainable infrastructure is and why it is important. In doing so, sustainable development is first defined, since the action space of sustainable infrastructure is framed within this concept and the limits of sustainable development. Given this action space, the paper then operationalizes sustainable infrastructure by prioritizing it among sustainability indicators. Through this operationalization it is possible to identify and act sustainably on infrastructure development and investments.

European experience is mixed, but several investigations suggest that a 50-80 per cent reduction of greenhouse gas emissions (GHGs) by 2050 is possible at a reasonable cost and with known technologies, given that decision makers have the know-how and the will to do so. But it is necessary to start acting now, and to act in a coordinated manner in order to reach this target at a low cost. The alternative to not acting now will become much more expensive, and may have severe consequences both economically and environmentally.

Thus, sustainable infrastructure is a necessary part of sustainable development and an obvious and most rational path to future development. But immediate action is needed in order to harvest the “low-hanging fruit” while they are still around.

## 2. DIMENSIONS OF SUSTAINABLE INFRASTRUCTURE

This paper uses the term “infrastructure” in a broad understanding of the term:

in·fra·struc·ture

Pronunciation: 'in-fr&-''str&k-ch&r, -(')frä-

Function: *noun*

1. the underlying foundation or basic framework (as of a system or organization)
2. the permanent installations required for military purposes
3. the system of public works of a country, state, or region; *also*: the resources (as personnel, buildings, or equipment) required for an activity

Source: <http://www.webster.com/dictionary/infrastructure>.

Sustainable infrastructure is one of the main components of sustainable development, due to its impact on energy consumption, material consumption, and land use. An important property of infrastructure is the huge investment costs and a long to very long service life. Thus the technologies implemented in infrastructure today, will have an impact on future sustainability and welfare development for many years from now.

Sustainable infrastructure is thus a necessity in order to reach sustainable development. And as the global climate is changing, the need for immediate action is increasing. As the *Stern Review* (Stern *and others*, 2006) points out, we can do this now at a reasonable cost, or we can wait too long and face severe economic and social consequences, all over the world.

Asia and the South Pacific region are very interesting with regard to meeting the challenge of climate change for two reasons. First of all, this region is very vulnerable to many of the consequences of climate change. Sea level rise, glacier melt, changed precipitation patterns; drought, desertification, etc. will all affect this region more than others due to both geographic properties as well as the level of infrastructure development. There should therefore be a huge incentive for the region to invest in sustainable infrastructure in order to achieve further economic growth and social development.

With these consequences in mind it might be that parts of the region have a competitive advantage in having a less developed infrastructure, and thus less sunk costs and infrastructure lock-ins.

## 2.1 Sustainable development

There are many important dimensions of sustainable development, and equally many definitions. The most commonly used being from the United Nations report *Our Common Future*:

*“... to ensure that humanity meets the needs of the present without compromising the ability of future generations to meet their own needs”* (WCED, 1987)

In doing so, sustainable development must be able to do the following:

- Provide services to an increasing population.
- Reduce the impact from infrastructure.
- Sustain economical growth and redistribution.
- Sustain environmental carrying capacity.
- Facilitate social development.
- Adapt to a changing climate:
  - Increased precipitation.
  - Rising sea level.
  - Drought.
  - Increased occurrence of extreme weather events.

Operationalizing sustainable development is therefore a challenging task due to the three dimensions of sustainability (environmental, economic, and social). To avoid the normative discussion of balancing the three indicators in this paper, I will concentrate solely on the environmental dimension of sustainability and the action space this leaves for infrastructure development with regards to energy, materials, and land use.

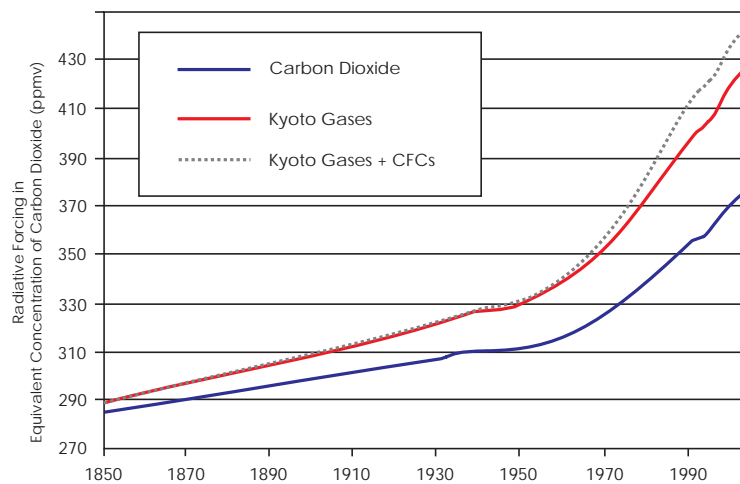
In order to get to grips with sustainable development it is necessary to prioritize among focus areas, and then act upon them. The two most urgent focus areas are climate change and the earth's carrying capacity (Meadows *and others*, 1972, NOU 2006: 18 and Stern *et al*, 2006), where the development and conservation of the earth's carrying capacity is dependent on the climate, and the climate, to a lesser degree, is dependent on the carrying capacity (although there are also feedback mechanisms here).

## 2.2 Global warming

It is now clear that global warming is the most urgent environmental problem to handle in order to secure sustainable development (NOU, 2006: 18; and Stern and others, 2006; IPCC, 2007). It is not the purpose of this paper to discuss global warming, but to address what consequences global warming has on infrastructure, directly and indirectly.

Global warming is related to greenhouse gases in the atmosphere, and is expressed in terms of CO<sub>2</sub>-equivalents. Since pre-industrial times (1750), the concentration of CO<sub>2</sub> in the atmosphere has risen from 280 part per million (ppm) to over 380 ppm today (Stern *and others*, 2006).

Figure 1 Historic concentrations of CO<sub>2</sub> in the atmosphere



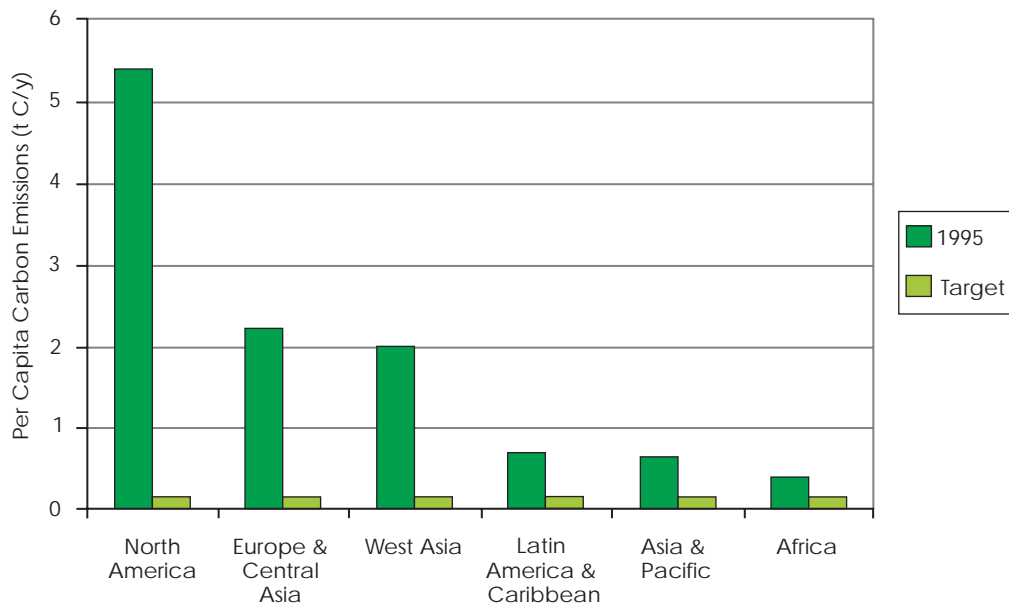
Source: Dr. L Gohar and Prof K Shine in Stern, 2006.

The atmospheric concentrations of CO<sub>2</sub> is already causing global warming, thus the issue is no longer a question of avoiding climate change, but about limiting global warming to a level that is tolerable for humans and the earth's carrying capacity.

We have already passed 350 ppm, the level of long-term stabilization, and it would require an annual reduction of 1 Gt of carbon emissions globally over the next 50 years to reach this level again (Hausemann, 2006). Ideally we should have stabilized CO<sub>2</sub> concentrations at 450 ppm by 2050, but this would require a global CO<sub>2</sub> emissions reduction of over 7 per cent annually, and this is believed to be unrealistic. A more realistic scenario is to temporarily overshoot this target, by allowing greenhouse gases to reach 550 ppm (with an average global warming of 2°C by 2100), and then reduce this over a period of at least a century. But even this scenario would require more than a 3 per cent annual decrease in CO<sub>2</sub> emissions. It should also be stressed that the overshooting pathway involves many uncertainties and greater risks.

A global annual reduction of 3 per cent may not sound much, but if population growth and equal distribution of resources are taken into account, it becomes clear that these reductions will become significant for all, especially the industrialized countries (Hausemann, 2006, and Stern *and others*, 2006), as shown in figure 2.

Figure 2 Annual CO<sub>2</sub> emissions per capita for different regions today and in 2050, with CO<sub>2</sub> stabilization at 550 ppm and emissions distributed evenly



Source: Hausemann 2006.

Table 1 shows the expected link between greenhouse gas concentrations and global warming. Table 2 shows the effect of global warming on several indicators.

Table 1 Greenhouse gas concentration and corresponding global warming

Stabilisation level (ppm CO <sub>2</sub> equivalent)	Temperature increase at equilibrium relative to pre-industrial (°C)		
	IPCC TAR 2001 (Wigley and Raper)	Hadley Centre Ensemble	Eleven Studies
400	0.8 – 2.4	1.3 – 2.8	0.6 – 4.9
450	1.0 – 3.1	1.7 – 3.7	0.8 – 6.4
500	1.3 – 3.8	2.0 – 4.5	1.0 – 7.9
550	1.5 – 4.4	2.4 – 5.3	1.2 – 9.1
650	1.8 – 5.5	2.9 – 6.6	1.5 – 11.4
750	2.2 – 6.4	3.4 – 7.7	1.7 – 13.3
1000	2.8 – 8.3	4.4 – 9.9	2.2 – 17.1

Source: Stern and others, 2006.

Table 2 Expected effects of global warming

Temp rise (°C)	Water	Food	Health	Land	Environment	Abrupt and Large-Scale Impacts
1°C	Small glaciers in the Andes disappear completely, threatening water supplies for 50 million people	Modest increases in cereal yields in temperate regions	At least 300,000 people each year die from climate-related diseases (predominantly diarrhea, malaria, and malnutrition)  Reduction in winter mortality in higher latitudes (Northern Europe, the United States)	Permafrost thawing damages buildings and roads in parts of Canada and Russia	At least 10 per cent of land species facing extinction (according to estimates)  80 per cent bleaching of coral reefs, including Great Barrier Reef	Atlantic Thermohaline Circulation starts to weaken
2°C	Potentially 20-30 per cent decreases in water availability in some vulnerable regions, e.g. Southern Africa and Mediterranean	Sharp declines in crop yield in tropical regions (5-10 per cent in Africa)	40-60 million more people exposed to malaria in Africa	Up to 10 million more people affected by coastal flooding each year	15-40 per cent of species facing extinction (according to estimates)  High risk of extinction of Arctic species, including polar bear and caribou	Potential for Greenland Ice Sheet to begin melting irreversibly, accelerating sea level rise and committing world to an eventual 7m sea level rise  Rising risk of abrupt changes to atmospheric circulations, e.g. the monsoon
3°C	In Southern Europe, serious droughts occur once every 10 years  1-4 billion more people suffer water shortages, while 1-5 billion gain water, which may increase flood risk	150-550 additional millions at risk of hunger (if carbon fertilization weak)  Agricultural yields in higher latitudes likely to peak	1-3 million more people die from malnutrition (if carbon fertilization weak)	1-170 million more people affected by coastal flooding each year	20-50 per cent of species facing extinction (according to estimates), including 25-60 per cent mammals, 30-40 per cent birds, and 15-70 per cent butterflies in South Africa	Rising risk of collapse of West Antarctic Ice Sheet  Rising risk of collapse of Atlantic Thermohaline Circulation
4°C	Potentially 30-50 per cent decrease in water availability in Southern Africa and Mediterranean	Agricultural yields decline by 15-35 per cent in Africa, and entire regions out of production (e.g. parts of Australia)	Up to 80 million more people exposed to malaria in Africa	7-300 million more people affected by coastal flooding each year	Onset of Amazon forest collapse (some models only)  Loss of around half Arctic tundra	
5°C	Possible disappearance of large glaciers in Himalayas, affected one-quarter of China's population and hundreds of millions in India	Continued increase in ocean acidity seriously disrupting marine ecosystems and possibly fish stocks		Sea level rise threatens small islands, low-lying coastal areas (Florida) and major world cities such as New York, London, and Tokyo	Around half of all the world's nature reserves cannot fulfill objectives	
More than 5°C	The latest science suggests that the Earth's average temperature will rise by even more than 5 or 6°C if emissions continue to grow and positive feedbacks amplify the warming effect of greenhouse gases (e.g. release of carbon dioxide from soils or methane from permafrost). This level of global temperature rise would be equivalent to the amount of warming that occurred between the last age and today – and is likely to lead to major disruption and large-scale movement of population. Such "socially contingent" effects could be catastrophic, but are currently very hard to capture with current models as temperatures would be so far outside human experience.					

Note: This table shows illustrative impacts at different degrees of warming. Some of the uncertainty is captured in the ranges shown, but there will be additional uncertainties about the exact size of impacts. Temperatures represent increases relative to pre-industrial levels. At each temperature, the impacts are expressed for a 1°C band around the central temperature, e.g. 1°C represents the range of 0.5–1.5°C etc. Numbers of people affected at different temperatures assume population and GDP scenarios for the 2080s from the Intergovernmental Panel on Climate Change (IPCC). Figures generally assume adaptation at the level of an individual or firm, but not economy-wide adaptation due to policy intervention.

Source: Stern and others, 2006.



### 2.3 Limits to growth and available resources

The limits to growth (Meadows *and others*, 1972) do affect sustainable infrastructure directly and indirectly in several ways. First, there is the availability of land for infrastructure development, both with respect to agricultural use, but also due to changed precipitation and snow/glaciers melting, and thus changed flooding patterns. Second is the availability of construction materials, both renewable and non-renewable. Third is the availability of renewable energy, mainly production of bio-fuels and hydroelectric power, which both need considerable areas. Fourth is the waste handling capacity of the environment. And last, the land that is needed to replace areas lost or made less efficient for the needs mentioned above.

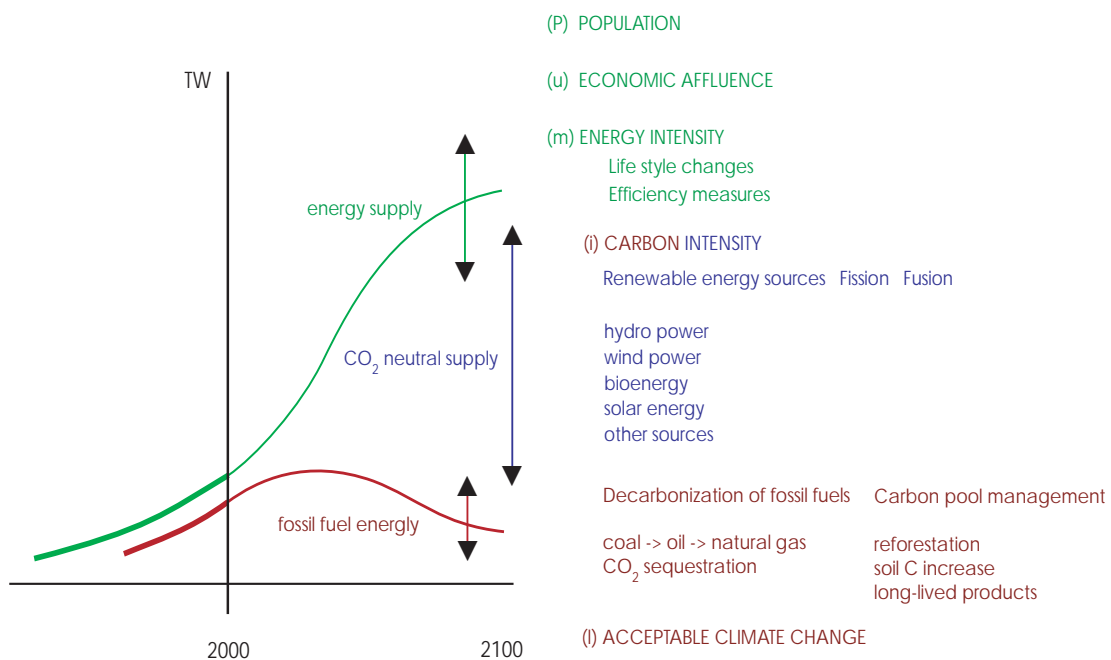
All of these issues define the action space for sustainable infrastructure development. If we are going to progress, these issues should be handled in an effective way. Thus, not only must we emit fewer greenhouse gases, we should also pay attention to land use, material consumption, energy consumption, and waste production. Industrial ecology and eco-efficiency are a promising framework for future infrastructure development.

The need for immediate action is obvious, if we combine the expected population growth with the current carbon dependency for energy production, given by the Kaya identity (Hoffert *and others*, 1988):

$$CO_2 = \frac{CO_2}{Energy} * \frac{Energy}{GDP} * \frac{GDP}{capita} * Population$$

If we limit ourselves to a stabilization level at 550 ppm in 2050 (see figure 2), this means that there is a huge gap between the current energy supply and future demand, which has to be filled by new renewable energy in the years to come.

Figure 3 The energy gap between projected energy demand and sources of energy



Source: Karlsson and Holmberg, 2006.

### 3. DOING MORE WITH LESS

The pathway to sustainability is thus about doing more with less, also called “dematerialization” or “factor X reduction” (von Weizsäcker *and others*, 1997). This concept is not radical considering that a factor 4 (and better) is achievable if the best available technology were implemented today. This is also the message of several reports commissioned for various governments (NOU, 2006: 18; Person *and others*, 2006; Stern *and others*, 2006), where the key message is: “Start implementing best available technologies in all new construction, renovation, and maintenance projects. If this implementation starts today, the results will be better and the costs will be tolerable.”

But such a system requires a new holistic way of thinking. Industrial Ecology is a promising holistic framework for sustainability, where the basic idea is that solar powered (direct and indirect) energy cascades through the techno-sphere and materials are kept as much as possible in closed loops through recycling and reuse, and therefore waste is minimized. Material Flow Analysis (MFA), Substance Flow Analysis (SFA), and Life Cycle Analysis (LCA) are key analytical tools within this framework. Eco-Efficiency is an often-used and powerful benchmarking tool, which if used correctly can function as a progress indicator.

#### 3.1 Material Flow Analysis (MFA), Substance Flow Analysis (SFA), and Life Cycle Analysis (LCA)

MFA and SFA are key analytical tools that measure sustainability. The core principle of MFA and SFA is the mass balance principle, derived from the laws of mass conservation (Bringezu, 2000; Bringezu and Moriguchi, 2002; and van der Voet, 2002; Brunner and Rechberger, 2004), which basically says that materials cannot appear or disappear, but rather only change state or form. A material (or substance) flow analysis thus studies how a material (or substance) flows through a system, using a three-step procedure (van der Voet, 2002):

- a) Definition of the system;
- b) Quantification of the overview of stocks and flows; and
- c) Interpretation of the results.

The fact that an MFA (or SFA) can provide information about the material balance for a system makes it a very powerful tool for monitoring sustainable development. Also, if combined with impact assessment tools such as LCA, the total environmental impact and improvement in this regard can be monitored. Such progress can be expressed in terms of eco-efficiency, a powerful way of benchmarking and communicating resource efficiency and environmental progress.

#### 3.2 Eco-efficiency

Eco-efficiency (E/E) was put forward in 1989 by Sturm and Shaltegger as a way of reporting environmental progress in production systems, and was later adopted by the Business Council for Sustainable Development (now the World Business Council for Sustainable Development, or WBCSD) prior to the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (BSCD, 1993).

An often-used definition of E/E today is “*the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle, to a level at least in the line with the earth’s carrying capacity*” (Keffer *and others*, 1999), and is reported as a fraction:

$$\text{Eco-efficiency} = \frac{\text{Added Value}}{\text{Environmental impact}}$$

The numerator and denominator can be expressed by many different indicators, both physical and monetary (UNCTAD, 2003). It is also worth mentioning that E/E can change dramatically due to monetary value changes, if a monetary reference value is not used.

Although E/E was developed for production systems, it has also been used for recycling systems (Huismann, 2003). Huismann's report on the eco-efficiency of WEEE recycling (Huismann, 2003), actually led to a change in the European Union directive for handling wastes from electrical and electronic equipment (The European Union 2003).

However, it is important to recognize the limitations of E/E as a benchmark and guiding tool for sustainability. That is, there are no physical limitations (limits to growth) to resource utilization within the E/E framework, which means that processes might be more eco-effective than before, at the same time as the sum of the processes are more unsustainable. Thus, for E/E to have any meaning on a regional or national level there must be a documented reduction in total environmental impact for the same region or nation.

#### 4. EUROPEAN EXPERIENCES

Europe has had a mixed experience with respect to development of sustainable infrastructure. On one side, there is the rapid increase in aviation; on the other side, there are strong incentives and investments in the railroad system, in order to move traffic from roads to rails. One target is that trains shall be the preferred mode of transport for all personal travel between cities for distances of less than 1,000 km (The European Union 2004b).

In housing, there are extreme variations across Europe, but all countries share the same development patterns of bigger residences and fewer people in each household. Thus domestic energy consumption per capita has been increasing. There is, however, no uniform trend in the environmental impact as a consequence of this increase, due to the many changes in energy carriers and distribution methods across Europe (Bohne *and others*, 2006). But from a sustainability point of view, domestic energy consumption is moving in the wrong direction.

In the energy sector, there are several initiatives to increase sustainability in the industry. First of all is the movement towards cleaner technologies, for example through upgrading existing power plants to more efficient, cleaner burning, and cleaner fuel. Many power plants have moved from coal to oil or gas.

But all of these initiatives are following an incremental path, which is not enough to make infrastructure sustainable within the timeframe and action space that 550 ppm CO<sub>2</sub>e allows for. Many initiatives have therefore been launched to end Europe's dependency on fossil fuel, and to promote more sustainable infrastructure and energy.

Europe is now moving towards the European Union's 7<sup>th</sup> Framework Programme, which sets the agenda on many issues, including infrastructure, for the years to come. The agenda is set through a process called "technology platforms". There are 27 such technology platforms, of which the four most relevant for infrastructure are:

- European Construction Technology Platform <http://www.ectp.org/>
- European Rail Research Advisory Council <http://www.errac.org/>
- European Road Transport Research Advisory Council <http://www.ertrac.org/>
- European Water Supply and Sanitation Technology Platform <http://www.wsstp.org/>

In parallel with the technology platforms, there have been many projects on the reduction of fossil fuel dependency (NOU, 2006: 18, and Person and others, 2006), more efficient transport and communications (Trendsetter, 2006; The European Union, 2005; and The European Union, 2004b), new renewable energy (The European Union, 2004a; The European Union, 2004b; The European Union, 2005; and Person and others, 2006), as well as new and improved standardization of infrastructure that indirectly improves energy efficiency (i.e. the upcoming the European Union building code).

Common to all of the reports on these projects are several generic conclusions:

- Investments in research and development of new and more sustainable solutions are expected to pay off in terms of the following:
  - Return of investments;
  - These new industries will create more and more interesting jobs;
  - Improved health to the population; and
  - Improved environment, both locally and globally.
- It is possible to respond to the climate challenge, but urgent actions are needed.
- Those countries that are able to act rapidly towards more sustainable infrastructure and industries will be the economic and industry leaders of tomorrow.

Of the more progressive projects are Sweden's goal of being "fossil-free" by 2020 (Person *and others*, 2006), by substitution with bio-fuel and other renewable energy, and Norway's project with a zero-emission gas-powered power plant by 2014, where exhaust CO<sub>2</sub> will be captured and used for pressure support in oil drilling offshore in the North Sea and thus enhance oil production.

There are also several policy measures implemented to drive development in the desired direction. In Sweden it is compulsory for all gas stations above a certain size to distribute E85, a mix of 85 per cent bio-ethanol and 15 per cent gasoline. The Norwegian government is subsidizing heat pumps, wood-pellet boilers, and electric heat control systems (for electric panel ovens), in order to reduce electricity consumption in Norway (Enova, 2006). From 1 January 2007, the Norwegian government now takes into account the amount of CO<sub>2</sub> emissions when calculating the tax on new cars. This change has lowered the price for small -to medium- sized cars and increased the price for large cars and SUVs. Similarly, the price was increase for petrol-driven cars and reduced for diesel-driven cars due to their fuel (CO<sub>2</sub>) to power ratio. This is shift in technology is however debated, since diesel driven car has a much higher NO<sub>x</sub> and particle content of their exhaust, and a demand for diesel particulate filter for diesel driven cars is investigated. However, the global problem of green house gas emissions is given priority over the local air pollution problems caused by NO<sub>x</sub> with this policy action.

#### 4.1 Policy options

In general there are four possible policy options with respect to the implementation of a desired development:

- Command and control
- Taxation
- Subsidies
- Education and research

Thus most policy options will be introduced with force from the governments, which in this case are new laws and regulations. These are of structural character, and therefore fit well into Giddens “structuration theory” (Giddens, 1981 and 1984):

*“All interaction involves the use of power, because all interaction is concerned with the production and reproduction of structure, drawing on rules and resources. Power relates to those resources which actors draw upon in interactions, in making a difference, i.e. structure is rules and regulations.”* (Giddens, 1981)

Many of these structures, laws, and regulations, are well known and understood. But there are also examples of less known and used regulations that could favor sustainable development. One of these is how the discount rate is set and used in present value calculations. For example, there is a huge difference between a discount rate of 7 per cent and 3 per cent over 21 years. That is, from a sustainability perspective, the more value one puts on the future, the lower the discount rate should be set. The regulations and specification of interest rates used in present value calculations should therefore be investigated as a policy tool for promoting investments into sustainable infrastructure.

According to the *Stern Review* (Stern and others, 2006), climate change is the greatest example of market failure ever seen, and immediate policy actions must be taken to reverse this development. This requires international cooperation and determination to solve these problems on a scale not seen since World War II. Also, there is a need for better coordination between policies in order to promote sustainable development. In order to succeed, policies should follow the set of conditions for successful policy achievements, as set forth by Sabatier and Mazmanian (1979):

- 1) The programme should be based on a sound theory relating to changes in target group behavior to the desired objectives.
- 2) The statute (or other basic policy decisions) contains unambiguous policy directives and structures to maximize the likelihood that target groups will perform as desired.
- 3) The administrators implementing the legislation possess substantial managerial and political skills, and are committed to statutory goals. From the first condition, it follows that they are given satisfactory information regarding the subject.
- 4) The programme is actively supported by organized (constituency) groups and key (legislators) managers throughout the implementation process.
- 5) The relative priority of legal objectives is not undermined over time by conflicting public policies or by changes in relative socio-economic conditions that limit the statute’s purposes or political support.

## 5. CONCLUSION

There is an overwhelming amount of scientific evidence of climate change, and there is only a limited period of time (until 2050) to change our behavior in such a way that our actions become sustainable. It seems that 550 ppm CO<sub>2</sub>e is the critical threshold value that should not be crossed, and this value thus defines the limits to our action space with regard to the use of fossil fuels as energy sources.

Infrastructure is an important part of the system, and sustainable infrastructure holds the key to sustainable development. The costs of meeting the climate challenge is tolerable if immediate action is taken; that is, if we are implementing best available technology from now on, in every new construction, repair, and maintenance project. For transportation, there is a need to move towards “fossil free” modes of transport, and focus should therefore be on developing rail and light rail solutions for urban transport and medium-range transport distances (less than 1,000 km).

Until recently, economic growth has been in direct proportion to the available work output (“exergy”) from energy (read: the use of fossil fuel) (Ayres, 2002). Given the consequences of environmental issues (global warming as the most urgent problem), it is evident that only those that succeed in decoupling production from the extraction and use of non-renewable resources will be able to have continuous economic growth in the future.

Thus, those who are successful in developing sustainable infrastructure will most likely be the economic leaders of tomorrow. This also opens a window of opportunities to those countries that are in a developing mode, where there are fewer sunk costs and lock-ins in existing infrastructure and modes of transport.

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# Revival of rainwater harvesting and management in Asia and the Pacific

*Mooyoung Han*

*Professor*

*Rainwater Research Center, Seoul National University*

*Republic of Korea*

## 1. INTRODUCTION

Most of the world's water problems occur because of uneven distribution of rainfall in terms of time and space. Countries in the Asia-Pacific region experience flooding after severe droughts each year. We are expecting more difficulty in the future because of climate change, which is expected to alter the distribution of rainfall. Existing infrastructure, such as storm water sewerage and river bank flood controls, may not be capable of containing the increased rainwater runoff, resulting in flooding. Drought may cause changes to the pattern of human activities and financial commitments that depend on the current climate. Many of these problems can be solved by proper management of rainwater.

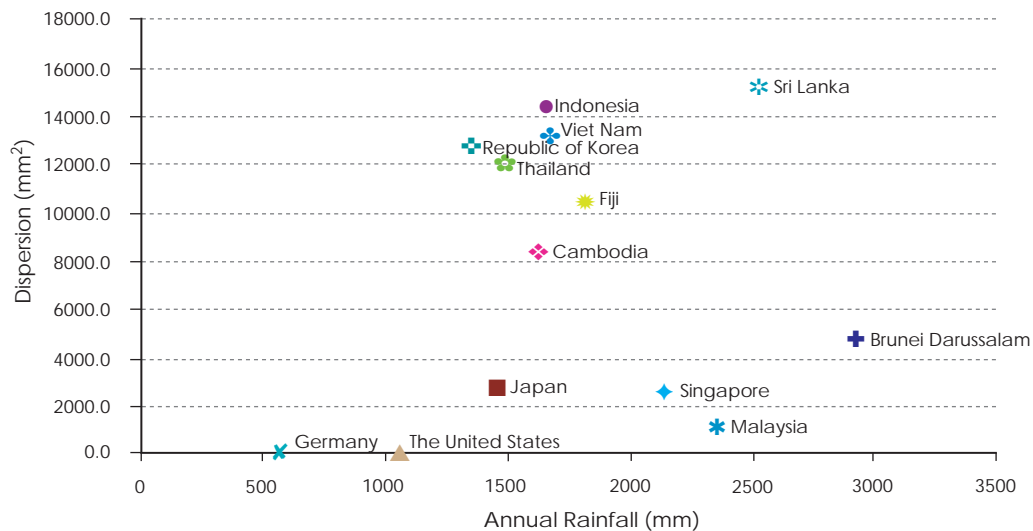
Water problems are very site specific, because they are influenced by rainfall patterns, geological and geographical conditions, as well as the population and their traditions and culture. Therefore a solution at one site may not be necessarily adaptable to other sites. Instead, the solution can be best found from the people who have lived sustainably in the same place, have overcome all the natural difficulties and abnormal weather conditions, and have melded all the experiences and knowledge into their traditions and culture.

In order to solve water problems in one country, we have to examine the history, traditions, and wisdom from that country, before taking knowledge from other countries. Although advanced technologies may help to overcome the problems, they can sometimes fail because the basic conditions and assumptions may be based in an underestimation of the severity of water problems.

For example, figure 1 shows the average amount and dispersion of annual rainfall in selected Asia-Pacific, European, and North American countries. Most Asia-Pacific countries have higher annual rainfall, but the dispersion is higher than in most developed countries. That means the water management in these areas is more difficult and explains the severe damage occurring in this region each year. We have to be very careful in adapting the technologies and management skills developed from other countries.



Figure 1 Average annual rainfall and dispersion for selected countries and areas



In this paper, the history of rainwater management practices in Asia-Pacific countries is introduced, with a focus on examples from Korea describing traditional practices and the current shift of rainwater management paradigm. The further research areas and actions needed in the Asia-Pacific region are discussed. Finally, the paper presents suggestions for building a regional network to promote rainwater harvesting.

## 2. THE HISTORY OF RAINWATER MANAGEMENT IN KOREA

In the history of the Gochosun Kingdom, which was founded in 2333 BC, the importance of rainwater management is well described. Dangun Wanggeom, the first King of Gochosun, ruled the country with his three teachers, who were masters of rain, wind, and clouds. The master of rain, named “Woosa”, must have been a very well-practiced expert in rainwater management. The ruling philosophy was “to benefit every party”, which might mean that people living upstream should take heed of the needs of people and the environment downstream. This is nowadays called a win-win strategy.

During the later Baekje Dynasty, several reservoirs were constructed. One of these is Byeokgoljae, constructed in 330 AD, which had a bank length of 3.3 km, a height of 5.7 m, and a reservoir area of 10,000 ha. The construction technology was transferred to old Japan, where a similar structure remains in operation.

In 1441, during the Chosun dynasty, the world’s first rainwater gauge, named “Chuk-u-gi”, was invented by King Sejong the Great. It consisted of a stone foundation, a water column, and a stick to measure the depth of the rainfall. From then, and until 1907, a nationwide rain gauge network was developed, which gathered rainfall data from local offices. Although some parts of this network have been destroyed, some 250 years of rainfall records still remain, which is the most important source of data to assist in understanding the long-term patterns of climate change.

Also during the Chosun dynasty, a special agency, Je-Eon-Sa, was organized by the central government with the mission to build and maintain reservoirs. As a result, around 18,000 small man-made lakes remain in each part of the country, mitigating floods and droughts and adding to the biodiversity of our eco-friendly nation.

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Figure 2 The world's first rain gauge

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Note: The rain gauge was developed in 1441 by King Sejong the Great. It was distributed to local governments under the direct supervision of the king and has been used since then. Rainfall data thus measured was gathered through a nationwide network and records were kept for more than 250 years after its development.

### 3. NEW PARADIGM OF RAINWATER MANAGEMENT

Since Asia-Pacific countries have experienced the most severe weather conditions, which is expected to become even more severe because of climate change, a new paradigm in the management of rainwater is required. Although these paradigms are developed in the context of a monsoon area, similar concepts can be applied to other dry or wet areas, or those areas which are or will be suffering from abnormal weather conditions throughout the world. Eventually it will help countries to meet the Millennium Development Goals (MDGs), and the efficient use of water will require less energy and support sustainable infrastructure.

#### *Rainwater is the source of all water*

All of our water sources, surface water, and groundwater originate from rainwater. Direct collection and use of rainwater can not only save the energy required for water

treatment and transportation, but also increase safety factors against damage by flooding, water shortage, pollution, or fire. Rainwater harvesting should be considered the first option for water supply for existing and new water supply systems.

#### *Management by area (instead of by line)*

Changes in the permeability of the land surface induced by development or heavy rainfall due to climate change may greatly increase runoff. Current measures to deal with this have been at the nearest stream, and include rainwater pump stations, dams, and elevated dikes. These measures deal with runoff in a chain of structures (management by line). It may be better to create a number of detention ponds or storage facilities on a small scale over the entire area on which the rain falls. This would not only prevent flooding, but also reduce the effect of drought. The stored water can be used to create small lakes or wetlands for a better environment.

#### *Decentralized management (instead of centralized)*

Traditionally, water supply systems have been based on a centralized system, where water is taken from a dam, treated, and distributed on a large scale. Although there may be merit in such large-scale systems, they are significant users of energy for water treatment and transportation. Instead, a decentralized system coupled with proper management will reduce the costs and energy requirements. If we implement the RWH system at an existing large-scale water supply system, we will create a more flexible and secure water management structure.

#### *Source control (instead of end-of-pipe control)*

Raw water taken from a river may contain turbidity, pathogens, or soluble contaminants collected from the entire catchment. These need to be reduced by treatment, which requires additional energy and money. However, if we collect rainwater near where it has fallen, we can maintain good water quality with relatively little treatment. An additional benefit of reducing the volume of runoff by direct storage or ground infiltration is the reduced threat of flooding at a local level. After collection, the stored water can be used for various purposes near its required location.

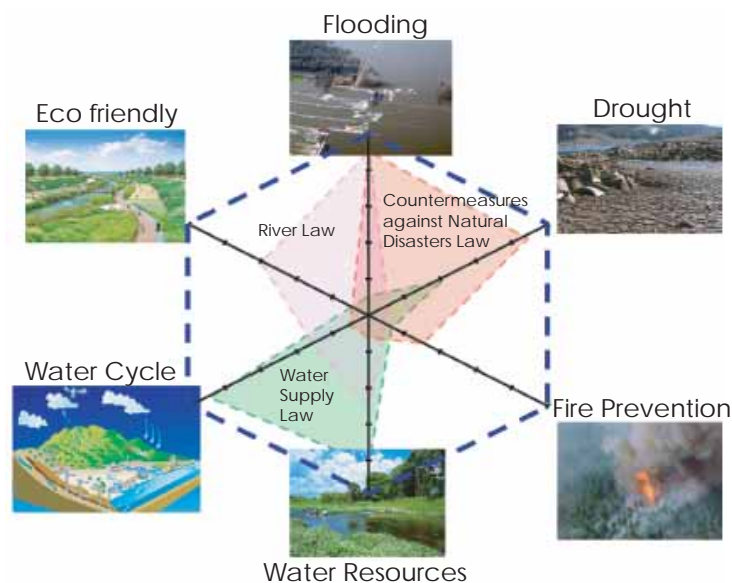
*Involvement of local action (instead of top-down policies)*

Rainwater harvesting involves many small-scale projects at the local level, instead of one large, remote project, and so involves a lot of stakeholders. Since the involvement and support of local people is very important, education and public awareness are crucial.

*Multi-purpose rainwater management (instead of single purpose)*

There are many water-related problems in the Republic of Korea, such as flooding, drought, water pollution, dry rivers, and mountain fires. These problems remain, possibly because in the past, each problem was dealt with separately. A number of individual ministries, each with its own interests and priorities, dealt with water problems. Solutions may sometimes be shortsighted and inefficient in national terms. The simple diagram shown in figure 3 illustrates this approach. Each law is shown conceptually. For example, the River Law shows that the major interest is flooding, with very little concern for drought. The Water Supply Law deals only with water resource management, with little emphasis on other major fields. An ideal management model would encompass all major issues.

Figure 3 Concept of multi-purpose rainwater management



#### 4. EXAMPLES OF A NEW PARADIGM OF RAINWATER MANAGEMENT IN THE REPUBLIC OF KOREA

Recently, there has been increasing interest within government, academic circles, and non-governmental organizations to promote the utilization of rainwater in the Republic of Korea. Some local governments, such as the Seoul Metropolitan Government (SMG), enforced an act to require installation of a rainwater utilization system for newly constructed buildings and also developed an incentive programme to promote rainwater utilization. Recently, rainwater management has been considered as an important measure to prevent natural disasters such as flooding and/or drought. Technical data and theories are being developed through the experience gained at several demonstration projects at schools and army bases.

The SMG has been plagued by repeated damage to the city by flooding, because the urban area is covered with impervious surfaces. As a remedy, SMG is now enforcing the first example of multi-purpose rainwater management.

#### 4.1 Seoul city rainwater management

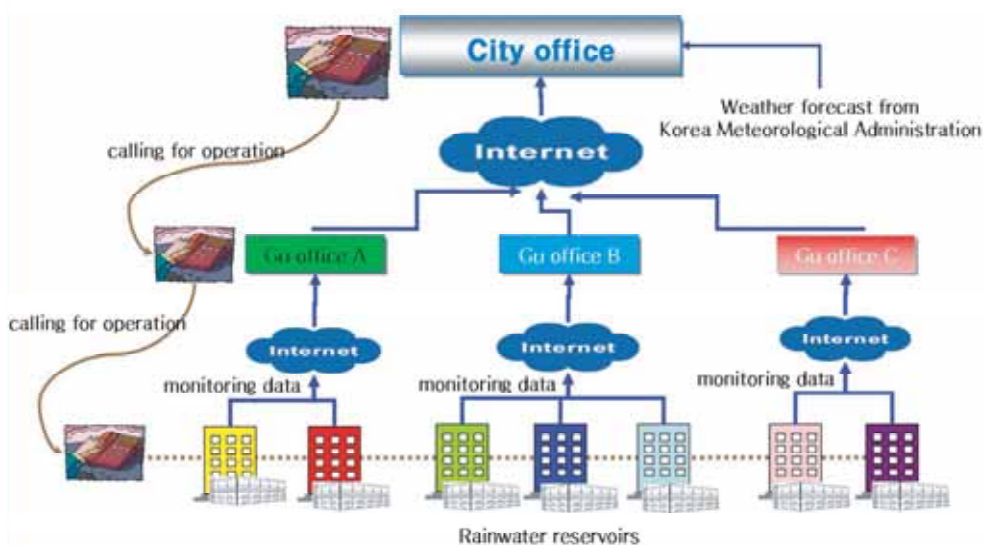
The city of Seoul announced a new regulation to enforce the installation of a rainwater harvesting system in December 2004. The main purpose is to mitigate urban flooding. The secondary purpose is to conserve water. This is expected to ensure the safety of the city and to improve the well-being of citizens as a result. Citizens are asked to cooperate by filling and emptying rainwater tanks according to directions from the disaster prevention agency.

A special feature of the new system is the provision of a network for monitoring the water levels in all water tanks at the central disaster prevention agency (figure 4). Depending on the expected rainfall, the central disaster prevention agency may issue an order to building owners to empty their rainwater tanks, either fully or partially. An incentive programme is planned for those who follow the order and some penalties for those who do not. After a storm event, the stored water can be used for firefighting and/or miscellaneous purposes such as toilet flushing and gardening.

The buildings included in the regulation are as follows:

- All public buildings: compulsory for new buildings and recommended to the extent possible for existing buildings.
- New public facilities such as parks, parking lots, and schools: to the extent possible.
- Private buildings: recommended for new buildings subject to building permission (floor area larger than 3,000 m<sup>2</sup>).
- Large development plans such as new town projects: installation of a rainwater management system as a first priority.

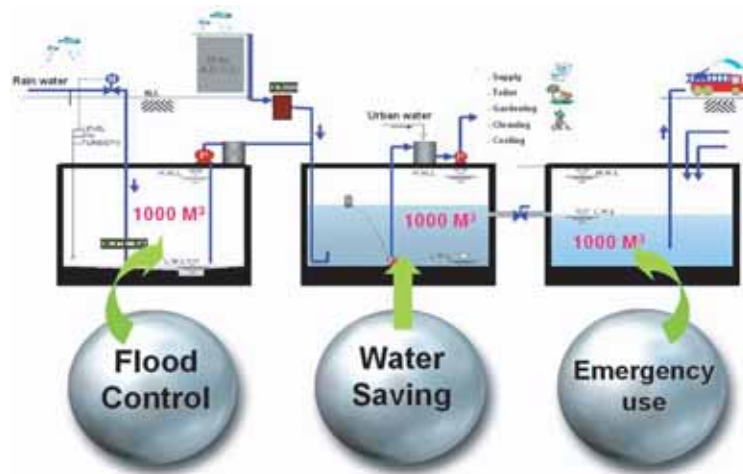
Figure 4 Diagram showing the monitoring of a multiple tank system for prevention of urban flooding and for water conservation



#### 4.2 Design of a multi-purpose rainwater tank in a building project

A specific rainwater system was designed for a recently constructed building (figure 5) at the Star City Project in Kwangjin-Gu, Seoul. A 3,000 m<sup>3</sup> rainwater tank was installed in the basement and divided into three sections of 1,000 m<sup>3</sup> each. The first section collects rainwater from the unpaved ground surfaces. It should be kept empty most of the time except when there is heavy rain. The second 1,000 m<sup>3</sup> section collects rainwater from the roof, which should be used for toilet flushing and landscaping purposes. The third 1,000 m<sup>3</sup> section should be filled with fresh water and used for supply during emergencies such as firefighting or accidents.

Figure 5 Example of multi-purpose rainwater tank design



#### 4.3 Examples of proactive rainwater management

The new paradigm is to manage the whole watershed on-site instead of managing the river after it has gathered all the rainwater in its watershed. Source control, or to manage the rainwater at the place it has fallen, has advantages with respect to water quality and quantity. However, contrary to the previous centralized management, it needs the understanding and cooperation of the people to implement the decentralized management. This requires proactive rainwater management, and has involved education of the public, school children, and the army. Some examples of education about rainwater harvesting and its promotion have been introduced. In addition, a strategic Rainwater Piggy Bank micro-credit project has been designed in order to promote rainwater harvesting at a household level.

##### *Education and public awareness*

In order to promote decentralized rainwater management, understanding the basis of the water problem by the populace and their active involvement is of the utmost importance. Education is important for both early schoolchildren and adults. About 50 schools in Kyounggi Province have installed a rainwater utilization system for the purpose of education about rainwater. More schools have become interested in environmental education and using rainwater harvesting as a part of an incentive programme to reduce their water consumption rates.

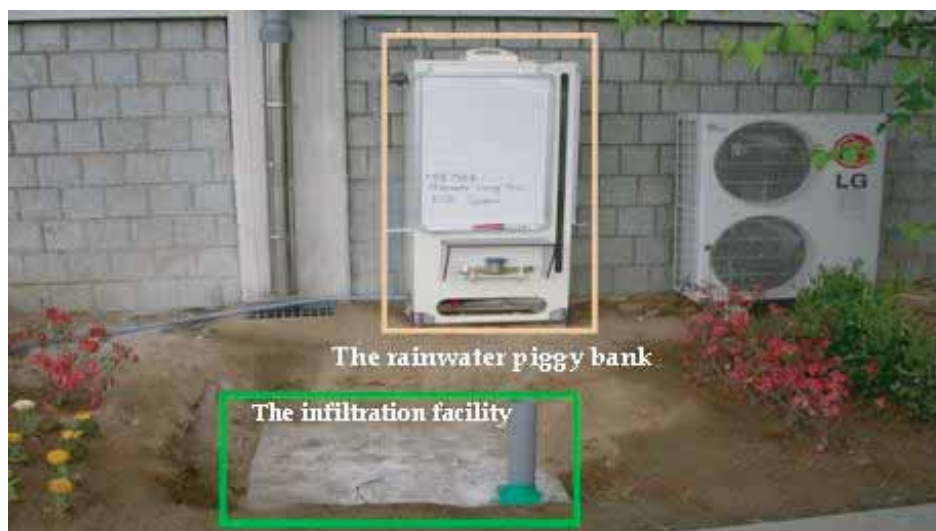
Some examples to raise public awareness about rainwater include the following:

- A new programme in the Ministry of Defense to teach soldiers about the importance of rainwater during their period of compulsory service is under preparation. This will enable us to teach half of the Korean adults about the importance of rainwater.
- The first rainwater museum opened at a middle school.
- Many people visit the rainwater center to see the rainwater systems developed on the campus of Seoul National University.
- Special programmes about the importance of rainwater are broadcast by SBS (Seoul Broadcasting System) on a regular basis.
- A worldwide network was formed through the International Water Association (IWA).

#### *Rainwater piggy bank micro-credit project*

A special rainwater promotion programme is in progress to promote rainwater systems at the household level in Seoul City. The system consists of a downpipe rainwater filter, a 400–1,000 liters rainwater tank (the “piggy bank”), a water meter, and an optional infiltration box (figure 6).

Figure 6 Rainwater system used for the rainwater piggy bank micro-credit project



This programme is financed by combining the money sources of government, industry, and the user. SMG passed a regulation so that they can financially support some part of the cost. As a combined effort with the government, a donor company, and the volunteer citizen, a special project has been designed. The SMG will donate 50 per cent of the installation cost, and the donor companies will pay 25 per cent. The remaining 25 per cent should be paid by the user, either in cash or by labour to install and maintain the rainwater system. The user will deposit the money that will be saved by using rainwater to the Rainwater Piggy Bank fund to help other people to install their own tank.

About 10 rainwater piggy banks have already been installed in the vicinity of Seoul National University as demonstration cases. It is hoped this will become widespread, with strong public involvement thanks to the novel financing process and also through donations.

## 5. FUTURE ACTIVITIES NEEDED

In order to promote rainwater harvesting with the suggested new paradigm, we need the following actions.

### 5.1 Research and technology development

Although rainwater harvesting has been used from the beginning of human history, little scientific and technical knowledge is available in terms of the design and operation of rainwater harvesting systems. First of all, we need to learn lessons from the past by investigating the old wisdom and philosophies from ancestors who survived in the Asia-Pacific region. In addition, parallel research on the following topics (as well as others) is needed:

- *Water quantity.* The design issue of how to collect, store, and treat rainwater requires a joint effort of architects or land planners and hydrology and hydraulic engineers.
- *Water quality.* It is important to maintain good quality of rainwater during collection and storage by appropriate treatment technologies. Health is an important concern when rainwater is used for drinking purposes. For the treatment of rainwater collected from different surfaces, such as roofs, roads, and fields, a low cost, low energy water treatment system is required.
- *Sewer system modeling.* Increasing the capacity of existing sewer systems becomes possible, with minor modification, by the installation of rainwater harvesting systems. These may prevent flooding due to the unexpected heavy rainfall events expected to be induced by climate change.
- *Background logic for decision makers.* A cost-benefit analysis to support decision makers in adapting the suggested new paradigm is required. Other water supply options, such as gray water systems, desalination systems, and the traditional centralized water supply system, should be compared using the same criteria. Implementation of a RWHM system is required to cope with increasing water demand and to increase the water independency ratio of a building or a city.

### 5.2 Information exchange

Despite the most severe weather conditions in the Asia-Pacific region, the wisdom and culture on how to survive has been proven throughout the millenniums. It is worthwhile to use the time-proven information that has been developed here in order to find possible solutions to many of the world's water problems.

Because there may be many different applications suited to different situations, exchange of information is extremely important. Thanks to the information technology that is available today, we can share the wisdom, knowledge, and experiences of case studies in a relatively easy way.

### 5.3 Education and public awareness

The most important and efficient way to solve the world's water problem is to teach the next generation when they are in school by including it in their courses. In Japan and the Republic of Korea, rainwater museums are open to students and the public, showing the importance of rainwater harvesting by displaying different technologies as well as cultures. The best way to inform the current generation is to use mass media, such as TV, newspapers, and the internet. For each special group, a unique education programme can be developed. For example, considering the compulsory army service for males in the Republic of Korea, an education programme on RWH in the army can easily

raise awareness of half of the Korean population. One of the most efficient ways of education is using DVDs, especially for the younger generation and general public.

#### 5.4 Regional networking

Networks for both experts and citizens in the Asia-Pacific region are suggested. The experts in the field of water resources management can cooperate in research, regulation, and technology development. For the citizens' network, a website is open to build up friendship and understanding among current and future generations. Through this network, people can share information about rainwater and rainwater culture and enjoy interacting with each other. Some interesting side events can be held, which include rainwater collecting contests, rainwater essays, drawing and photo contests, and other activities for discovering traditions and culture related to rainwater.

## 6. CONCLUSION

Water problems are site specific, so the solutions should be site specific, too. Therefore, the solution to the water problems in the Asia-Pacific region can best be found from the old wisdom and traditions accumulated in this region, incorporated with modern technology.

In order to meet the requirements of the MDGs, mitigate flooding and drought, and maintain sustainability during changing climate and energy crises, a new paradigm for rainwater management is suggested. The main concepts are to consider rainwater as the main source of water, to manage by area on a decentralized basis, to control water near its source, to involve local activists, to promote multi-purpose uses, and be proactive. With this new paradigm, various activities are required. These include the involvement of different stakeholders, research and development of technologies, developing a logical background and supporting materials for decision makers, education and public awareness, and constructing worldwide networks.

The vision of rainwater harvesting is to create a harmonized environment by properly and wisely utilizing rainwater, appreciating that it is a gift from heaven, as illustrated in figure 7. The upper part (the handle of the umbrella and the raindrops) signifies that the rain comes from heaven. The lower part represents the earth and nature. The middle part (the stem of the umbrella) represents the people (人), who connect heaven and earth. The overall meaning of this logo is the harmony and balance of heaven, earth, and people that can be achieved by proper use of rainwater, a gift from heaven.

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Figure 7 A logo to represent rainwater harvesting and its vision

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# Small water impounding project: A small eco-efficient infrastructure in the upland communities of the Philippines

*Samuel M. Contreras*

*Chief Agriculturist*

*Bureau of Soils and Water Management, Department of Agriculture*

*The Philippines*

## 1. INTRODUCTION

The Philippines has an average annual rainfall of 2,400 mm, which is adequate to meet the annual water demand for crop production. However, rainfall is not evenly distributed throughout the year in most parts of the country. This seasonal variation in rainfall, aside from the differences in geographical conditions, thus lead to the persisting problem of water being “too much or too little” in some parts of the country. The situation is aggravated by the continuous degradation of our critical watersheds. These once-healthy and biodiverse watersheds were subjected to degradation over the past several decades resulting in excessive runoff and flooding in the lowlands during rainy months and water deficits, particularly in the upland areas during dry months. Therefore, structures that could collect and store rainfall and run-off during its abundance are very crucial. These rainwater-harvesting structures (i.e., small water impounding projects, or SWIPs) could be constructed in the middle reaches of our watersheds where there are high potentials for development of such structures due to the predominantly rolling to hilly topography. The depressions and inland valleys in the upland areas could be explored and harnessed for reservoir development. Now that the agriculture sector considers upland areas as a potential food basket of the future, there is a need to put in place the necessary interventions to maintain its productivity and protect and preserve its resources. In general, these areas have marginal soil and water resources. Farmers lack the knowledge on appropriate soil and water conservation technologies, and in most cases they receive limited technical assistance and agricultural support services.

Rainwater harvesting through small water impounding projects (SWIPs) has long been implemented by the Department of Agriculture (DA) through the Bureau of Soils and Water Management. It could transform poor upland rural communities into more self-reliant and viable communities while harmonizing natural resources management and infrastructure development. More importantly, it also enhances the environmental services of agriculture in terms of flood mitigation, fostering groundwater recharge, and sediment capture. This paper seeks to provide a better understanding of the SWIP as an eco-efficient infrastructure in the uplands, the project description and the process of its development, the current implementation status, and future prospects.

## 2. PROJECT DESCRIPTION

### 2.1 General

The rainwater harvesting project is about more than providing irrigation to upland crops. The project facilitates multiple uses of stored water, which are as follows:

- For irrigation, domestic purposes, and livestock production in critical, less accessible upland areas;
- Strategic small-scale upland structure for flood prevention and control in high rainfall areas;
- Enhances and facilitates recharging of groundwater and spring sources for domestic and other uses; and
- Provides value-adding activities and environmental impacts such as recreation, and development of habitat for wildlife and biodiversity, respectively.

The project also strengthens the convergence of national agencies (e.g. Department of Agriculture, Department of Agrarian Reform, and the Department of Environment and Natural Resources) and the Local Government Units (LGUs) in the pursuit of rural development. SWIPs also support sustainable development as they satisfy human needs and maintain a healthy environment that could be enjoyed by future generations.

The Department of Agriculture (DA), through its Regional Field Units and the Bureau of Soils and Water Management (BSWM), implements SWIPs of not more than 15 meters in height. This is in line with the provisions of the Agriculture and Fishery Modernization Act of 1997 (AFMA) that sets the limits of structures that could be implemented by DA/BSWM. The costs of SWIPs range from about US\$1,200–3,000 (with an exchange rate of US\$1:PhP50) per hectare of service area, with an average of about US\$2,000 per hectare. With a structural height of 5–15 meters, the average storage capacity is about 0.30 million cubic meters (MCM). Figure 1 is a picture of typical SWIPs showing portions of the embankment, the reservoir, and the watershed, while figure 2 shows a part of the service area of the project.

### 2.2 Project structural components

Figure 3 shows the various structural components of a SWIP. As shown, a typical SWIP has several major structural facilities or components; namely, a dam and reservoir, outlet works, emergency spillway, irrigation distribution system, and access road. The functions of these components are interrelated in nature. The dam structure holds the collected water from the watershed while the reservoir is the water storage or pool created by the construction of the dam.

The outlet works (inlet structure) serve as the passage of water for release to the main canal. It consists of a gate valve, steel pipes, and a dissipator. The location of the control structure or the gate valve can either be the upstream side of the dam (i.e., with a mechanical or trickle spillway) or at the outlet of the steel pipe in the downstream side.

The emergency spillway serves as the safety valve of a SWIP as it releases excess water that cannot be stored in the reservoir. The design can be either a grassed spillway with lesser slope or gradient or a chute type concrete spillway consisting of an approach channel, a discharge channel (chute), and a hydraulic jump-type energy dissipator.

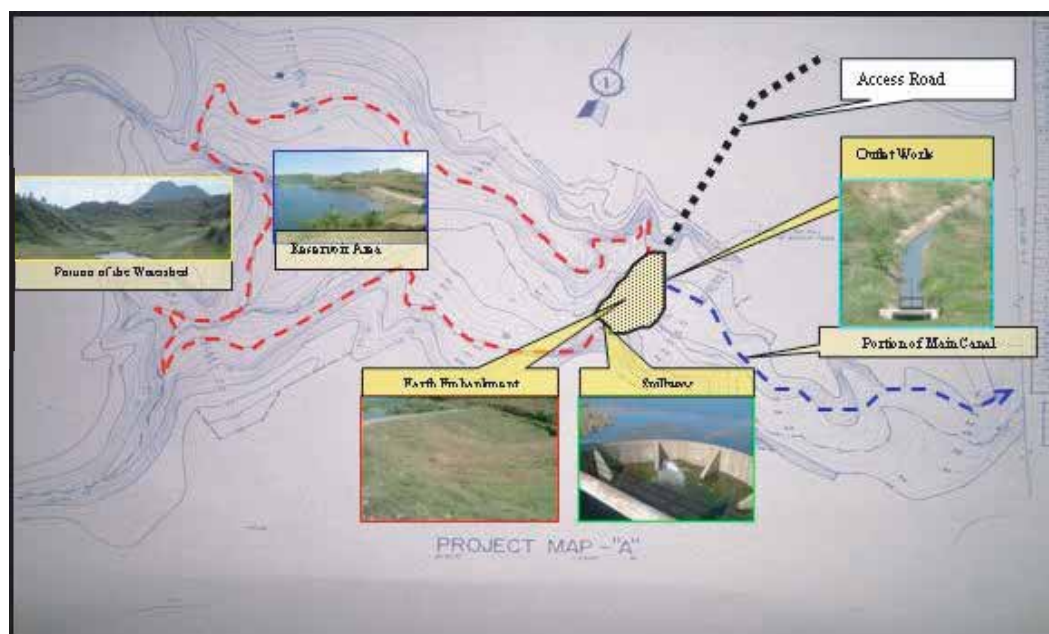
Figure 1 A SWIP constructed in Talugtug, Nueva Ecija, Philippines in 1999. It has a storage capacity of about 640,000 cubic meters and serves about 50 hectares



Figure 2 A portion of the service area (green part) of a SWIP and the surrounding higher uplands (brown dry area)



Figure 3 A typical SWIP development plan showing the various structural components and facilities.



The irrigation distribution system consists of canals and canal structures (e.g. division boxes, drops, crossings) for the efficient distribution of impounded water from the dam to the service area.

Accessibility of the project is facilitated through the provision of a gravel or earth-surfaced road stretching from the service area or nearest farm road to the dam embankment as shown in figure 3.

### 3. PROJECT DESIGN AND DEVELOPMENT

#### 3.1 Preliminary survey and investigation

Figure 4 outlines the different steps and activities in the development of SWIPs. Prior to the project planning and development, initial identification and selection of the proposed project site are undertaken. In most cases, farmers groups and LGUs initially identify proposed project sites. Afterwards, a reconnaissance survey and investigations of selected sites are carried out to confirm their suitability (i.e., based on the criteria for selecting project sites). An agro-economic survey, land use and soil survey and investigation, topographic mapping, and geologic investigation are undertaken to collect necessary data or inputs for the subsequent technical and financial/economic feasibility studies. Selected sites then undergo a series of studies as briefly discussed in the following subsections.

#### 3.2 Technical feasibility

- a) Water requirements (calculated through a field water balance study), reservoir inflow, and sedimentation studies are undertaken as baselines in the succeeding reservoir operation study. This operation study simulates reservoir runs for different extents of the service area by cropping period until a maximum area is attained (i.e., with respect to the design storage capacity) with minimum reservoir spill or shortage (BSWM, 1997);

- b) Flood yield study/analysis that indicates the expected design flood for a given return period and the results of the reservoir operation study are inputs into the flood routing analysis to determine the appropriate size of the spillway;
- c) Total water requirement (from field water balance study) and the result of the reservoir operation study are inputs into the design of outlet works and the irrigation system;
- d) The design of the main structure is based on the type of embankment materials available and the foundation geology;
- e) The final output is the project engineering design for the various project components and facilities that include the following: (1) main dam, (2) spillway, (3) outlet works, irrigation works, and access road; and
- f) The resulting project engineering plans and design are inputs into the preparation of project cost estimates and the programme of work.

### 3.3 Economic viability

- a) Irrigation/agricultural benefits from the project are derived based on agro-economic study and with reference to results of the reservoir operation study that shows the service area by cropping period; and
- b) A financial/economic study is undertaken based on the analysis of irrigation and agricultural benefits, agricultural production cost, estimated project cost, and operation and maintenance cost. Streams of benefits and costs are analyzed for the expected project life span (e.g., 25 years).

### 3.4 Social acceptability

Project acceptability is determined upon completion of the project engineering plans and design, which are presented to farmers, particularly the affected farmers. This is initially determined during the field investigation and socio-economic survey and is finally confirmed during the institutional ground working and consultation prior to project implementation.

### 3.5 Environmental impact assessment

An environmental impact assessment will form part of the overall feasibility study, which could support the application for the Environmental Clearance Certificate (ECC). The environmental impact assessment will highlight the SWIP functions as a soil and water conservation structure and its environmental services of facilitating the recharge of groundwater and spring sources. It is also an important flood mitigation structure that contributes in preventing floodwaters from inundating fertile bottomlands. More importantly, it stores and conserves rainwater that could be put into economic uses.

Figure 4 Activity flow chart for small water impounding project (SWIP) development

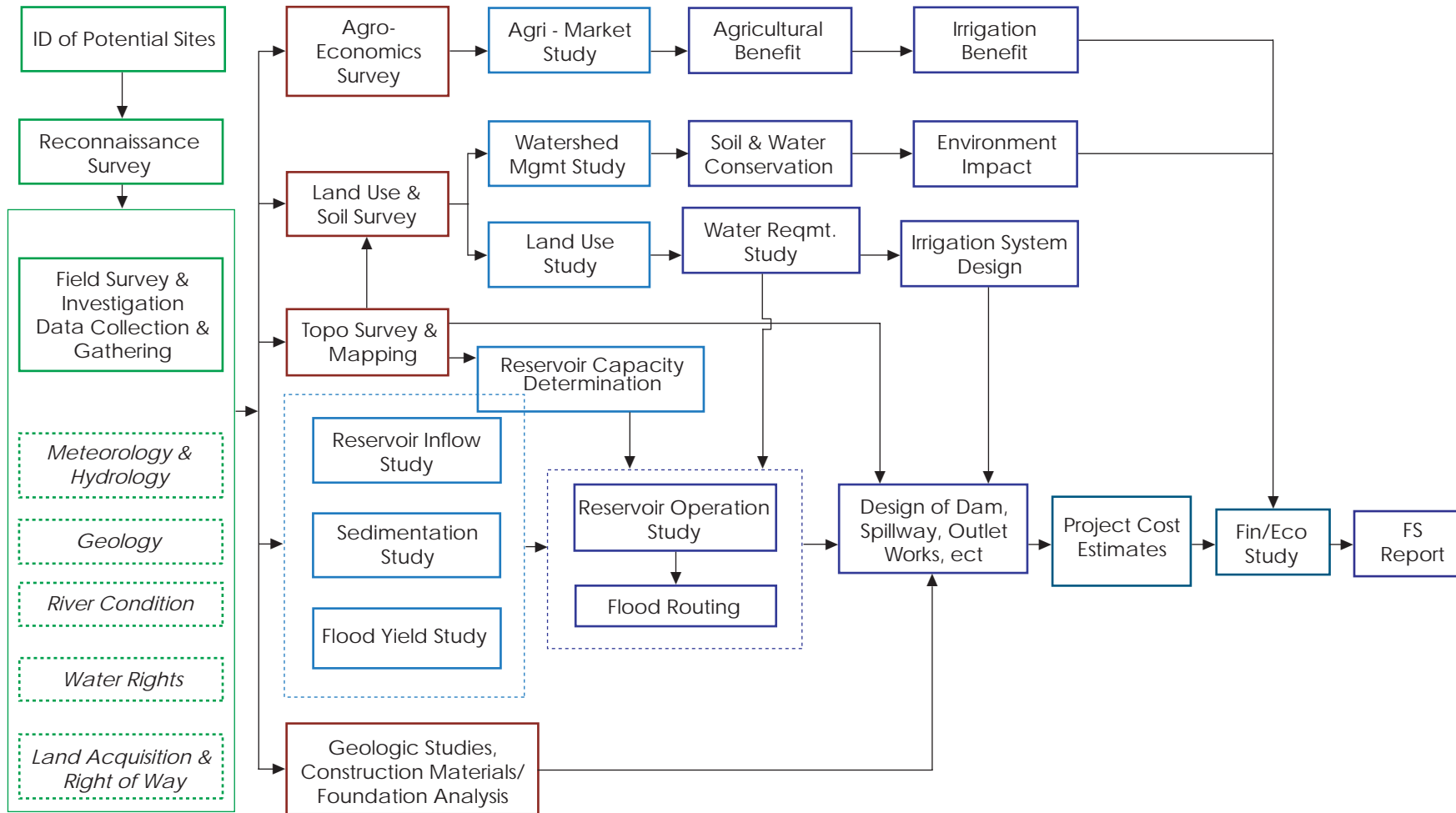
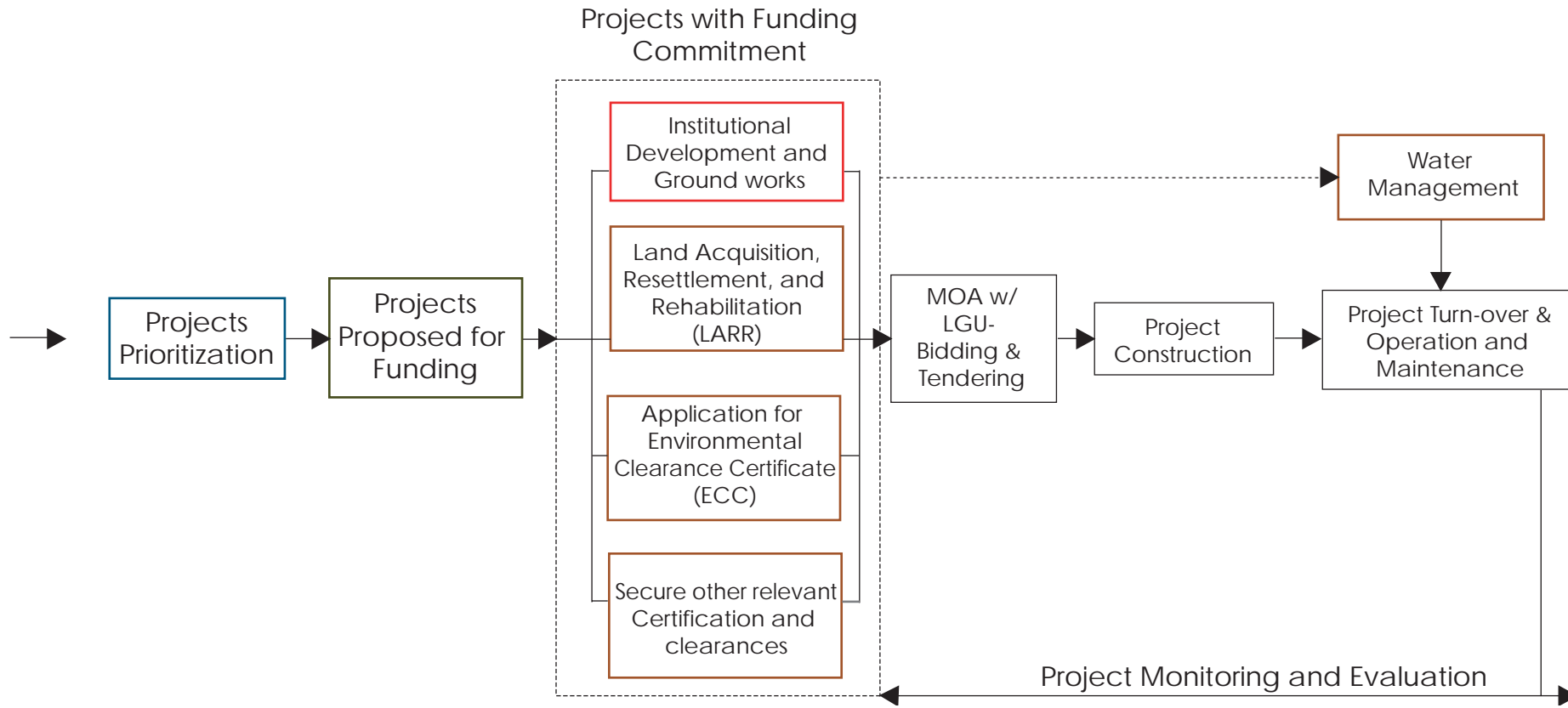


Figure 4 Activity flow chart for small water impounding project (SWIP) development (continued)





#### 4. SCHEME OF IMPLEMENTATION

SWIPs are funded through various projects and programmes of the government. Presently, they are implemented in partnership with the LGUs that have the technical capability to implement such types of projects. In most cases, LGUs provide counterpart funds, a scheme in which both the national government and local government share accountability to the project. The DA also provides technical trainings to LGU staff as part of its programme on capability building and the creation of an enabling environment at the local level. The LGU is responsible in the right-of-way negotiation with affected farmers and in the direct provision of agricultural support services to the project beneficiaries.

The DA, in collaboration with the LGU (through its Office of the Municipal Agriculturist), provides training to farmer-beneficiaries on the operation and maintenance of small water impounding systems. The farmer-beneficiaries are then organized into an association, which is duly responsible in the project operation and maintenance (O and M). In some cases, farmers provide labour, particularly in the construction of the canal and canal structures.

#### 5. STATUS OF IMPLEMENTATION

##### 5.1 Completed projects

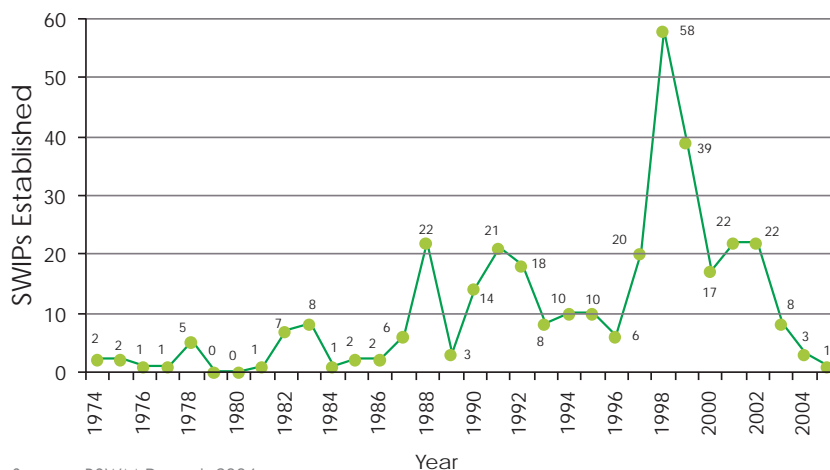
As of December 2005, there were 340 operational SWIPs implemented by the Department of Agriculture Regional Field Units and the Bureau of Soils and Water Management providing irrigation water to 18,200 hectares and benefiting 14,300 farmer-beneficiaries. Figure 5 presents the yearly distribution of SWIPs from 1974 to 2005, while figure 6 shows the regional distribution of SWIPs during the same period. As shown, the peak of implementation was achieved during the 1997-1998 period when SWIPs were considered one of the major interventions to mitigate the impact of El Niño during the period. In terms of regional distribution, Region 2 has the greatest number of projects implemented, followed by Regions 1 and 3. The number of projects seemed to be related to the type of climate that dominates a region. For instance, Region 2 is under a Type 3 climate, which is characterized by not-so-pronounced rainfall but is relatively dry from November to April. Regions 1 and 3 have very distinct wet and dry seasons. A Type 2 climate is characterized by no dry season with maximum rainfall from November to January, while Type 4 is characterized by rainfall more or less evenly distributed all throughout the year.

##### 5.2 On-going projects

As of October 2006, a total of 16 SWIPs are currently being established in four provinces of Region 2 through the DA-Regional Field Unit, related to the region's implementation of its Flood Mitigation Master Plan. Once completed, these projects can also generate a total service area of 1,233 ha that could be provided with supplemental irrigation. It is also being implemented through a Memorandum of Agreement with the LGUs, which provide counterpart funds in the implementation of the projects.

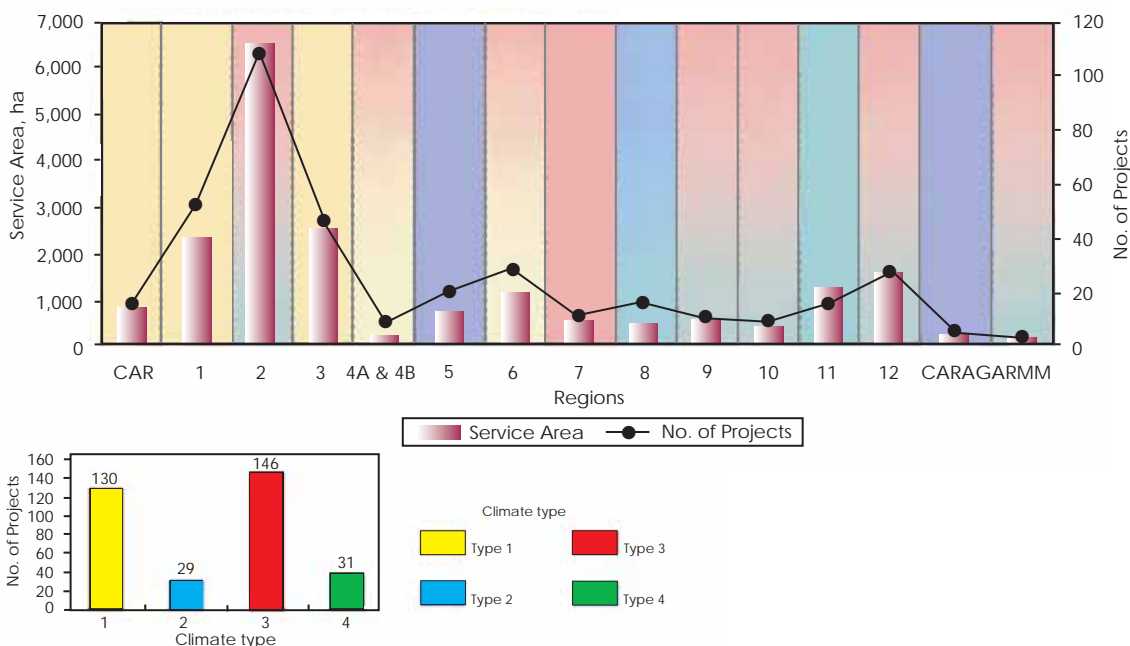
Under the Agrarian Reform Communities Development Project - Phase II, the BSWM has provided technical assistance to eight Agrarian Reform Communities (ARCs) in the preparation of feasibility studies for seven new water impounding projects and one project for repair and rehabilitation. Out of these proposed projects, seven projects were subjected to evaluation by the Sub-project Approval Committee (SAC), and all were approved for implementation. These projects are distributed in four regions, which could serve 570 ha in agrarian reform communities.

Figure 5 Distribution of SWIPs by year of establishment as of december 2005, Philippines



Source: BSWM Report, 2006.

Figure 6 Distribution of SWIPs by region and type of climate, Philippines



Source: BSWM Report, 2006.

## 6. GENERAL PERFORMANCE OF SWIPS

### 6.1 Project benefits and impacts

Within the context of BSWM’s mandate, SWIPs are primarily designed for soil and water conservation. The conserved water, however, can be used for supplemental irrigation, inland fish production, and to some extent for domestic purposes. The average service area of a SWIP is about 55 ha per project, benefiting 42 farmers per system. SWIPs increase the effective service area by almost 100 per cent (i.e., based on the service area both with and without the project). This means that SWIPs can increase the cropping intensity significantly through the utilization of the impounded water for supplemental irrigation. Monsalud *and others* (2003), during a study on SWIPs conducted in 2002 in Talugtog, Nueva Ecija, Philippines, identified the benefits at various levels that can be derived from a SWIP. These include:

*Farm level*

- Increase cropping intensity and yield per unit area;
- Facilitate growing of crops (e.g., vegetables, onion, garlic, tomato) other than rice;
- Integration of fish production and livestock raising; and
- Utilization of water in the reservoir for other purposes (e.g., cleaning farm animals, washing clothes).

*Community level*

- Fish production results in the availability of cheap fish for the community and additional income for the water users association and the local people;
- Labour demand increases through the increased cropping intensity and integration of fish culture;
- Area becomes destination of local tourist as swimming and picnic grounds;
- Facilitate construction of better roads and introduction of new techniques in farming by the LGUs; and
- Spirit of cooperation in the community put into practice.

The same study noted that a SWIP is important not only because it gives assurance for the availability of water during the dry season, but also contributes to the farmers' ability to cope with the impact of El Niño. In this respect, the farmers learned to make adjustments in farming practices and accept alternative strategies (e.g., alternate wetting and drying as a water saving technology, crop diversification) to avoid total crop failure.

## 6.2 Current problems and basic approaches to finding solutions

While benefits and impacts from SWIPs are fully recognized by the farmers, there are also situations in which projects performed below the expected level due to one or more of the following factors:

- Insufficient or reduced storage capacity due to silting of reservoirs, particularly old projects;
- Poor operation and maintenance of the system by the farmers association;
- Poor water management resulting in water wastage;
- Inactive farmers associations; and
- Deterioration of project structural components resulting in low system inefficiency.

The following general approaches should be undertaken to address the above issues and concerns:

- Undertake community-based watershed protection and management through
  - Provision of information to farmers to improve their awareness on the nature and value of watershed management to the life of the project (public education), and
  - Involvement of the farmers in the development and implementation of watershed management projects (public participation);
- Intensify farmers' training on project operation and maintenance (O and M) with parallel efforts on the review of an O and M manual, and monitoring and follow up of farmers association O and M activities;
- Strengthen LGUs' participation in the project implementation and institutional development activities;
- Provision of technical assistance and agricultural support to farmers; and
- Rehabilitation of some existing small water impounding systems to restore their system efficiency.

## 7. CONCLUSION: FUTURE DIRECTIONS FOR SMALL WATER IMPOUNDING PROJECTS

The growing concerns on water scarcity in the agriculture sector pose a major challenge among decision makers to put more focus on making this resource more available. In a tropical country setting such as the Philippines, abundant rainfall is considered as an available water resource for development, and yet it is not fully tapped due the seasonality of its occurrence. Ironically, during its abundance it could result in uncontrolled surface run-off that often causes erosion and flooding of low-lying areas. Rainwater harvesting through SWIPs can reduce the volume and force of run-off and subsequently its eroding power, thereby minimizing soil erosion and silting of fertile bottomlands. Rainwater harvesting simply means the collection and storage of rainwater and surface run-off for more productive applications (e.g., supplemental irrigation, water for livestock and domestic purposes, and inland fish production). It thus contributes to the improvement of water use efficiency within a basin, as unproductive losses and unstable run-off are reduced. It is also recognized as one of the strategies that could be adopted in the middle to upper reaches of the watershed to help mitigate floods downstream by reducing peak flood discharge from a specific watershed during the rainy season.

The project has long been established and yet it has not yet gained so much momentum in terms of putting a national policy on rainwater harvesting. This may involve policies prescribing the storage and management of rainwater in specific areas, for example, within a watershed by putting a number of small-scale detention ponds or reservoirs where the rain falls. Small-scale projects can be undertaken at the local level involving few stakeholders and which the LGU can easily handle. Hence, we ought to see the following future directions on rainwater water harvesting through SWIPs:

- Establishment of smaller scale projects that can be easily managed by farmers and that will ensure a more equitable sharing of limited resources;
- Incorporation of small-scale detention ponds or reservoirs as schemes of rainwater harvesting in a specific watershed to contribute in providing the water requirements within the watershed;
- Pursue more R and D efforts, particularly on water management and water quality protection; multiple water use and water use efficiency improvement; and on finding the most economical design for SWIPs;
- Intensify public awareness and education campaigns on the importance of rainwater harvesting;
- Strengthen local government unit participation in project development and project institutional development activities; and
- Encourage more participation of private sector in the promotion and implementation of the rainwater harvesting schemes.

Rainwater harvesting transforms rainwater into a more productive resource, rather than just allowing it to become an agent of soil erosion and flood. This initiative of utilizing rainwater should be continuously pursued in line with the government's efforts of ensuring food sufficiency, increased farm productivity and farm income, and employment generation to achieve sustainable agriculture and rural development while supporting environmental sustainability.

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# Sustainable urban design: Climate measures in transportation policies

Maki Nakamura  
*Ministry of the Environment*  
*Japan*

## 1. INTRODUCTION

Today global warming is a serious menace for human beings, and taking measures to control global warming is an urgent task for all countries.

In Japan, greenhouse gas (GHG) emissions are increasing despite various efforts that have been taken to reduce them. What is the cause? What do our efforts lack? The analysis on the recent trend of GHG emissions reveals that the increase in emissions is related to such phenomena as increases in automobile traffic and commercial floor area caused by urban sprawl.

Based on the analysis, this report shows that urban sprawl causes increases in GHG emissions and other social problems, and considers how future cities should realize a sustainable community.

## 2. CURRENT STATUS OF GHG EMISSIONS

First, let us look at the current status of Japan's GHG emissions (figure 1). Under the Kyoto Protocol adopted in 1997, Japan committed to reduce GHG emissions by 6 per cent compared to the base year of 1990 during the period of 2008 to 2012.

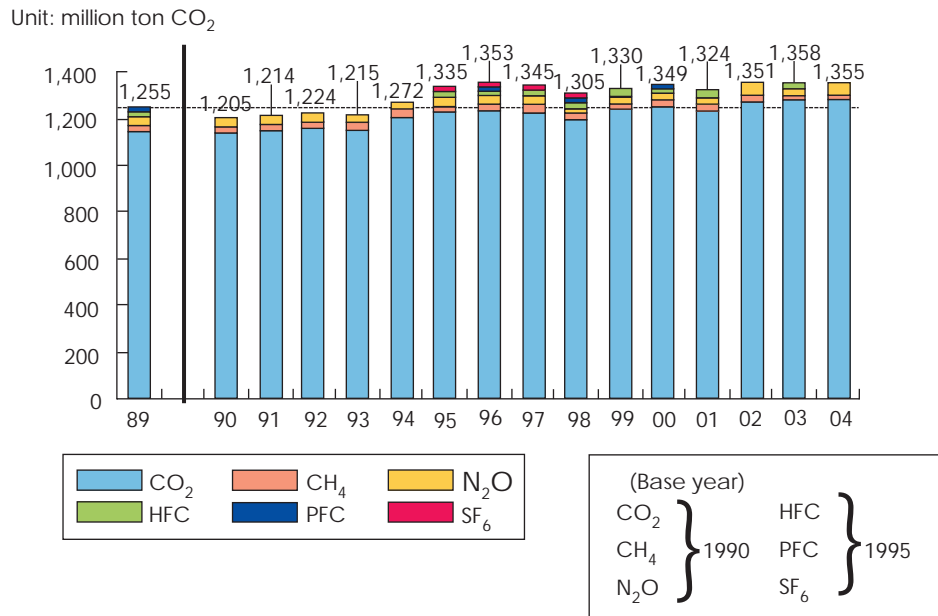
However, Japan's GHG emissions have been increasing, and total emissions in 2003 were 1,339 billion tons, an increase of 8.3 per cent compared to 1990. Out of this number, CO<sub>2</sub>, which totaled 1,279 billion tons, accounted for most of the GHGs.

Figure 2 shows CO<sub>2</sub> emissions by sector. We can see that CO<sub>2</sub> emissions in each section are increasing, except for the industrial sector. Although the industrial sector is the largest source of CO<sub>2</sub> emissions, its percentage contribution to CO<sub>2</sub> emissions is declining.

Let us look at the trend of CO<sub>2</sub> emissions from automobiles, which account for most of the total CO<sub>2</sub> emissions in the transportation sector (figure 3). The blue columns indicate total CO<sub>2</sub> emissions, showing mild increases. The line graph shows the ratio of change of CO<sub>2</sub> emissions by factors that affect the quantity of emissions. The blue line indicates the change ratio caused by traffic volume; red for fuel consumption; and purple for speed, respectively.

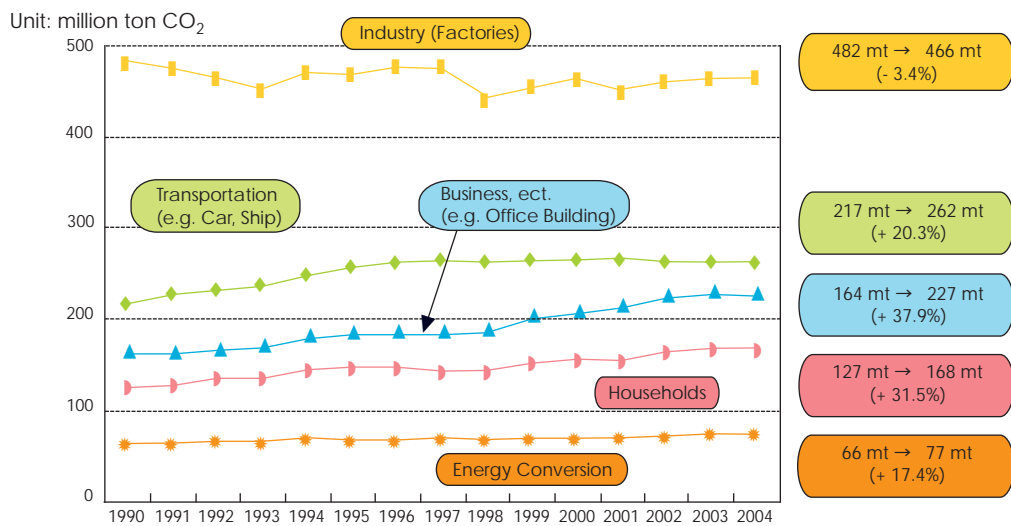
According to this chart, while CO<sub>2</sub> emissions from fuel consumption and speed decrease, the rise of traffic volume causes an increase in CO<sub>2</sub> emissions.

Figure 1 GHG emissions of Japan



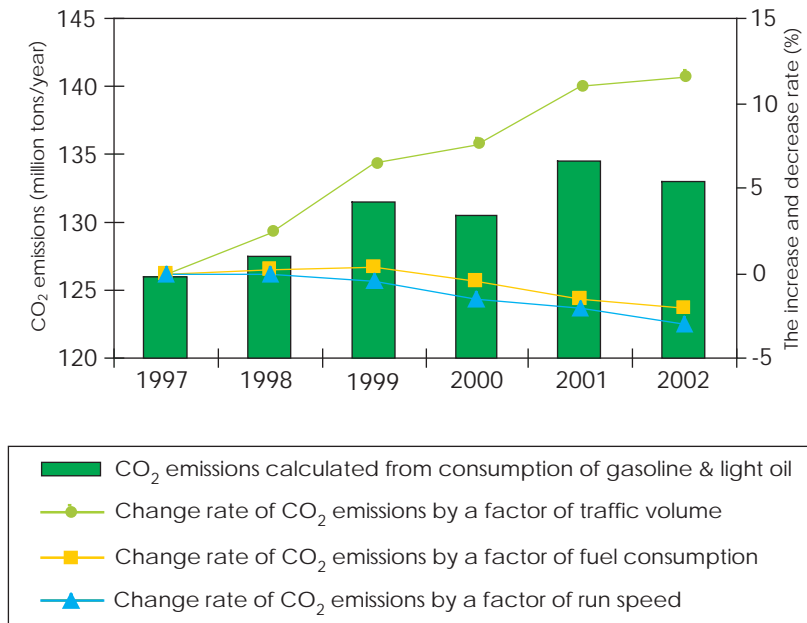
Source: Ministry of the Environment (MOE), Japan.

Figure 2 CO<sub>2</sub> emissions by sector



Source: MOE.

Figure 3 Trends in CO<sub>2</sub> emissions by various causes



Source: Ministry of Land, Infrastructure and Transport. "Report of the road policy meeting for preventing global warming" (in Japanese), 2005.

On the other hand, figure 4 and figure 5 show the current status of floor space and energy consumption in the business sector. The business sector has marked the highest increase rate of CO<sub>2</sub> emissions.

Figure 4. Change in floor area by sector

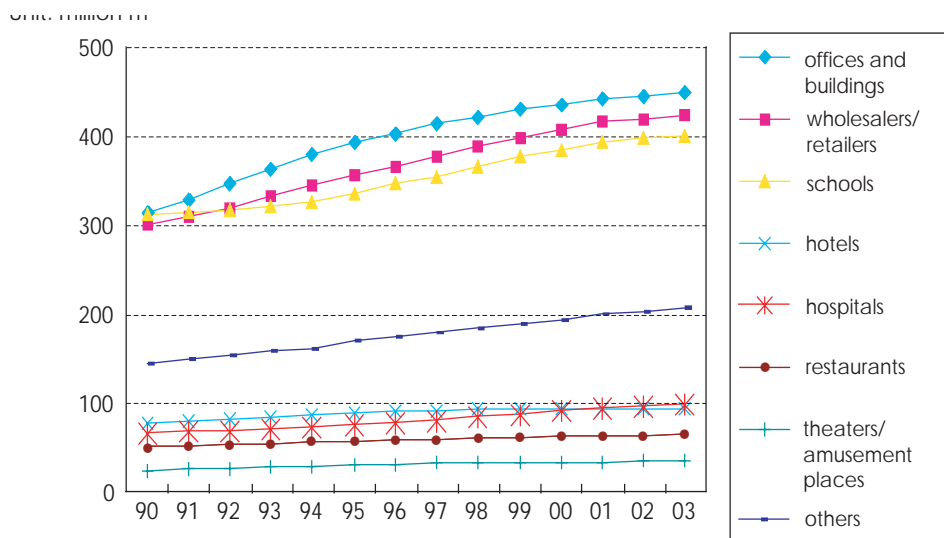
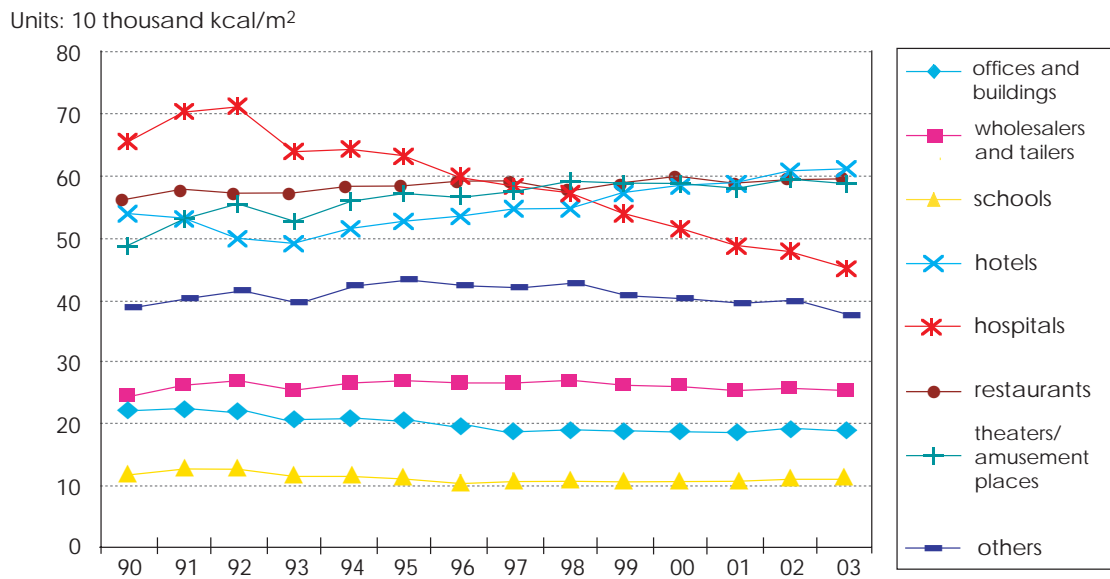




Figure 5 Energy consumption basic unit by sector



Source: The Energy Data and Modeling Center "2005 EDMC Handbook of Energy and Economic Statistics in Japan", 2005.

Figure 4 indicates the change in floor areas by business type. It shows that in each type including offices, retailers, schools, and hospitals, the floor area has increased. Figure 5 indicates trends in energy consumption per square meter by business type, showing little change.

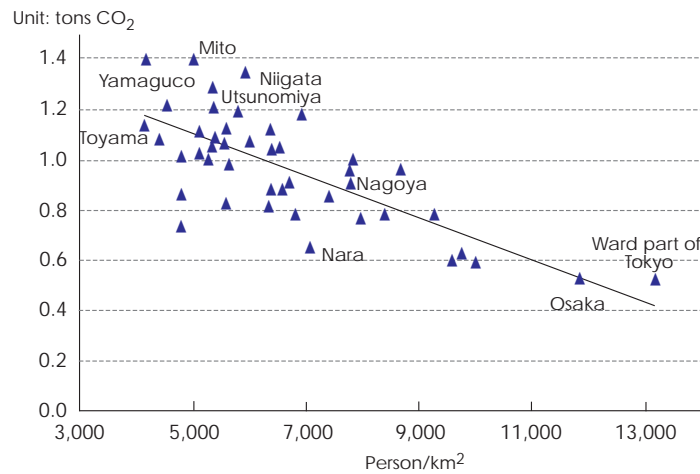
As seen in these two graphs, the increase in CO<sub>2</sub> emissions in the business sector has been induced by increases in energy consumption, which accompanied the expansion of total floor area.

### 3. URBAN STRUCTURE GREATLY AFFECTING CO<sub>2</sub> EMISSIONS

Today in Japan, we have witnessed the phenomenon that we call urban sprawl. Increases in automobile traffic and commercial floor area are a part of this phenomenon. In this context, it is considered that the major cause of recent increase in CO<sub>2</sub> emissions is urban sprawl.

Now, let us consider the relationship between increases in CO<sub>2</sub> emissions and urban structure more specifically. Figure 6 shows the relation between population density and CO<sub>2</sub> emissions level. It shows that cities with low population density in midtown areas tend to emit more CO<sub>2</sub>.

Figure 6 Population density in urban areas and CO<sub>2</sub> emissions in the passenger transportation sector



Source: National Institute for Environmental Studies (NIES). "Analysis and estimation of transport sector GHG emissions of municipalities" (in Japanese), 2004.

Figure 7 Three prefecture capital cities



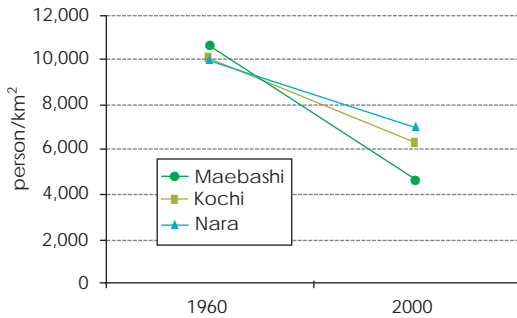
What is the cause of this phenomenon? Let us take up some cities in Japan as examples, and consider the links between urban sprawl and CO<sub>2</sub> emissions. Figure 7 shows three cities which are prefecture capitals: Maebashi, Kochi and Nara. Although the population of each city is slightly different, the population density of each was almost the same in 1960. However, the range of population decrease over the past 40 years differs among them as seen in figures 8 and 9.

Figure 8 City profile and trend of population density of urban area

1960	Maebashi	Kochi	Nara	2000	Maebashi	Kochi	Nara
Total population (person)	181,937	196,288	134,577	Total population (person)	284,155	330,654	366,185
No. of households	39,695	54,447	31,026	No. of households	106,078	139,997	133,774
Total Area (km <sup>2</sup> )	113.4	131.9	211.9	Total Area (km <sup>2</sup> )	147.34	145.0	211.6
DID population (person)	106,825	136,845	66,916	DID population (person)	204,541	227,948	321,668
DID area (km <sup>2</sup> )	10.2	13.5	6.8	DID area (km <sup>2</sup> )	45.3	43.7	45.9
DID population density (person/km <sup>2</sup> )	10,473	10,137	9,841	DID population density (person/km <sup>2</sup> )	4,514	6,360	7,012

Note: DID = Densely Inhabited District  
 Source: Ministry of Internal Affairs and Communications (MIC), Japan "National Census (1960, 2000)".

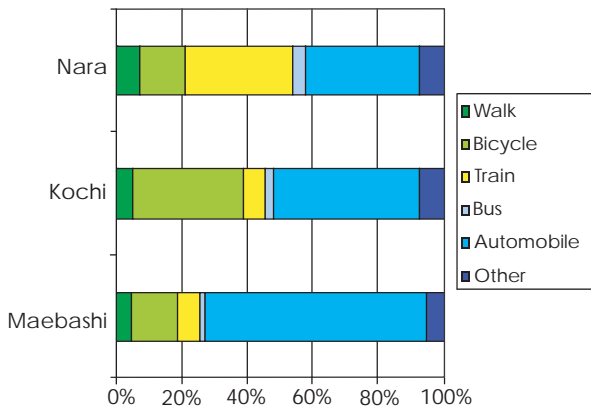
Figure 9 Change of population density in three cities



Source: MIC "National Census (1960, 2000)".

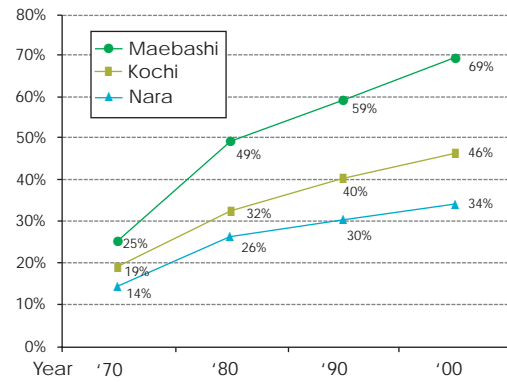
Figures 10 and 11 indicate that while the ratio of automobile users in those three cities is high and increasing, the ratio of bicycle riders in Kochi City and railroad passengers in Nara City is high. Also, figure 12 shows that the per capita annual CO<sub>2</sub> emissions in Maebashi City are the largest among the three, followed by Kochi and Nara, according to the ratio of automobile users. This tendency reflects the urban structure of each city.

Figure 10 Share of transportation type for commuting



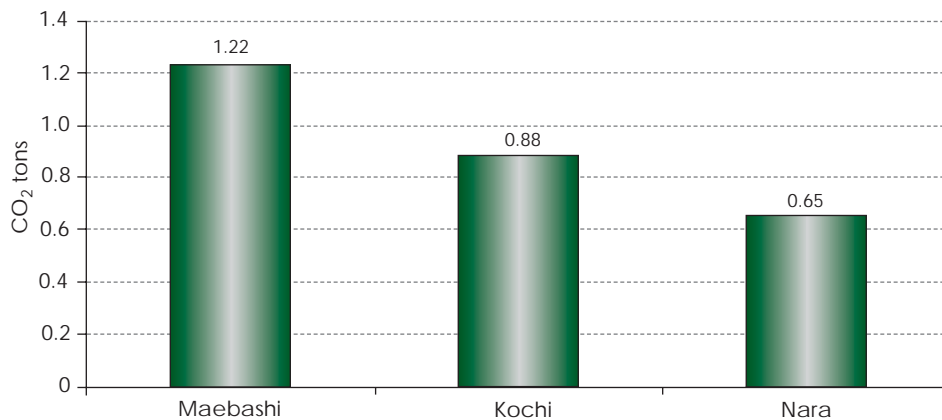
Source: MIC "National Census (2000)".

Figure 11 Ratio of commuters using automobiles



Source: MIC "National Census (1970-2000)".

Figure 12 CO<sub>2</sub> emissions per person/year (passenger transportation sector)



Source: MIC "National Census (2000)", NIES "Analysis and estimation of transport sector GHG emissions of municipalities" (in Japanese), 2004.

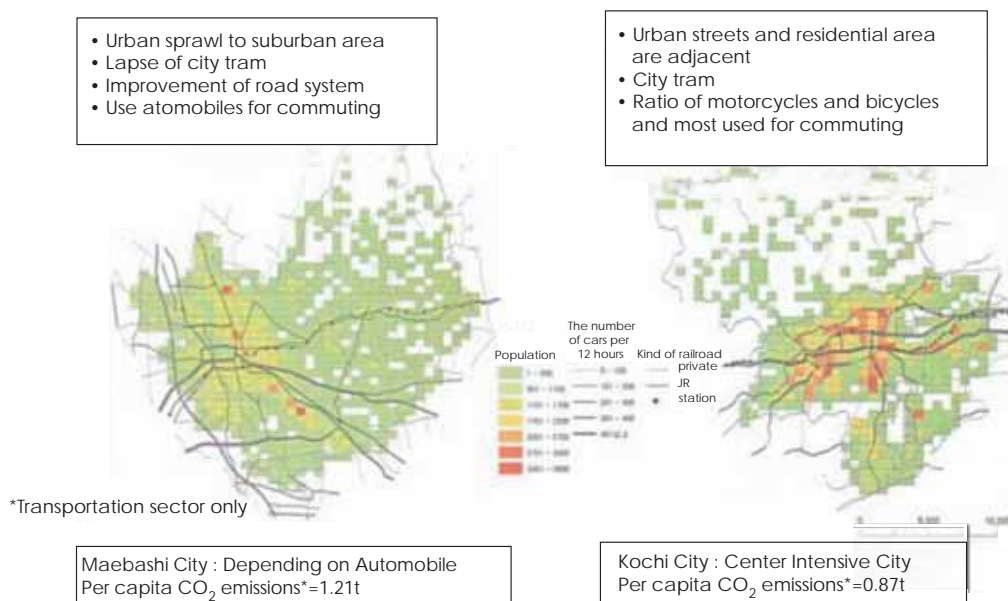
In Maebashi City, the city tram service on national roads was cut in 1953 and road construction was proactively promoted. There were no railways connecting suburban areas and midtown areas, and the automobile traffic had been increasing. As a result of this, urban sprawl advanced while population density significantly decreased. Maebashi City is a typical automobile-dependent city.

In Kochi City, city trams are still in service. Population accumulation is clear in the center of the city. On the other hand, road construction has advanced in recent years, and the population in midtown areas decreases while it is increasing in suburban areas. In Nara city, the population tripled over the past 40 years. Development under the initiative of railway companies has advanced. Houses were constructed around the train station and connected by sufficient bus lines. Nara city is, as it were, a city formed on the basis of public transportation. At the same time, traditional urban areas of the city have been kept neat by regulations on development and the height of buildings.

Let us look at the map of Maebashi and Kochi (figure 13); red and orange indicates areas of high population density. Although urban sprawl has been likewise advancing in both cities, there is a clear difference in population distribution. In Maebashi on the left, populous areas are scattered along the roads; while in Kochi on the right, populous areas are centered in the midtown area.

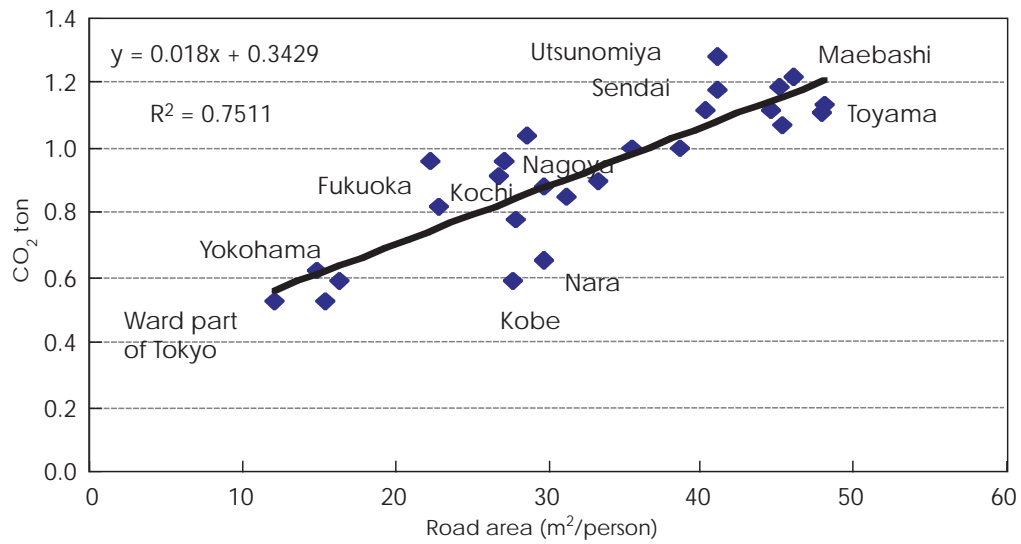
As mentioned above, road construction seems to promote formation of cities based on automobile traffic, bringing an increase of CO<sub>2</sub> emissions together with a decline of midtown areas. We can see that more clearly when we plot per capita road area and CO<sub>2</sub> emissions on a graph. Figure 14 shows that cities with a bigger road area per capita – that is, cities with more road construction – tend to emit more CO<sub>2</sub>.

Figure 13 Population density in Maebashi and Kochi



Source: MIC "National Census (2000)", Japan Digital Road Map Association, Geographical Survey Institute Japan "Numeric map 25000 (space data base)" (in Japanese).

Figure 14 Correlation of road area and carbon dioxide emissions per capita



Source: MIC "National Census (2000)", Cities data, NIES "Analysis and estimation of transport sector GHG emissions of municipalities" (in Japanese), 2004.

#### 4. ISSUES OF SPRAWLING CITIES

Besides the increase in CO<sub>2</sub> emissions, sprawling cities have been causing a wide range of social problems, impairing local sustainability.

For example, a decline in midtown areas and the uniform scenery of local cities are among serious issues. As seen in the photo on the left below (figure 15), people seem to have disappeared from a once-popular shopping district, leaving closed shutter shops. Also, large scale shopping malls are lined up along suburban roads all over Japan (figure 16).

Figure 15 Shopping districts we call a "shuttered street"



Photo by: Ministry of Environment, Japan.

Figure 16 Americanized scenes with a long line of stores having large parking lots



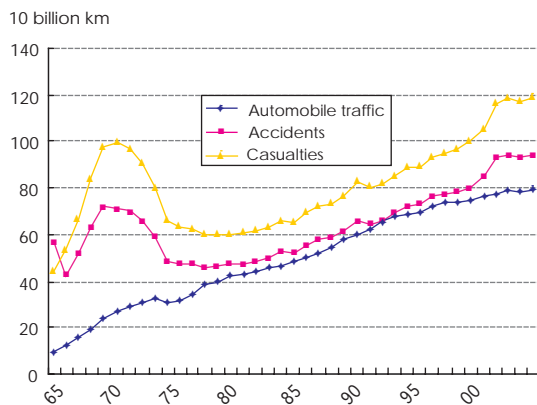
Photo by: Toyama prefecture.

Another issue is the increase in maintenance costs of infrastructure. According to the estimation by Aomori City, a prefectural capital located in northern Japan (see figure 7), in order for 13,000 people to move from midtown to the suburbs between 1970 and 2000, the administrative cost for the construction of roads and sewerage required approximately 35 billion yen, nearly equal to US\$300 million. In addition, due to the extended roads, a large amount of the cost is used for snow removal every year. Based on the reconsideration of past policies aimed at suburban development, Aomori City has changed its strategy to creating a “compact city” in which major functions including commercial facilities, offices, houses, schools, and hospitals are put together.

Increases in traffic accidents and obesity are also becoming issues for concern as the automobile traffic-oriented society advances (figure 17). In Japan, since the 1980s, the number of accidents and casualties has increased with expanded automobile traffic. This graph lets us feel an apprehension that the number of traffic accidents shall continuously increase if the society based on automobile use proceeds. Moreover, research by the National Institute of Health and Nutrition shows that obesity in young and middle-aged males in agricultural areas has rapidly increased and this is due to reduced work and more dependence on automobiles (survey conducted in 2002). Needless to say, the health condition of citizens greatly affects the cost of medical care and social security.

Figure 17 Automobile traffic, traffic accidents and obesity

Correlation of the volume of automobile traffic and the number of traffic accidents

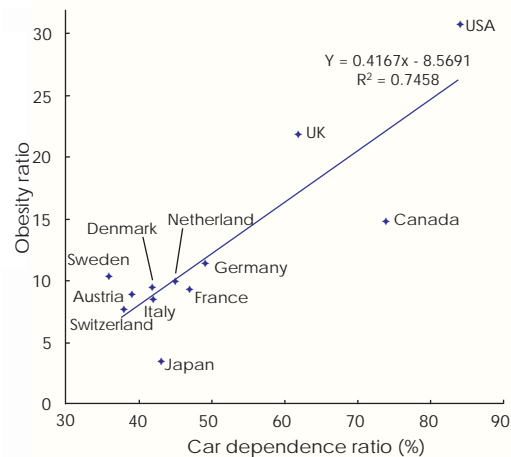


Note: Car dependence ratio: The ratio of car use when people go out (other possible transportation means are by foot, bicycle, public transportation, and so on) (1998-1999).

Note: Obesity ratio: The ratio of people whose BMI is more than 30 (1999-2002).

Source: OECD Health Data 2005, Mainichi Daily News (04.11.27).

Correlation of the car dependence ratio and the obesity ratio



Source: Ministry of Land, Infrastructure, and Transportation "Annual report of automobile transportation statistics" (1965-2003), National Police Agency "traffic accidents statistics" (1965-2003) (in Japanese).

## 5. RE-ACCUMULATION OF CITY COMPONENTS

To address those issues the government of Japan has been seeking ways to “re-accumulate” city components. Re-accumulation of city components means gathering city components such as houses, commercial facilities, and public accommodations from the suburb to the center again and constructing a network of public transportation to connect them. Such a “compact city” is expected to mitigate dependence on automobiles and the other problems mentioned above.

It is clear that measures to promote urban sprawl are not proper in terms of Green Growth; namely, measures such as the development of houses not accessible to public transportation, unlimited road construction to absorb increases in automobile traffic, tacit acceptance of unplanned roadside development, etc. may impair local sustainability. In order to stop urban sprawl and to build sustainable communities, we should understand the exact social costs resulting from urban sprawl and seek to re-accumulate urban functions in a central area to formulate compact cities.

When we construct social infrastructure such as roads, railroads, and housing, it is important to forecast the social benefits of meeting transportation and housing demands. However, we must also estimate the infrastructure's indirect influence over the long term, such as the increase of CO<sub>2</sub> emissions by inducing traffic and the maintenance cost of new neighboring infrastructure. It is crucial to establish an accurate assessment to reduce urban sprawl.

Also it is important to maintain and develop public transportation to build cities that have easy access to downtown areas and streets on which pedestrians and bicycle riders can easily travel. To create compact cities in which functions indispensable for daily life are accumulated in the center, it is crucial to take proper management of the urban planning system. This would include permits and designating areas for development, which would help prevent sprawling of large-scale commercial facilities, public facilities, and unregulated urbanization.

Recently in Japan, the *Act on Activation of Midtown* and the *City Planning Act* were revised to include new schemes to promote formation of compact cities (see text box below).

However, once a community's dependence on automobiles is established, it is very difficult to re-accumulate urban functions, since automobile owners feel more comfortable to travel anywhere with a car. Therefore, to prevent urban sprawl, it is crucial to take measures before the automobile-based city is established.

Currently, the number of automobiles has been increasing all over the world. However, based on examples in Japan, it is clear that infrastructure construction with too much weight on roads shall promote urban sprawl and cause many problems. Japan's local cities have been challenged with a difficult problem now as a result of having pushed forward urban development relying on automobile transportation.

#### Revision of Acts on Urban Design in Japan (summary)

##### Revision of *Act on Activation of Midtown*\*

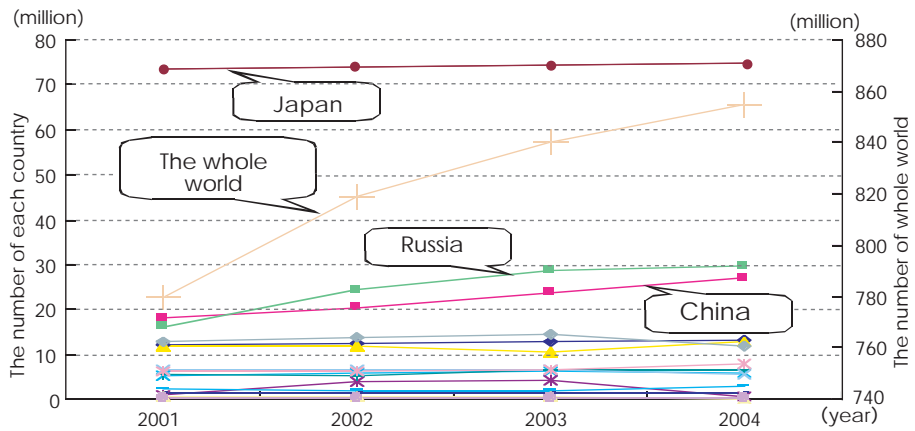
- Stipulation of basic principles and responsibility provision
- Introduction of "selection and concentration" system by national government
- Legislation of a council on urban activation with participation by various actors
- Drastic improvement of support measures

##### Revision of *City Planning Act*\*

- Reform the procedures of urban planning in constructing large-scale commercial facilities
- Include construction of public facilities among the subjects of the development permission system
- Deregulate the procedures for development of urban centers
- Enhancement of regulation of suburban development

\* Provisional translation from Japanese

Figure 18 The trend of car possession of some SINGG member countries

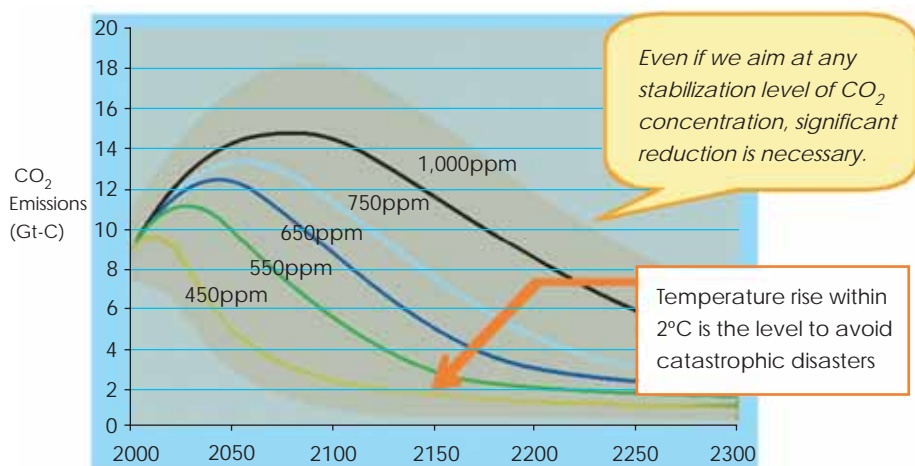


Source: "World Motor Vehicle Statistics Vol.5" (in Japanese), 2006, Japan Automobile Manufacturers Association, Inc.

We live in the age when a significant reduction of GHGs is necessary. In order to reduce impacts by climate change, we should stabilize atmospheric concentration of GHGs at a certain level. Although reduction measures may differ according to the target levels of GHG concentration, significant reductions are indispensable for stabilizing GHGs at any level.

Urban structures could influence CO<sub>2</sub> emissions greatly. A policy about urban design is one of the keys to reduce CO<sub>2</sub> emissions and to achieve Green Growth.

Figure 19 Change in global CO<sub>2</sub> emissions responding to various stabilization levels



Source: the IPCC WGI Third Assessment Report (2001).



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# Challenges for environmentally sustainable transport in Seoul

*Gyeng Chul Kim*

*Director, Department of Urban Transit, Seoul Development Institute*

*Republic of Korea*

## 1. INTRODUCTION

Throughout the 1990s, Seoul faced demographic changes that created new transportation demands that the city could no longer respond to. These changes in transportation patterns increased private car use, unorganized bus transportation routes, and travel across longer distances. Buses were once the most widely used mode of transportation, but demographic changes devastated the service. The transportation system was in chaos and urgently needed reform. The traditional method of piecemeal approaches for the bus system reform no longer worked, as evident in the mid-1990s in the Republic of Korea. Innovative and intensive reorganization strategies, rather than fragmented approaches, were necessary.

The Public Transportation Reform is a major step towards sustainable mobility. The key of its success lies in its integrated approach combining organizational measures, innovative technology, infrastructure development, and transport operation. Seoul is one of the rare cities to have implemented such comprehensive reform, in such a short period of time, and working simultaneously at different levels. Measures included, among others:

- Construction of exclusive median bus lanes;
- Reorganization of the bus network (categorization of bus lines into express, trunk, feeder, and local lines);
- Reform of the institutional framework (contract provision of bus operators and a semi-public operation system);
- Integrated multimodal electronic fare system (T-Money);
- Integrated transport operation and information service (TOPIS);
- Compressed natural gas (CNG) buses; and
- Car traffic management and enforcement of illegal parking.

The reform has generated many benefits, including greater operational efficiency through better alignment of transport capacities and demand. In addition, the launch of the integrated fare system decreased overall public transport deficiencies and led to a growing number of passengers. This in turn led to increased revenue collection by transport operators; decreased need for government subsidies; improved traffic conditions for buses; improved decision-making processes; and greater transparency between operators and the Seoul Metropolitan Government.

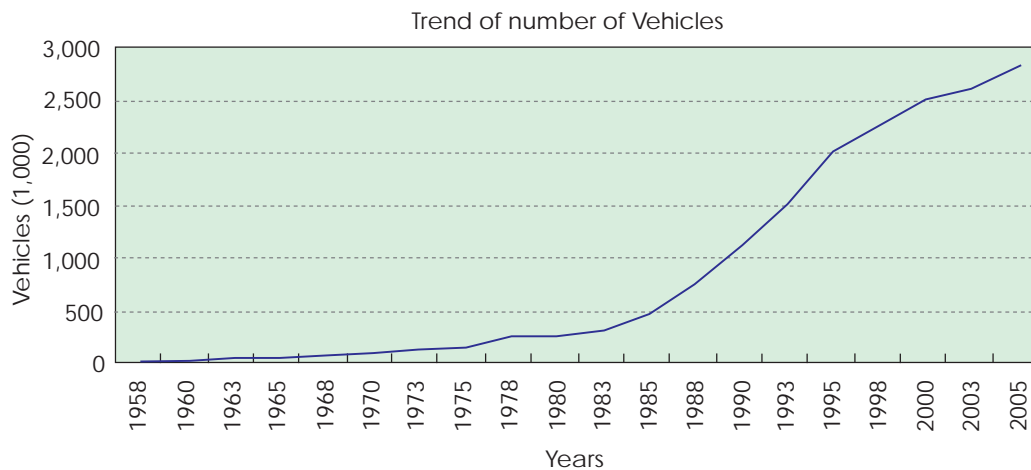
This paper reviews how the bus transport reform in Seoul came together at many levels through the establishment of a new institutional and regulatory framework, the restructuring of bus service operations and management, and the alignment of investment programmes to environmental concerns, while ensuring greater quality of services for consumers. Such integration and political leadership are the main highlights of this case study.

## 2. OVERVIEW OF TRANSPORTATION IN SEOUL

In the early 1950s, Seoul began to reform its urban transportation system in response to rapid demographic changes. Since then, Seoul has experienced population growth of at least four-fold within 50 years, and real income growth of at least 40-fold. Such dramatic changes led to land scarcity, rising housing prices, and traffic congestion in the capital. As a result, overcrowding forced migration into the surrounding suburbs where more than 12 million people now reside. The existing transportation infrastructure could no longer sustain the changes in transportation patterns, which have shown an increase in the average length of trips and the number of daily trips per person. The total number of daily trips for populations in the outer portions of suburban areas increased five times, from 5.7 million to 29.6 million between 1970 and 2002. A continuously growing economy ensures additional growth in the travel demands concentrated in these areas.

Private transportation quickly gained popularity as a means of traveling throughout the 1980s and 1990s, while the buses and taxis were largely disregarded. The rise in the number of passenger cars contributed the most to the increase in travel and total number of automobiles registered. By 2003, 21.5 per cent of the population owned cars, jumping from only 0.2 per cent in 1973.

Figure 1 Number of total registered vehicles

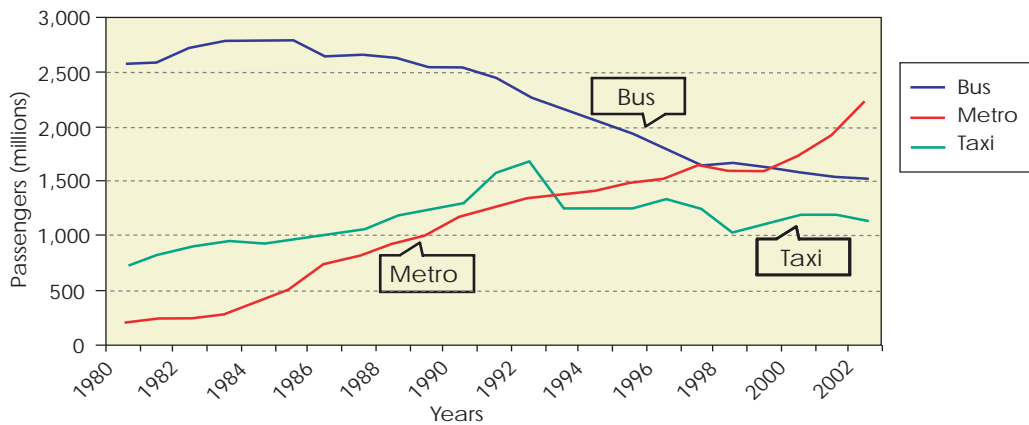


Source: Seoul Metropolitan Government and Seoul Development Institute.

Previously, buses were the primary means of transportation for over 80 per cent of the daily commutes; the remainder included taxis (17.6 per cent) and subways (1.1 per cent). The share of buses began to fall sharply as subway lines came into operation, but much of the drop is attributed to the rise in private car use. In addition, during the same period, governments attempted to reduce traffic congestion by adding more buses and granting more licenses to private bus and taxi operators.

The existing infrastructure was no longer capable of absorbing such large increases in private car use, thus resulting in serious traffic congestion within the city and on radial arterial highways connecting the suburbs to the city center. Congestion costs were estimated to exceed US\$8 billion a year, amounting to 4 per cent of GDP by 2003. Increased car use has also caused high levels of air pollution, noise, traffic accidents, and excessive use of scarce land for roadways and parking facilities.

Figure 2 Change of transportation mode share in Seoul (1980-2002)



Sources: Ministry of Construction and Transportation and Korea Transportation Database.

To deal with such problems, the Seoul Metropolitan Government centered its efforts on expanding Seoul’s transportation network. This has been implemented in three stages: (i) development of a mass transit system from 1950 to 1980; (ii) restructuring of the bus system; and (iii) implementation of a new strategy in urban land use.

### 3. BUS SYSTEM REFORM

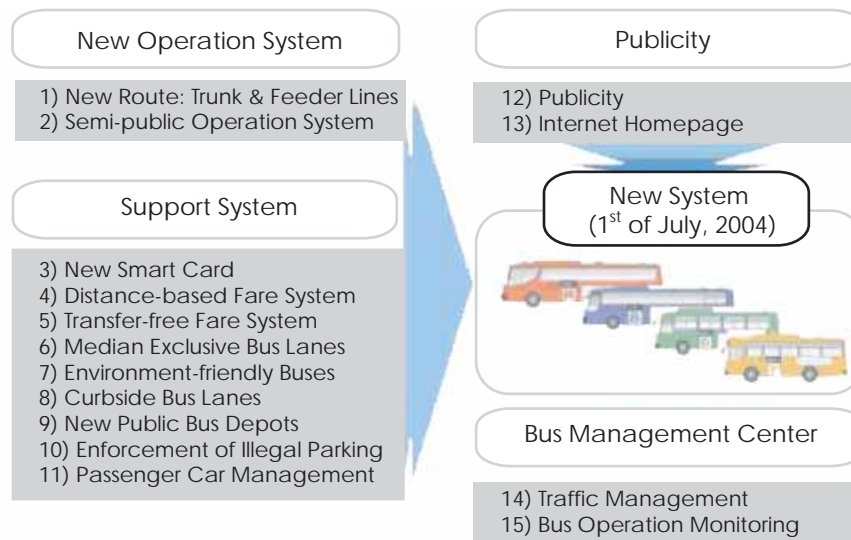
Prior to the bus system reform, buses were unable to compete with other modes of transportation. In 2000, bus reform plans came underway. The objectives of the reform were to redesign the provision of bus transport services within the Seoul Metropolitan area in light of environmental concerns, increasing passenger satisfaction, and achieving financial sustainability in the industry.

The determinants of change can be divided into external and internal drivers. The external factors are related to socio-economic and political aspects. The internal factors, on the other hand, are associated with the lack of standards and inefficient operators. Addressing these factors was crucial for the viability of the bus system.

#### 3.1 Main targets of bus system reform

Seoul’s bus renovation project was planned in response to consumers’ needs and expectations in terms of urban mobility, rapid urbanization of the metropolitan area, and environmental concerns. The key to solving traffic congestion and maintaining a sustainable transportation system is simultaneously improving public transportation while restricting use of private passenger cars. The aim of Seoul’s bus renovation project was to revitalize the bus system through improving the regulation and operation of bus services. Reform introduced new forms of governance in the bus transport industry. Additionally, the reform also introduced new monitoring methods, reorganized route networks, created median lanes, improved the quality of business, and introduced a new incentives framework for bus drivers and operators. To achieve this aim, several projects were prepared and implemented. All of these projects, discussed in following sections, were integrated and implemented as packages in order to effectively address the complex issues faced by the bus transport industry in Seoul.

Figure 3 Public transport reform in Seoul



### 3.2 New fare system

The new system unified and coordinated the fare structure to integrate both bus and rail services. The previous fare system resulted in bus riders traveling shorter distances and paying relatively more because buses charged a single fare. The new fare system varies by mode of transportation and total distance traveled. For passengers transferring out of Seoul, the fare is charged based only on the total distance traveled and not on the transportation mode used. Within Seoul, the single fare for bus service starts at 800 Korean won (approximately US\$0.8) for the first 10 kilometers (km), and increases by 100 won for each additional five km. The base fare also includes up to four free transfers to both other bus lines and the subway. Users have the option of paying with a smart card or with cash, but users paying by cash do not have free transfer privileges and must also pay a surcharge of 100 won regardless of transportation mode.

The distance-based fare system replaced the flat-fare system, including free transfers within 30 minutes. The effectiveness of free transfers between buses and the subway substantially increased bus ridership. Table 1 shows a comparison of fare structure and fare levels before and after the reform. The introduction of the smart card eased payment and also attracted users by its multiple benefits. Transportation expenses generally decreased because of the reduced cost for each trip (average costs decreased from US\$0.674 to \$0.632) and popularization of the “subway monthly commuting ticket”. The new fare system made a large contribution towards increasing services and ridership.

Table 1 Bus fare structure before and after reform

		July 2003	July 2004
Structure	Bus Only	Flat fare	Flat fare
	Transfer	50 won discounted from fare charged	Free (distance-based)
Fare	Card	650 won	800 won
	Cash	700 won	900 won

### 3.3 Infrastructure

Two major types of bus-related infrastructure were created and improved: the bus route network and exclusive median bus lanes.

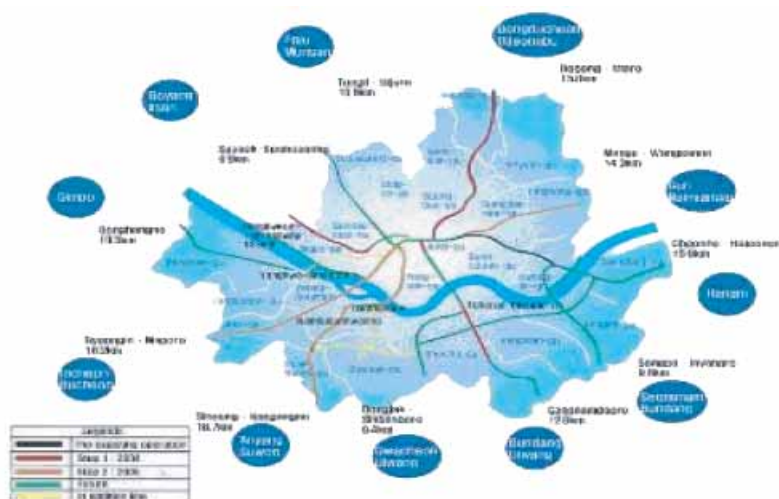
#### *Bus route network*

The bus route network was entirely re-designed to integrate all bus routes in the metropolitan area. All bus services are now grouped into four types and color-coded to make them easily distinguishable. The red long-distance intercity buses connect outlying suburbs with each other and the city center. The blue trunk buses operate between sub-cores and along major arterial corridors in Seoul. The green feeder buses, including community buses, provide local services to feed subway stations and express bus stops. Finally, the yellow circular buses provide local services within the city's center. Route numbers were also reconstructed, enabling passengers to easily identify the zones where buses start and end.

#### *Exclusive median bus lanes*

Previously, exclusive bus lanes were installed along the curb side. This provided only insignificant improvements in traffic congestion, especially at intersections where turning cars continued to interfere with traffic. During the reform, median bus lanes replaced former curbside lanes. Much effort was invested to expand and upgrade these lanes from 219 km to 294 km. Exclusive median bus lanes run throughout three major corridors (27 km), and expanded to six corridors (58 km) by 2005. The development of a Bus Rapid Transit (BRT) network, high-quality median bus stops, priority traffic signals at intersections, real-time information for passengers and system operators, and new, state-of-the-art buses all contributed to the success of exclusive median bus lanes. Substantial improvements were seen in the overall average bus speed, with increases of up to 20 per cent. By 2006, there were already 86 km of such exclusive median bus lanes over six different corridors, which continue to expand rapidly.

Figure 4 Existing and planned exclusive bus lanes in Seoul (16 routes, 191.2 km)



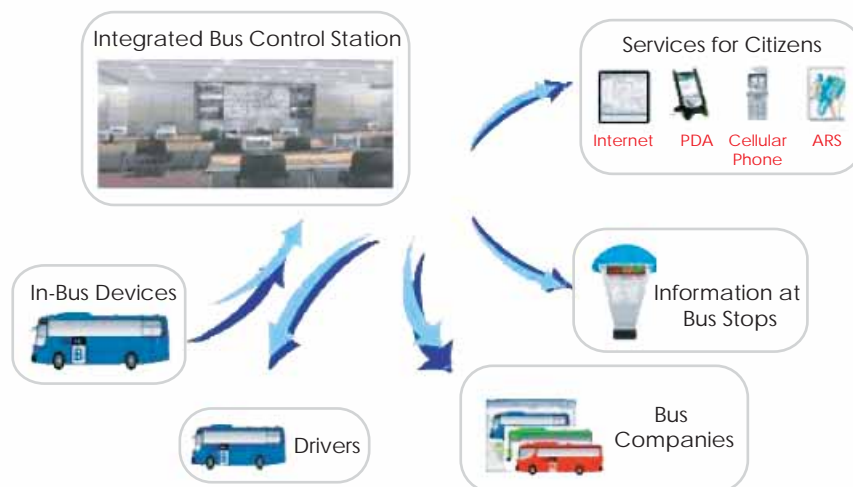
### 3.4 Technological innovation

#### *New smart card system*

A new smart card was introduced to facilitate inter-modal ridership. The new smart card system is a stored-value, multi-purpose smart card (called T-Money). Smart cards have had advantages for both passengers and bus companies. Passengers can use their smart cards for bus and rail travel, transfer fare discounts, and to choose between pre-paid and credit card-linked options. For bus companies, fare revenues can be calculated more accurately with the new smart card system. In 1997, Seoul became one of the first cities to use a radio frequency identification card system (the Mifare card from Philips) for fare collection. However, after six years of implementation, the limited capacity of memory, slow transaction speed, and security problems weakened the system. Thus, a new card system using an integrated circuit (IC) chip was developed.

The new smart card satisfies international standards and has increased capacity after adopting the Europay, Mastercard, and Visa global standard (EMV), which helps ensure that smart cards, terminals, and other systems are interoperable. This allows it to provide multiple functions, supports more accurate management of bus scheduling, and increases the transparent management of bus fare revenues. Future plans will extend smart card services for taxi use and high street shopping. In addition, the Seoul Metropolitan Government developed a bus management system (BMS) to increase the efficiency of bus operations.

Figure 5 Bus management system (BMS)



The BMS integrated the Transport Operation and Information Service (TOPIS), which provides data on traffic information that can be uploaded to various transportation agencies in the metropolitan areas. This combined the Intelligent Transport System (ITS) and Global Positioning System (GPS) technologies to assess buses' positions, control scheduling, and provide bus information to passengers via internet, mobile phone, and personal digital assistant (PDA). Such information also supports research and assists in decision-making processes.

### 3.5 Quality and passenger safety

The previous bus system failed to provide quality to riders and was not environmentally friendly. New features designed to enhance passengers' comfort included: improved design of bus stops,

increased number of seats on buses, and ensuring the cleanliness of vehicles' interiors. To improve quality, Diesel Particulate Filters (DPFs) were installed in most buses, and new types of vehicles were introduced, such as low-floor buses, articulated buses, and CNG buses. The Seoul Metropolitan Government also installed a bus information system (BIS) to provide information on arrival times for passengers waiting at bus stops.

Figure 6 Articulated bus introduced in Seoul



The 300 low-floor buses have run on CNG since early 2006. Eventually, all blue and red express buses will be low-floor buses running on CNG. In addition, loading platforms will be installed at bus stops so that getting on and off express buses will be easier, faster, and safer. The government now views the BRT expansion as a more cost-effective and faster method to provide express public transport service as compared to expanding the metro system, which requires much more time and capital investment.

### 3.6. Environmental concerns and passenger car reduction policy

#### *The opening of Seoul City Hall Plaza*

Seoul City Hall Plaza was opened on 1 May 2004. The area, previously jammed by traffic, exhaust, and noise, was returned to the citizens, transformed into an open town square park with a large grass lawn. It has succeeded in restraining traffic flow in this area and securing space for pedestrians.

Figure 7 Reform of Seoul City Hall Plaza (before and after)



#### *The restoration of Cheon Gye Cheon*

Cheong Gye Cheon is an historical stream that has run through Seoul for the last 550 years. It was covered by roads and highways in 1937, with a daily traffic volume of 190,000 vehicles. The restoration of this six km stream has made a great contribution to the realization of people-oriented, environment-friendly policies, and sustainable transport. Public transportation was encouraged to relieve the huge traffic flows, and the bus reform has played a great role in decreasing car traffic volume by two-thirds, or 125,000 vehicles per day.



Figure 8 Restoration of Cheong Gye Cheon (before and after)



#### 4. ACHIEVEMENTS OF THE BUS SYSTEM REFORM

The bus system reform enhanced operation and regulation capabilities of public transportation services in the Republic of Korea. The Seoul Metropolitan Government forcefully targeted critical concerns during the 1980s when transportation patterns were shifting and bus services failed to provide an alternative option. The leadership of the Seoul Metropolitan Government in taking the necessary steps to reform the institutional framework of public transport operations was a major step towards sustaining success over the long term.

The reform fosters integration and coordination that enhances improvements in operation and regulation. All of these achievements confirm the willingness of the Seoul Metropolitan Government to improve mobility and the urban environment in Seoul. This solely came about as a result of participatory initiatives and a consensus-building forum involving the Seoul Metropolitan Government, bus operators, transport and city professionals, and citizens.

Table 2 Seoul's bus system before and after reform

	2003	2004
Daily bus passengers (thousands)	4,869	5,350
Daily transit passengers (thousands)	9,307	9,888
Frequency (minutes)	5-15	5-15
Bus speed (km/h)	13 km/h	17.3 km/h
Comfort (low-floor buses)	-	78 buses
Convenience (red zone pavement)	-	142 spots
Punctuality <sup>1</sup>	0.537	0.493

<sup>1</sup> Difference ratio of the permitted headway and actual operational headway.

Targets that were implemented to improve the transport system achieved increasing mobility, efficiency, ridership, road safety, and information dissemination; at the same time, they mitigated negative impacts such as poor traffic conditions, pollutant emissions, and energy consumption.

Table 3 Increased number of passengers for subway and bus (thousands/day)

	2003		2004		Percentage Increase
	July	August	July	August	
Bus	3,793	3,744	4,142	4,140	9.9
Subway	2,699	2,557	3,055	2,867	12.6
Total	6,492	6,301	7,197	7,007	11.0

The reform emphasized passenger-friendly and environmentally conscious services and buses that would mitigate negative impacts. Quality was achieved through three main initiatives: improving road safety; decreasing pollutants and energy consumption; and reaching consumer standards. Road safety profoundly increased when a mandatory bus driver quality certification was implemented. A competitive education programme stressed driving-safety behaviors and understanding the use of smart cards, BMS, and GPS technologies. The significant decrease in bus-related traffic accidents is only partly attributed to driver education; the reorganization of bus routes that improved scheduling and timeliness of bus travel also reduced reckless driving.

Table 4 Change in number of passengers after reform (thousands/day)<sup>2</sup>

Category	Public transport (a+b)	(a) Subway	(b) Bus (b=c+d)	(c) Trunk lines	(d) Feeder lines
July 2004 - May 2005 Average	9,765	4,545	5,220	4,068	1,152
July 2003 - May 2004 Average	9,282	4,497	4,785	3,863	922
Changes	483	48	435	205	230
Rate (per cent)	5.2	1.1	9.1	5.3	24.9

Table 5 Bus-related traffic accidents and casualties

Year	Number of accidents	Lightly injured	Number of the injured		Total
			Heavily injured	Deaths	
2003	654	916	49	6	971
2004	478	704	36	0	740
Change (per cent)	26.9	23.1	26.5	100	23.8

<sup>2</sup> Data from 1 July 2004 and 11 January 2005 were eliminated due to the card terminal errors.

Environmentally friendly buses were also in the center of the reform planning process. The number of CNG buses increased from 1,504 to 2,100, and simultaneously diesel particulate filters (DPFs) were adopted. The use of CNG and DPF energy products significantly reduced air pollutants, such as carbon dioxide (CO<sub>2</sub>), nitro-oxygen (NO<sub>x</sub>), hydrocarbons (HC), and particulate matter (PM). Only CNG buses and those with DPFs installed may drive in the exclusive median bus lanes, which is required through legislation by the Seoul Metropolitan Government.

Table 6 Energy pollutants and consumption

	2003	2004
Safety (traffic accidents)	3,949	3,094
Accidents per day	21.9	17.2
Air pollution (CO <sub>2</sub> : tons)	1,798.8	1,526.4
Air pollution (NO <sub>x</sub> : tons)	6,889.8	5,846.2
Air pollution (HC: tons)	390.5	331.4
Air pollution (PM: tons)	302.2	245.6
Energy consumption (CNG: 1,000 m <sup>3</sup> )	34,413	41,731
Energy consumption (Diesel: 1,000 m <sup>3</sup> )	147,064	126,485

Quality standards for buses, such as clean interiors, comfort, and accessibility for users, have been greatly improved. Such standards extend to service providers, such as engineers who are regularly educated about maintenance of buses, smart card systems, BMS, and GPS technologies. Effectiveness of service providers can be tracked through the complaint resolution system.

Table 7 Number of public complaints after the reform

Type of Complaint	April 2004	December 2004	May 2005
Transport card and fare	59,871	4,820	640
Service routes	1,216	44	15
Service schedules	1,638	141	29
Bus stops, route maps	561	24	4
Service of bus driver	392	40	30
Publicity of route and fare	331	19	1
Etc. (suggestions, transfer)	981	48	34
Total	64,990	5,136	753

## 5. LESSONS LEARNED AND CONCLUSION

Over the last 40 years, the Seoul Metropolitan Government has attempted to reform the bus operating system several times but had continuously failed. The failures were caused by the strong opposition of the bus industry and bus users, as well as the government's top-down, vertical approaches with its weak decision-making leadership. These factors were prominent in the failures

of the Seoul bus reforms of 1996 and 1997. However, the 2004 bus system reform had the support of citizens and organizations that urged the government to establish the bus reform citizen committee (BRCC).

Planning and implementing such a huge project could have not been possible without the leadership of decision makers. The entire transport reform was implemented successfully under the mayor of Seoul. Pushing his main projects forward, he made every effort to manage and minimize the various conflicts through consultation and discussions with citizens and stakeholders. It is meaningful that the concept of "New Governance" was substantially introduced as a new direction of the administration through the public transportation reform. The previous top-down approaches by the central government and the Seoul Metropolitan Government have been changed into a process led by a committee and supported by citizen groups and collaborative organizations.

The reform is the result of a participatory approach based on a consensus-building process involving the Seoul Metropolitan Government, bus operators, transport and city professionals, and citizens. The leadership of the Seoul Metropolitan Government took the necessary steps of reforming the institutional framework of public transport operations in order to increase efficiency and rationalize costs. In this respect, public transport operators benefited from the support of the Seoul Metropolitan Government, which helped them to modernize their fleet and adopt innovative technologies. After a phase of stabilization, this framework is expected to increase the responsibility and entrepreneurship of public transport operators by encouraging them to adopt a service-oriented approach.

Identifying alternative financing sources is a concern of all public transport organizations worldwide. In Seoul, the subsidy ratio of public transport operations is far lower than in the majority of networks in the world, but it is improving. However, due to the scarcity of public funds, it is important to consider other sources, such as value capture from property development, road use pricing, congestion charging, parking revenues, and other measures, in order to progressively reduce subsidies from the Seoul Metropolitan Government.

In conclusion, the bus system reform has been successful in addressing the needs of Seoul's population. The reform outcomes and methods have received attention both at home and abroad, leading to awards for Seoul's efforts to improve the city's public transportation. Seoul was named the winner of the 2005 World Technology Network (WTN) for Environment Award and received the Sustainable Transport Award from Environmental Defense and Transportation Research Board (TRB) in the United States in January 2006. The success from this experience not only speaks for the reform of the bus system but for reforms in other areas as well.

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# Eco-efficient energy infrastructure initiative paradigm

*Woodrow W. Clark II*

*Managing Director, Clark Strategic Partners, Los Angeles, California*

*The United States of America*

## 1. INTRODUCTION

When the first signs of the California energy crisis became apparent in the spring of 2000, then Governor Davis and few public policymakers or staff were either informed or knowledgeable about energy issues. By the summer of 2000, the state government began to focus intently over what to do. With presidential and congressional elections coming that fall, politicians could see their careers now measured in terms of energy shortages and climate change. In fact California voters decided to “recall” Governor Davis for being at fault for escalating energy prices; threats of blackouts; and concern over the impact on the environment. While it was not Davis who created the “de-regulated market” for energy, he got the blame from the voters in 2003. Even with emergency legislation passed in October 2002 that created at least the legal mechanisms to tackle the crisis and prosecute the power companies who manipulated the markets, that was not enough to persuade the California voters. Throughout 2001-03 more legislation was passed, much of which the new Governor, Arnold Schwarzenegger was able to use and prevent further rolling blackouts and massive increases in energy costs.

By the holiday season of 2000-2001, the crisis was beyond simple economic explanations. Fingers pointed to fuel suppliers, deregulation, environmental laws, high consumer demand, lack of generation, and a series of other social and political causes. The experts appeared on radio and TV with a chorus of solutions and suggestions, yet the “challenge” was to keep the power on (literally by seconds) while searching for near-term solutions for the summer of 2001 and longer-term ones into the next years and beyond.

### 1.1 Public policy with goals and objectives

Herein is an outline of issues and potential strategies for developing a long-term approach to any region, community, or nation-state’s eco-energy infrastructure. Consistent with the other infrastructure categories that the California Governor’s Commission on Building for the 21<sup>st</sup> Century addressed in 2002, the discussion frames long-term goals with a 20-years time horizon, in addition to the immediate challenges that California needs to address to make progress on those long-term goals. The proposed strategies fit in the framework of a long-term approach for viewing energy-related infrastructure needs.

In 2005 Governor Schwarzenegger created a public-private team of over 250 people who reported on a Hydrogen Highway Roadmap. Then in 2006, bipartisan support for ballot bond measures totaling over US\$60 billion would be passed by the California voters for a variety of infrastructure needs. Eco-energy issues are part of these infrastructure needs but it remains to be seen

if the programmes and ideas from Governor Davis' Commission for the 21<sup>st</sup> Century are followed. Below are some specific ideas and programmes for eco-efficient energy infrastructures.

Several specific cases and programmatic ideas are given as examples as to how to meet the eco-energy challenge. Basically, California had not done planning in the area of infrastructures for over 30 years. Governor Davis started considering these issue in 1999 prior to the energy crisis. In fact, originally there was no reference or mention of energy as an infrastructure issue in the summer of 1999 when the Executive Order was issued to create an Infrastructure Commission for the 21<sup>st</sup> Century. By the fall of 2000, energy was specifically added due to the growing energy crisis. Much of the content of the discussion provides the basis for a formal presentation and inclusion into the 21<sup>st</sup> Century Commission's report itself. Examples of the goals for long and short terms are:

#### *LONG-TERM (10 years) GOALS*

The long-term (10 years) goals for the nation-state energy challenge are:

- Ensure that all citizens have reliable, affordable, and cleaner energy.
- Achieve a diversified energy base, by increasing the share of renewable sources of power to one-quarter (25 per cent) of the total.

#### *SHORT-TERM (3-5 years) GOALS*

The more immediate, short-term (3-5 years) energy challenges are:

- Meet the short-term energy needs of all citizens through conservation, efficiency, and emergency measures that lead to a long-term integrated system.
- Develop a plan for increasing the diversity of future power generation sources and transmission methods.
- Create a cabinet-level entity to consolidate energy-related functions, and coordinate inter-agency resources for greater efficiencies.

### 1.2 Crisis leads to change for government and business

The energy crisis in any nation-state is a challenge for all its citizens. This crisis had deep historical roots. Experts showed that the problems associated with the current situation are the result of a complex web of events, many of which predate the state's actual electrical restructuring, and many that were not even part of the restructuring. Yet the "design flaws", as some economists labeled it, were not the only problems. Nor can experts point to the so-called success of other states or nations. There were few.

The few examples of any successes were often cited and include New York, Pennsylvania, and New Jersey. In fact, if the chart were made one year ago, many would have placed California's deregulation in the success column. Then for these other states came the summer of 2005. The entire northeast of the US (over 50 million people), including these three states among others, had a long power blackout in August 2003. Europe also had an extensive blackout in the same time period. In France alone, over 12,000 died due to the heat and other conditions related to energy shortages.

Leaving energy, water, environment, or waste management, among other infrastructure sectors, to the "market" or "competitive forces" of supply and demand was wrong in the first instance. The predictable results were monopolies of supply. Instead, all governments must adhere to a higher standard for the public good. The basic issue in other words is a "philosophical", and hence political, one. Governments cannot allow monopolies of vital infrastructure sectors like energy.

The purpose of business is to make money and control markets, as well as to quell competition. Basic economics teaches this perspective and is apparent in historical understanding of other vital public sector infrastructures, such as transportation, telecommunications, and information technology. The United States government's court case against Microsoft is a recent example. This does not mean that these sectors must be heavily regulated or controlled by the government.

Indeed, that would be difficult and counterproductive. However history has shown that there is a need to consider the public good in certain infrastructure sectors (Meyer, 2000). Equally important, there are business opportunities in these sectors, as when electricity and transportation sectors are integrated and hence can share the need such as infrastructures for a highway that can also transmit or conduct energy via wires, pipes or sub-stations. In some countries, the building of hydrogen highways is directly linked to the use of hydrogen for local on-site power for buildings. The concept is that hydrogen as fuel for vehicles may not be ready for the mass market for another 8-10 years. Meanwhile both transportation and energy needs for power can be shared and built into the same infrastructures. When energy and transportation systems are leveraged into related resources such as the use of electricity and/or hydrogen then the result are lower prices to consumers in both sectors (Lund, 2000). Energy and environment, like water and waste, should not be subject to such economic and business forces that leverage each sector with the other one (Clark, 1998, 2001, and 2002). Hence the overall public good is served by more efficient and less costly but reliable systems.

It is this last point that perhaps is the most significant for those who have searched for a definition of "sustainable development" since the Brundtland Report in the late 1980s.

*Sustainability is one of the most ubiquitous words in contemporary development discourse...[as it is] a well-accepted value as far as environmental protection is concerned, but its implementation has been slow because of perceived conflicts with other community goals, especially economic development. (Bradshaw and Winn, 2000: 1)*

California is in the midst of becoming the first "sustainable" nation-state. More significantly, it is transforming the energy and environmental protection regulations from the past decade into the opportunities for new emerging technologies, clean energy, and environmental industries. As Porter and van Linde (1995) and Clark (2000) note, environmental regulations can spawn clean economic and business development. Investment in renewable energy and environmental technologies, generation, and related emerging technologies is critical (Younger, 2000).

Examples of business cases and public policies are presented below, as the California energy challenge becomes the leading impetus to a sustainable society. Strategies and public policy recommendations are outlined.

## 2. THE NEXT TWENTY YEARS

### 2.1 Meeting the eco-energy infrastructure challenge

A reliable supply of cleaner energy is clearly essential to any nation-state's continued economic progress and quality of life. It is a foundational component of the state's infrastructure. The demand for energy is pushed upward both by structural changes in the economy and lifestyle decisions. Over the next 20 years, all nations must solve the problem of matching cleaner supply with increasing demand.



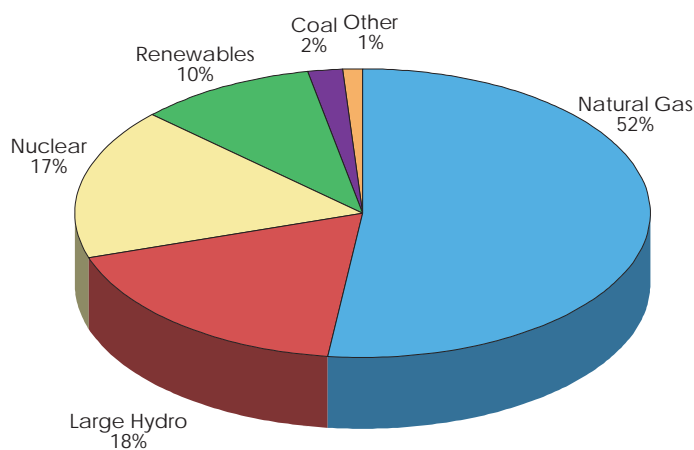
## 2.2 Short-term energy trends and issues

Projected California state requirements for energy needs in the year 2020 are: 40 per cent more electrical capacity, 40 per cent more gasoline, and close to 20 per cent more natural gas (California Energy Commission, 2001). Additional large gas-fired energy plants need land, water, and fuel; they produce air emissions and other impacts requiring mitigation.

The state had no plans to expand or import its oil refinery capacity, so that its future need for an additional six billion gallons of gas would need to be imported. However, gasoline, when combined with increasing transportation demand and traffic congestion, created a significant increase in air emissions. Los Angeles' air pollution levels declined until 2002 due to strict air emissions requirements. However, it later saw increasing air pollution due in large part to an increase in vehicle highway usage.

Furthermore, the need for additional natural gas for "clean" fuels to power vehicles and energy generation caused the state's annual demand for 40 per cent natural gas to raise to over 50 per cent in recent years. Additional means of transportation via highways, pipelines, and liquefied natural gas terminals (which were completed by 2005) to California were seen as the policy and economic solutions. However, the state would become more and more dependent on these external (often foreign) and capital-intensive resources, which would create stranded costs for the long term. This is a key issue in that stranded costs are those capital costs which need to be expensed and paid for over 20-30 years due to debt repayments. Hence the new facilities mean that a community, city or state will be paying for these costs for a long time and thus limit new technologies, alternative fuels and cost saving measures. Therefore, the state would be at the mercy of the natural gas industry and its price fluctuations, which tripled from 2001-03 alone. And as Meyer (2000) notes, by the end of this century, the worldwide gas supply will be exhausted.

Figure 1 Share of in-state power generation fuel mix



Source: Rand Institute, February 2001.

The immediate strategy for meeting higher energy demands, however, should be incorporated into a long-term fuel source diversification strategy so as to limit future dependency on any one type of fuel. As Figure 1 indicates, by the spring of 2001 the state already derived 52 per cent of its fuel supply from natural gas. All but one of the new power peakers and plants that were approved and funded are natural gas fired facilities. By mid-summer 2001, 9,000 MW of new power plants were natural gas fired. However, also by mid-summer, over 4,000 MW of renewable energy facilities were under active negotiations to round out the California Power Portfolio.

### 2.3 Long term plans: Renewable portfolio standards

While the energy crisis in 2000-01 had the attention of the public at the time, over the long-term, demand reduction strategies must become a “way of life” for the state’s businesses and residents. The state has the fifth-largest economy in the world. California ranks as the tenth-largest user of energy in the US and is among the top three states in conservation, efficiency, and demand reduction. Nevertheless that is not enough to avoid predicted energy shortages in the future.

For example, in February 2001, the governor announced an energy conservation goal of 10 per cent demand reduction by the state government and asked citizens to seek at least an 8 per cent reduction. In March 2001, statistics showed an overall 9 per cent reduction from the year before. By June 2001, the state had achieved 12 per cent conservation savings. This amounted to about 5300 MW saved from the year before from the overall 52,000 MW of power used daily by all Californians.

This conservation programme, known as Flex Your Power (figure 2) allowed the state to escape serious blackouts during the peak demand period from June–August 2001. The programme provides public awareness about energy usage, conservation, and efficiency. It is so successful that it continues today under different governments and political philosophies (see <http://www.fypower.com/>).

By the summer of 2001, a number of new power plants were planned for construction (over 10 are now in operation and another 17 are being built). Most of these plants are power peakers designed to address the immediate need for more capacity in the near-term summer and fall of 2001. This additional power supply primarily required the use of natural gas, most of which is brought into the state.

The systems did not use renewable energy sources. By 2002, the state issued a Renewable Energy Portfolio Standard (RPS). Goal of 20 per cent renewable energy generation by 2025. At the time, the state had less than 10 per cent and did not include hydroelectric dam generation. When Governor Schwarzenegger took office he soon thereafter (2004) declared that the state would meet a RPS goal of 25 per cent in 2013. Since then he and local communities have all pushed the RPS up to 25 per cent by 2010.

Figure 2 Flex your power programme (2001-today)



In developing its long-term strategy for energy, nations and regions need to address energy issues such as conservation, efficiency, supply, and transmission. Part of the tactical definition of sustainability includes the control over, or at least the setting of, rules for commerce

and business. Assuming that energy is a commodity (electrons) that must be regulated, and rules are set by government for its use, then there is a need for the state to have control/make rules over energy generation and transmission.

### 3. ACTION PLAN

#### 3.1 Framework for eco-energy efficient infrastructure planning

Given these issues, trends, and strategies to meet energy goals, as well as new positive opportunities on the horizon, there are new ideas that can guide a state's plan to meet its future energy needs. Clearly, there are a number of parameters that frame a plan for the future. The European Union did something similar in 2003-04 with a focus on regions and innovation (Clark, 2004a and b). The basic actions to consider are:

- ✓ Learn from the past. The past 30 years of energy trial-and-error is a vital source of lessons, both positive and negative, about how to manage our energy future. Decision makers must be candid about what has worked and what has not.
- ✓ Make decisions in the near term that align with long-term goals and strategies. The current crisis, which will no doubt be resolved in the near term, provides our challenge and hence an opportunity for all sectors to provide future residents with reliable, affordable, and clean energy for the long term. Decisions today clearly frame the choices for tomorrow.
- ✓ Operate through collaboration and partnership whenever possible. With the necessary changes in policy, resource commitments, behavior, and increased capacity, all partners from the household, community, and regional levels in the business and civic sectors together must help solve this problem.
- ✓ Enhance energy self-sufficiency. A government must accurately project, measure, and monitor its actual energy needs, and develop a sufficient supply to meet those needs, using a mix of conventional and alternative energy suppliers, coupled with increased efficiencies and demand management strategies. Future fuel supplies should be based on a diversity of sources, to avoid market distortions from over-reliance on one or a few sources.
- ✓ Use new "return on investment" models for public sector investment. Create an investment finance model, as used in other states and industrialized countries with considerable success, which allows for equity investment, particularly venture and risk capital for energy and environmental research, early product development, etc.
- ✓ Use green accounting. Create new public sector accounting methods such as those used now in the private sector. Traditional accounting cost-benefit models that only promote governmental incentives include tax breaks, rebates, or loan guarantees, have met with varying degrees of success and are not adequate.
- ✓ Place a high priority on a return on the investment for all investors. These have typically been managed through a public-private partnership. Government needs to be able to have an "equity stake" in its investments through grants, finance mechanisms, and incentives.

- ✓ Integrate energy efficiency and self-sufficiency into all infrastructure systems. All infrastructure investment, whether land use, housing, school facilities, or water delivery, should be held to the highest standard of energy efficiency, including:
  - a) Transportation, which accounts for about 40 per cent of the state's total daily energy consumption.
  - b) Water, which requires more energy than it currently generates.
  - c) Waste, which through biomass and other environmental methods can potentially generate large amounts of power.

Efforts should be made to ensure efficient technology transfer across infrastructure systems, e.g., fuel cells can serve two infrastructures, such as energy and transportation, at the same time (Clark and Paolucci, 1997). The fuel cell can be used in a vehicle for daily usage, and also be used to power buildings. This turns a crisis into a challenge, and thus into an economic opportunity. Regions and nation-states can become the leaders in sustainability with energy and environment becoming synonymous with economic growth and business development (Clark, 2001).

That is the challenge from the energy crisis. Building on the investments that a state has already made in the diverse tools and technologies for renewable and alternative energy sources, we can develop our future energy capacity consistent with the state's commitment to clean sources of energy. We can work with leadership companies to foster and disseminate information on best practices for use by other public, civic, and private sector partners.

### 3.2 Case study: Distributed renewable energy systems

Distributed energy systems or local and regional control over energy within the overall state framework for sustainability forms the basis for a new energy infrastructure (Clark, 2004c). There is great potential for distributed energy generation systems, especially renewable or clean energy systems. Developed primarily in Europe, many communities in the United States are now developing similar programmes, focused in many cases on co-generation or combined cycle (the combined production of heat and electricity) using renewable energy.

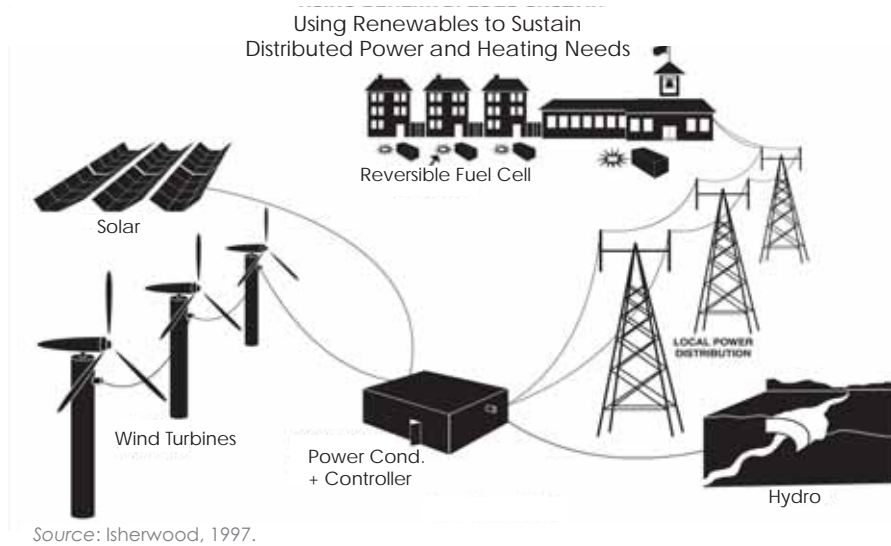
Energy can be a "dispersed" energy system (Summerton and Bradshaw, 1991) or distributed energy systems on the local level (Lund, 2000). Energy will not be subject to a central grid and control by only a few companies. Isherwood *et al* (2000) outline in an optimization model on how such distributed energy systems would work in remote communities. Examples of renewable distributed systems were done in Alaska and Maine. Figure 3 is an illustration of how a local distributed energy system could work.

### 3.3 Case study: Agile energy systems: The potential for renewables

Public incentives to support the wind industry in the late 1970s and early 1980s led to many investments for tax breaks instead of for business development. When the subsidies ended, most companies went out of business. However, one wind energy firm emerged from bankruptcy under a new management team with one of the original investors, and is very successful today.

It operates at a good profit and provides excess power for the grid in its region. The business model works for over 400 investors (shareholders) who believe in the value of renewable energy. Other renewable energy developers and manufacturers (including PV, biomass, and geothermal

Figure 3 Distributed energy generation systems



energy) are taking the opportunities to mix central grid-connected energy generation with on-site or local power generation, combining energy demands with entrepreneurship and business prowess. These “agile energy systems” combine all the eco-efficient energy systems and technologies. Some journalists have described these approaches to energy as akin to the way information flows on the internet.

#### 3.4 Case study: Industrial symbiosis: Converting waste into raw materials

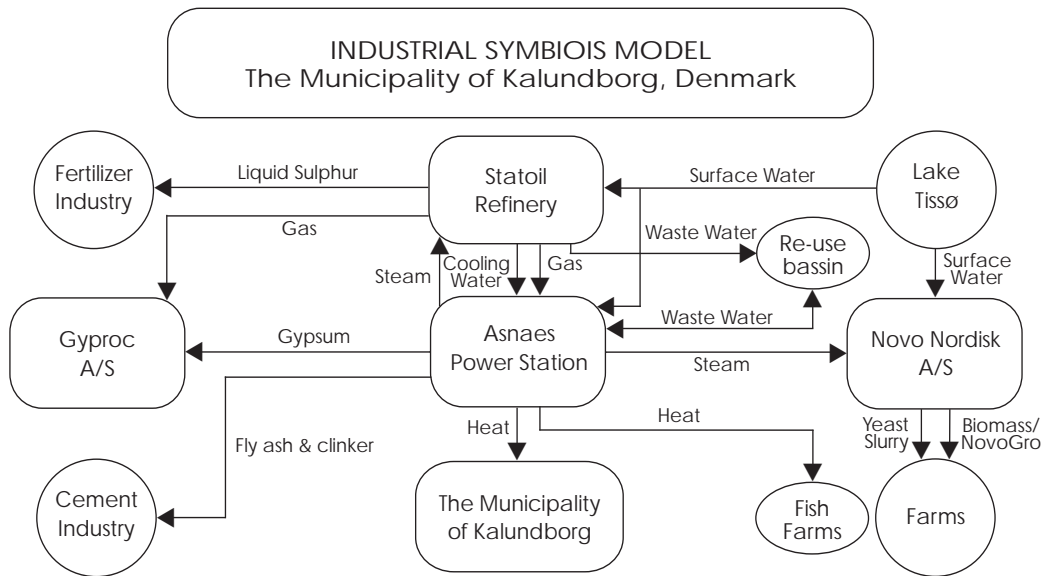
A number of “best practices” exist that demonstrate in a practical manner that new forms of eco-energy infrastructures can be implemented across sectors. For more than 25 years the city of Kalundborg in Denmark has had an industrial development project involving at least three sectors: energy, environment, and waste.

The city created a programme called “industrial symbiosis” where the waste of one company became the raw material for another. This local business-energy model is a public-private sector partnership involving companies in the three sectors, with a very positive economic benefit. Another advantage is the location and control of the energy infrastructures at the local level.

The industrial symbiosis model has gained international attention and major industrial corporations replicate the process in other communities. Energy infrastructure firms have developed tools and computer programmes for use by communities and regions for replicating the model. Figure 4 illustrates how this integrated system works.

Finally there are numerous examples of buildings and communities who practice eco-efficient energy systems. Buildings can be certified as Leadership in Environment and Energy Design (LEED) or “green” and also have hybrid or combined technologies for many purposes, ranging from conserving water, waste, and energy to providing power for the building. One example in figure 5 is from the Natural Resource Defense Council (NRDC) in Santa Monica, California.

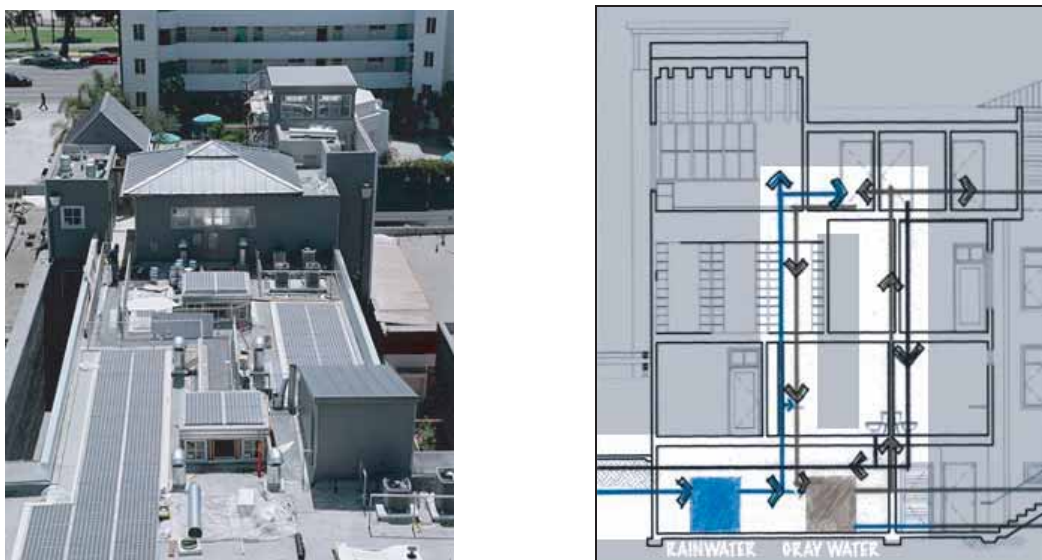
Figure 4 Industrial symbiosis model



Source: The Symbiosis Institute, The Industrial Development Council, Kalundborg Region, Denmark.

This building is entirely self-sufficient. All of its resources are reused and supplied within the building. Waste water is recycled for watering plants. Solar power supplies all the building's energy needs. Figure 5 shows the top of the building and how the solar panels are positioned along with the natural air circulation ducts on the roof.

Figure 5 Natural resources defense council (NRDC): Inside hybrid eco-efficient energy system (on left). NRDC roof top with solar power and roof ventilation (on right)



Source: Natural Resources Defense Council, Santa Monica, CA. 2005.

## 4. PROPOSED STRATEGIES FOR GOVERNMENT

### 4.1 The solutions and action items

Public policymaking must be public-private partnerships that provide finance, regulations, standards, and codes. California, for example, seeks to become “energy independent” through implementing diversified energy and environmental policies and creating eco-efficient infrastructure such as the “Green Hydrogen Highway”. A public-private partnership created a roadmap that has now been funded by the state and is being implemented. The basic implementation aspects of public policy for infrastructure are the following:

- Civic markets, public sector as market driver with the civic core focus.
- Public policy must be set at the top with rules, standards, programmes, and mechanisms for implementation.
- Procurement procedures that focus on eco-efficient specifications.
- Finance mechanisms such as life cycle analysis and industrial symbiosis, whereby the wastes from one industry are the raw materials for another.
- Due diligence over the policies and programmes for implementation and operation.
- Public outreach and awareness for conservation and lowering demand.

There is a dynamic global paradigm change in which the public is aware and concerned about global warming and climate change. Infrastructure is a key element in the stability and economic development of any community. This paradigm and public awareness means that eco-efficient and environmentally compatible systems must support a reversal of global warming.

The key elements to the eco-efficient energy paradigm are the following:

- Major transition in the way global policymakers and industry decision makers frame and implement sustainability to solve energy and environmental issues.
- Diversification of energy supplies at the state and local levels through clean and renewable sources.
- Hybrid technologies combining renewable energy and storage devices to cut costs and combine efficiencies.
- Definition of time periods and terms: short-term transition of 3-5 years from a “clean” to a “green” hydrogen economy and infrastructure.

### 4.2 Four elements for eco-efficiency

Elected or appointed decision making group must make policies and set standards that are publicly acknowledged, distributed and enforced. Moreover, education is a critical part of public policy because there must be trained and educated people to implement, monitor, and maintain eco-efficient energy infrastructures in the future. Examples of the elements in such a programme can be developed and structured in four eco-energy efficiency areas for public policy as seen in figure 6 over leaf.

Figure 6 Example of an eco-efficient energy infrastructure community proposed for Hong Kong, China

STELLAR ENERGY SOLUTIONS



HYDROGENICS -- HYDROGEN

Source: Stewart energy Systems, Toronto, Canada, 2005.

- (1) Conservation, efficiency, and performance energy demand programmes
  - a) Retrofit all energy-consuming conditions in buildings and communities to maximum efficiency and use of materials.
  - b) Use state-of-the-art technologies for conservation in all buildings.
  - c) Meter and monitor systems for energy flows and to audit results of new policies and programmes for buildings and complexes.
  - d) Leverage funding from the private sector with the public sector into partnerships.
  - e) Aggregate purchases and specifications (that is, the accumulation of all demand for specific products so that they can be purchased off one Master Contract) for systems through detailed technical audits.
  
- (2) Set high public policy goals, e.g. 1 MW solar/PV systems per location
  - a) Contract private industry as third parties to co-finance, install, operate, and maintain.
  - b) Provide areas and locations such as parking lots and building roofs.
  - c) Apply LEED (Leadership in Environment and Energy Design) standards for buildings as integrated into a renewable eco-energy power system.
  - d) Apply local incentives for solar/PV to complement the state or nation's policies (e.g. programmes in California, Denmark, Germany, and Japan for solar and wind, bio-mass, and conservation/efficiency).
  - e) Establish national public policy such an Energy Act and Action Plan with finance incentives as grants, equity, rebates, or tax breaks.
  - f) Procure public eco-energy efficiency supplies through aggregated buying of systems, vehicles, buildings, and equipment, etc.
  - g) Implement hybrid systems with renewable energy power generation along with storage and future technology innovations.



- (3) Sustainable development curriculum for education, training and trades
  - a) Buildings and complexes focus on training courses as certificated, licenses and degrees from academic institutions, unions or trade groups.
  - b) Career opportunities created to train for new jobs, entrepreneurial companies and advanced degrees in this field.
  - c) Collaborate with unions, private businesses, public, government, and non-profit sectors.
  - d) Provide actual experiences on campus through building programmes.
  - e) Develop sustainable development curricula for education in solar, wind, geothermal, hybrids, etc. as well as new businesses, accounting, operations, and maintenance.
  
- (4) Renewable energy generated central plants
  - a) Establish efficient renewable energy central plants in malls, office buildings, college campuses, and residential communities.
  - b) Set goals for LEED standards in all buildings that have the communities integrated into central power plants.
  - c) Connect entire building groups or use multiple central plants throughout a region.
  - d) Finance central plants from third parties based on the complex, building, or area's load demands.
  - e) Construct buildings with sustainable water, waste, transportation, and related infrastructures.

## 5. CONCLUSIONS AND RECOMMENDATIONS

Sustainable communities in terms of energy must be seen as “independent”. That is, eco-energy independence is the goal for local communities. Such goals are often perceived as a threat to the established approach to energy and related infrastructure planning and implementation. Nation-states tend to want to control and centralize infrastructure systems into a central power and administrative authority. Traditional energy (and other sectors such as water, waste, environment, etc.) infrastructure is no different. The issue is that governments must be concerned with energy and other infrastructure for the public good. This basic vision remains the same.

Although the historical paradigm is changing, the new paradigm of eco-energy efficiency is not a totally opposite approach from the conventional eco-energy paradigm that currently predominates. In other words, the eco-energy paradigm is not a choice between public and private generation. That is the classic economic approach that has been shown to be wrong. Instead, eco-efficient energy systems have a civic core or public good purpose with strong input from the private sector. The new paradigm is a “civic market” approach. The result in energy is “agile systems” or eco-efficient energy systems that combine industrial symbiosis, energy conservation, and demand controls along with renewable energy central grid and on-site generated power.

As an example, Los Angeles has a programme for its nine community colleges that illustrates how sustainable development in the 20<sup>th</sup> century was very much non-existent. It focused on energy needs that were supplied only by central power plants, primarily from the Los Angeles Department of Water and Power (LADWP). Over 45 per cent of the energy generated for the Los Angeles area (over 2.5 million customers) came from coal-fired plants on Indian reservations in another state. The LADWP is the largest publicly owned energy system in the US.

The development of sustainable systems such as renewable energy sources was slow and costly until only the last decade. But conventional central power plants still exist today and with deregulation or privatization have been transferred (sold) from public sector control to private sector companies. The result has been both chaos and outright financial ruin. Many are bankrupt and others simply committed fraud.

Visionary public officials must create public policies for eco-efficient energy infrastructures. Public policy needs to lead through actions including the securing of financial resources. For sustainable development to succeed, local and regional resources need to be created, leveraged, and combined with new technological advances to create agile or flexible energy and environmental systems depending on their own local needs, resources and human capital. Colleges and sub-areas of cities can be the model for agile eco-energy systems. Such communities provide infrastructure services for local power, water, telecom, waste, and transportation, among other things, to clusters of buildings such as homes, businesses, and office complexes as well as shopping streets and malls, colleges, public buildings, and apartment buildings in the local community.

This model of sustainability works and exists globally. There are corporations who work in these areas, and associations provide data and information. Above all sustainability must provide energy independence and security. In the end, sustainable communities must develop waste, water, transportation, and telecommunications for their regions. These communities need to be interconnected with other communities, which redefine the conventional central power plants and unsustainable infrastructure systems that exist today.

Today, the paradigm change to sustainable communities will continue to be difficult and painful (smaller central power companies mean a reduced workforce and income), but are necessary for a less polluted environment and cleaner world for tomorrow. And as these companies reorganize, new companies and technologies are being created for the future. The result is new business development opportunities along with educational and entrepreneurial firms. In the end, the transitional changes will not take long to result in economic benefits to the communities and nations.

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# Green building system: Eco-efficient construction strategy adapted to the climate of Asia and the Pacific

Chungyoon Chun and Hyojin Kim  
College of Human Ecology, Yonsei University  
Republic of Korea

## 1. INTRODUCTION

Buildings are big consumers of chlorofluorocarbons as well as fossil fuels. In many developed economies, buildings use about 50 per cent of fossil fuels. Thus in order to realize worldwide sustainable settlements, the saving of energy in the building sector is all-important.

In this paper, we want to propose an eco-efficient construction strategy as one of the solutions to global climatic change. The rising problem of global climatic change has highlighted the need for a new approach in designing buildings that considers energy use in buildings. These new paradigms such as Passive Design, Green Building, or Ecological Architecture become a significant part of the path to a sustainable future. The first part of this paper will introduce these new movements in architecture.

## 2. PASSIVE BUILDING

We can mention regionally appropriate buildings or passive buildings as core strategies for sustainable settlements. In ancient times, people developed climate-adapted buildings and houses for their local environments. We can call these buildings regionally appropriate buildings, and a number of examples of regionally appropriate design could be found from traditional architecture (figure 1). Traditional dwellings were developed in different shapes according to their regional climate. The Mongolian *ger* is very effective in blocking the wind. Tropical Queenslander houses show high ventilation efficiency by its open design, and an igloo in Alaska has the most effective shape for minimizing heat loss.

However, in these days, buildings in every urban area have almost the same design. The panoramic scenes of Seoul; Singapore; Tokyo; Hong Kong, China; and other developed cities are very similar, and the designs of buildings are very similar, too. People might be hard to distinguish these developed cities only with their photographs, and this means that regionally appropriate design hardly exists in Asia's urban areas. Moreover, with the spread of air conditioners and Heating Ventilation and Air Conditioning (HVAC) systems, modern buildings have changed their character into high-energy buildings. As an alternative plan to high-energy building, passive design has been proposed.

Passive design means designing buildings to avoid or reduce the need for mechanical cooling or heating. Good passive design responds to local climate conditions in order to make occupants

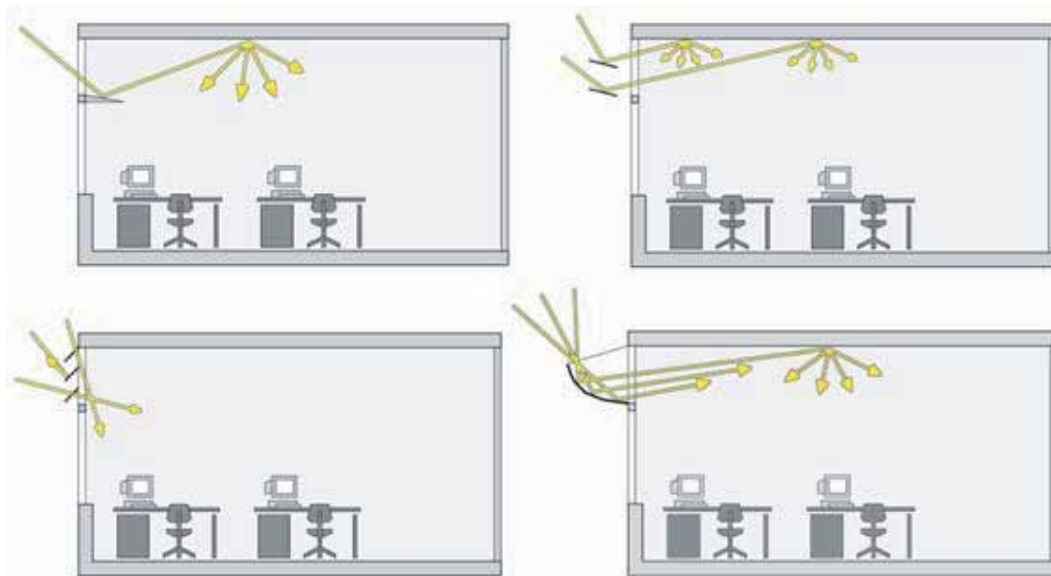
more comfortable, and it also reduces the running costs of a building by using less energy and other resources. Climate-responsive design and green building could be also regarded as synonyms for passive design. Climate-responsive design is an integral part of the environmental framework that is being developed to reduce environmental impacts and provide for people's well-being. One main feature of climate-responsive design is to use passive climate control systems rather than rely on active energy systems that consume non-renewable resources.

Both passive design and regionally appropriate design intend to make settlements more sustainable through the utilization of environmental energy. Environmental energy means the energy gained from the sun, water, soil, and air. Future buildings will turn more and more to passive and active measures to make use of environmental energy, which can reduce energy demands and consumption while protecting the environment. In the next section, the paper will introduce how to use environmental energy through some building examples.

## 2.1 Environmental energy from the sun

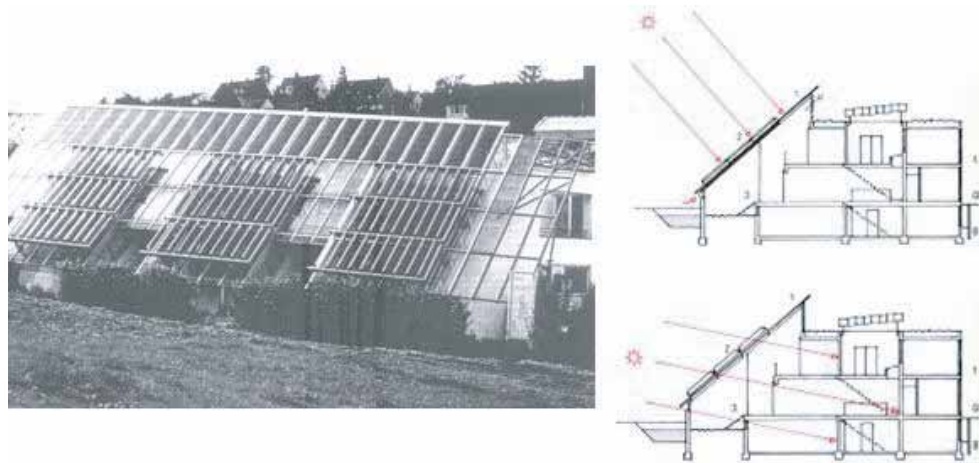
We can use solar energy by using daylight refraction systems and photovoltaic (PV) modules on building envelopes. We can maximize indoor lighting by using daylight refraction mirrors and prisms. Figure 1 shows various daylight refraction techniques, which provide comfort as well as savings from not having to use artificial lighting energy. Figure 2 shows a residential complex designed by HHS Architects + Planner BDA for the 1993 Stuttgart International Garden Exhibition. The intelligent façade of this building with photovoltaic modules can be adjusted to the angle of sunlight depending on the season, and this PV module produces an energy yield of 1,300 kWh per year, about two-thirds of the building's annual electric power demand.

Figure 1 Various daylight refraction techniques



Source: <http://www.schorsch.com>

Figure 2 Residential complex, 1993 Stuttgart International Garden Exhibition

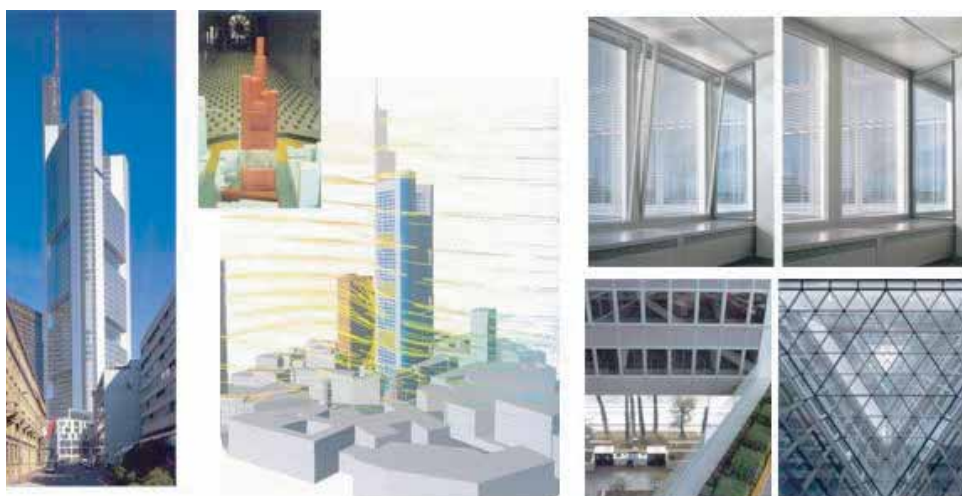


Source: Klaus Daniels, *The Technology of Ecological Building*, Birkhäuser Verlag, 1995.

## 2.2 Environmental energy from air

Through natural ventilation, we can reduce the cooling loads of buildings (Figure 3). Commerzbank headquarters in Frankfurt, Germany, uses a central atrium and double skin façade to promote natural ventilation. Computational Fluid Dynamics (CFD) analysis and wind tunnel experiments were conducted before construction to predict the distribution of atmospheric pressure and the blast effect by this tall building. As a result, energy use for cooling, heating, and ventilation were significantly reduced compared to the energy use in conventional air conditioned buildings.

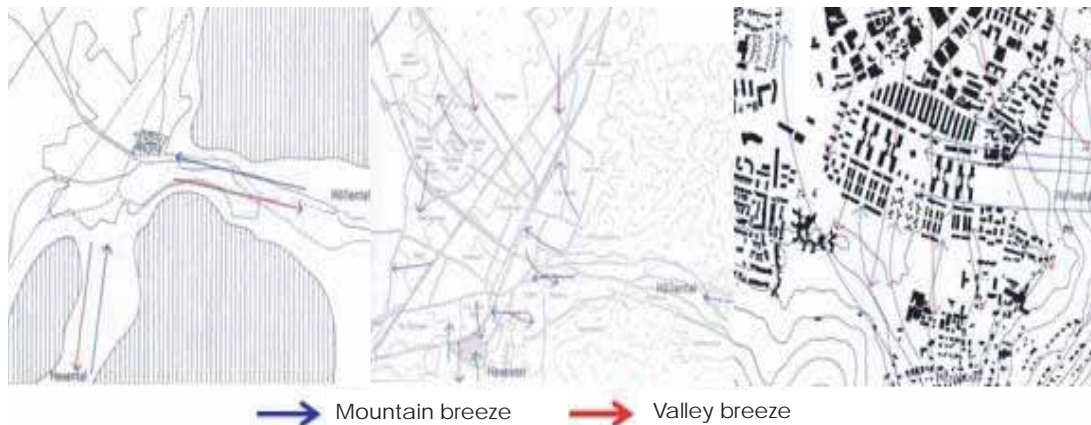
Figure 3 Commerzbank headquarters in Frankfurt, Germany



Source: Colin Davies and Ian Lambot, *Commerzbank Frankfurt: Prototype for an Ecological High-Rise*, Birkhäuser Boston, 1997.

The natural ventilation strategy can be applied at the city scale, too. Freiburg, Germany, minimized urban overheating by natural ventilation. The city created wind paths to alleviate thermal stress on the city. The street pattern has been laid out with consideration of the prevailing wind currents in this region – a mountain breeze during the night and valley breeze during the day – so this plan could minimize the heat loads of whole city (figure 4).

Figure 4 Freiburg in Breisgau district, Germany (Architect: Professor Pfeifer, Lörrach)

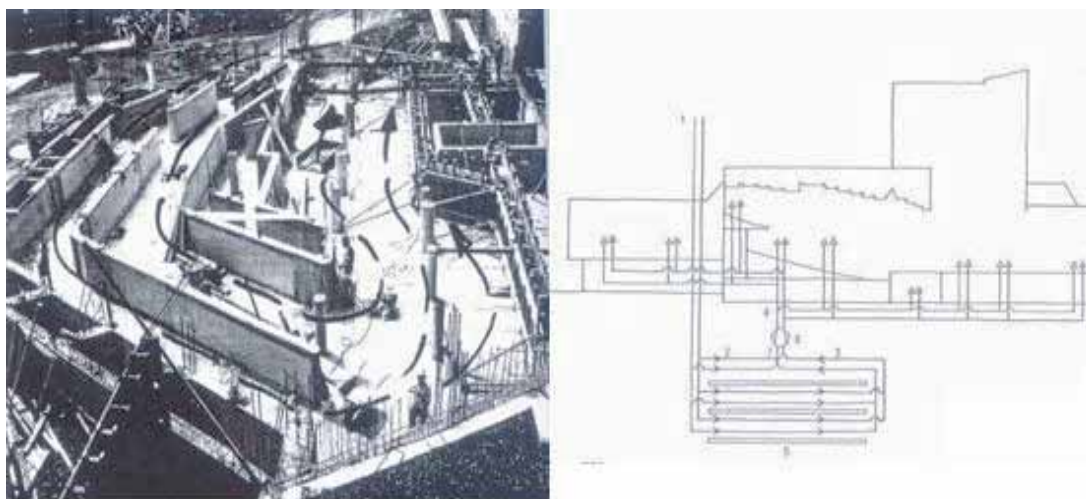


Source: Klaus Daniels, *The Technology of Ecological Building*, Birkhäuser Verlag, 1995.

### 2.3 Environmental energy from soil

By using stable earth and a groundwater temperature throughout the year ranging from 8°C to 12°C, we can cool air in summer or heat it in winter. Figure 5 shows the 140 meter-long thermal labyrinth beneath the ground floor of a new municipal theater in Heilbronn, Germany, with arrows indicating air flow. Figure 6 shows cave dwellings in Tunisia and China located in desert climatic zones. High thermal mass buildings absorb and store heat inside the walls, roofs, and floors during the daytime and release heat each night, making it ready to absorb heat again the next day. Thus these cave dwellings with high thermal mass could reduce the cooling loads and have a cool indoor temperature in spite of hot outside weather conditions as a result of the time lag effect, i.e., the time delay due to the thermal mass.

Figure 5 Thermal labyrinth under construction (left) and its cross-section (right)



Source: Klaus Daniels, *The Technology of Ecological Building*, Birkhäuser Verlag, 1995.

Figure 6 Cave dwellings in Tunisia (left) and China (right)



Source: Nick Baker and Koen Steemers, 2000, Energy and Environment in Architecture, Taylor & Francis.

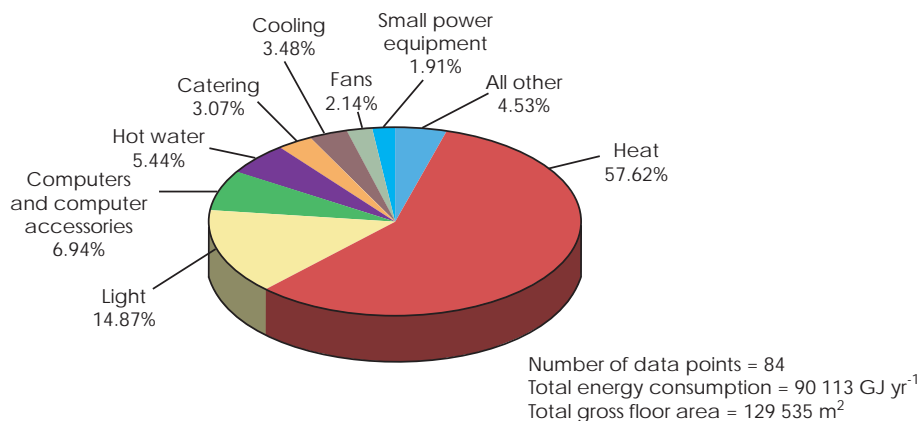


Source: Sei-Kwan Shon.

### 3. ENERGY USE IN EXISTING BUILDINGS AND THERMAL COMFORT

If we adopt the above-mentioned passive design and climate-responsive design to newly constructed buildings, it can reduce much of building-related energy consumption. Then what can we do for existing buildings? Figure 7.1 and figure 7.2 show annual energy consumption and carbon dioxide emissions of 84 office premises in England (ND Mortimer, MA Elsayed, and JF Grant, 2000). The biggest part is heating and cooling. Thus in order to save energy in contemporary high-energy buildings, it would be very important to find ways to reduce heating and cooling loads.

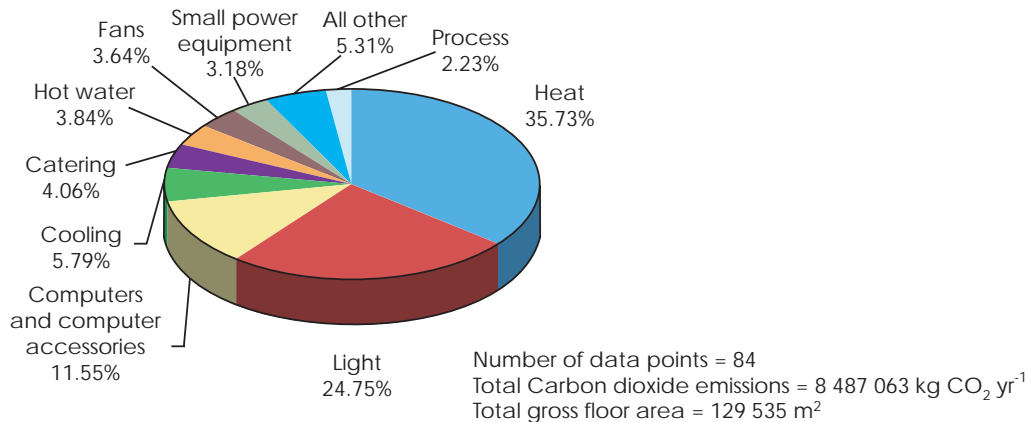
Figure 7.1 Aggregated annual energy consumption



Source: ND Mortimer, MA Elsayed, and JF Grant, 2000. Patterns of Energy Use in Nondomestic Buildings, Environment and Planning B: Planning and Design, 27(7): 709-720.



Figure 7.2 Carbon dioxide emissions by application for office premises



Source: ND Mortimer, MA Elsayed, and JF Grant, 2000. Patterns of Energy Use in Nondomestic Buildings, *Environment and Planning B: Planning and Design*, 27(7): 709-720.

The purpose of heating and cooling is to provide thermal comfort to the occupants, so this is the key issue in reducing heating and cooling energy needs. Thermal comfort is defined as “the condition of mind which expresses satisfaction with the thermal environment on ASHRAE Standard 55-2004<sup>1</sup> and ISO 7730-2005<sup>2</sup>.” Thermal comfort is an important aspect of user satisfaction, and the right temperature for thermal comfort is an important factor in deciding the amount of heating and cooling energy to use. Two models have been widely used to define comfortable conditions. One is the heat balance model, which is based on the results of laboratory experiments in the climate chamber; the other is the adaptive model, which is based on field survey results.

The heat balance model is based on the physics of heat exchange between the human body and the environment. It considers four environmental factors (temperature, thermal radiation, humidity, and air speed) and two personal factors (the occupants’ clothing and activity). The heat balance model is useful in defining the influence of various elements on the heat exchange, which ultimately governs our thermal relationship with the environment. However, when compared to people’s actual thermal responses in real situations, the results have been disappointing, particularly where people are in buildings with a lot of temperature variation. Because the experimental work used to build the heat exchange indices was carried out in climate chambers, they have little to tell us about the clothing people will normally be wearing, their metabolic rate, or their expectations about the environment. As a result, researchers are looking at the adaptive approach to see whether it can better predict thermal comfort.

The adaptive model is based on the adaptive principle. According to the adaptive principle, if a change producing discomfort occurs, people react in ways that tend to restore their comfort. These reactions include physiological, psychological, social, technological, cultural, or behavioral strategies. By linking people’s actions to comfort, the adaptive principle links the comfort temperature to the

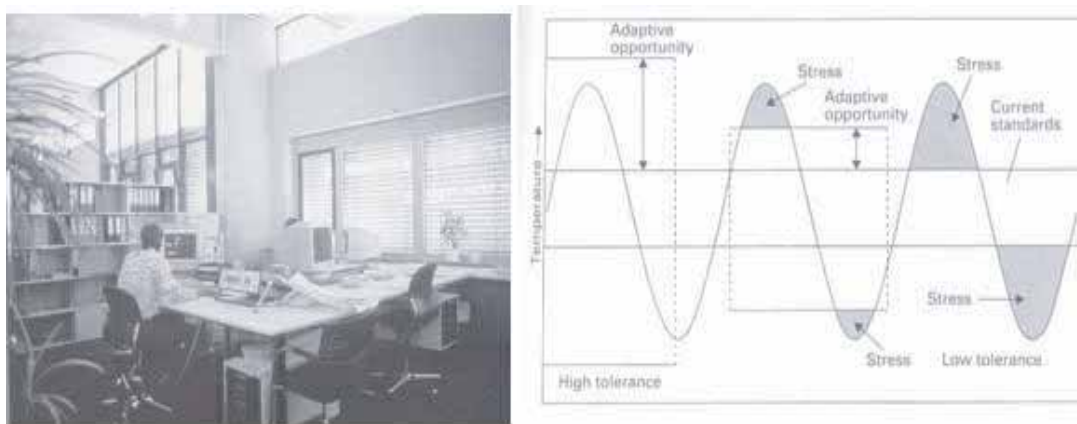
<sup>1</sup> ASHRAE, 2004. ANSI/ASHRAE Standard 55-2004. Thermal Environmental Conditions for Human Occupancy. Atlanta: American Society of Heating Refrigerating, and Air-conditioning Engineers, Inc. (ASHRAE)

<sup>2</sup> ISO, 2005. ISO 7730. Ergonomics of the Thermal Environment-Analytical determination and interpretation of the PMV and PPD indices and local thermal comfort criteria. Geneva: International Organization for Standardization.

context in which subjects find themselves. So, the comfort temperature is a result of the interaction between the subjects and the building or other environment they are occupying. Thus, people given more opportunities to adapt themselves to the environment, or to adapt the environment to their own requirements, will be less likely to suffer discomfort (Fergus Nicol, 2005).

There are many examples of adaptive opportunities including the following: the use of environmental controls including fans, heaters, and coolers; a movement within a space or between spaces to find more comfortable conditions; an addition or removal of clothing; adjustments of posture; and changes of activity. Figure 8 shows a workplace rich in adaptive opportunity and the effect of adaptive opportunity. As the adaptive opportunities become greater, more stress was reduced.

Figure 8 A workplace rich in adaptive opportunity (left) and the effect of adaptive opportunity (right)



Source: Nick Baker and Koen Steemers, 2000. *Energy and Environment in Architecture*, Taylor & Francis.

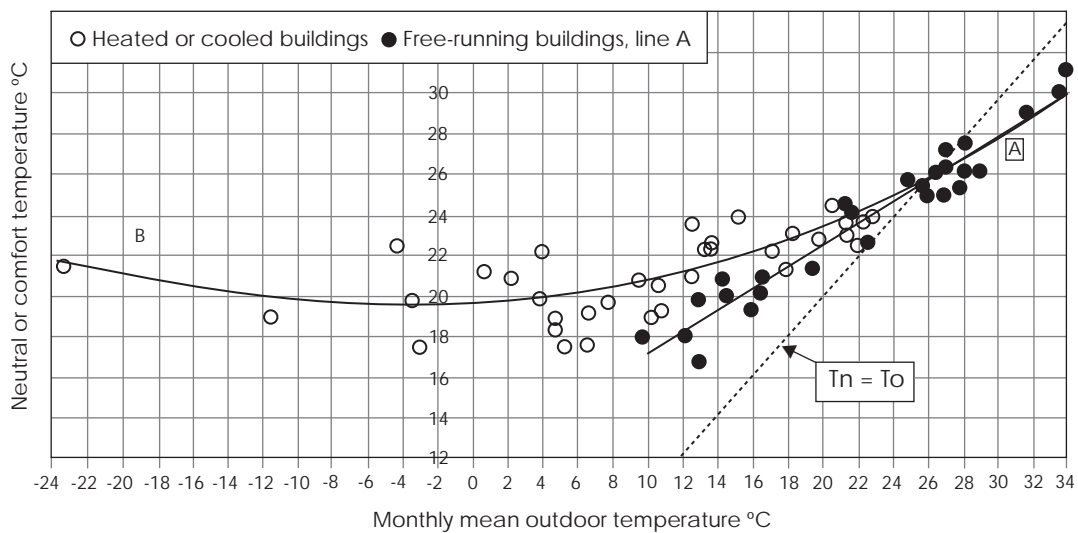
#### 4. ADAPTIVE MODEL AND HEATING AND COOLING ENERGY

In these days, many researchers and designers pay great attention to this adaptive model because of global energy problems. Humphreys (1978) plotted the indoor comfort temperature against outdoor monthly mean temperature based on a number of worldwide surveys (figure 9). As a result, free-running buildings (i.e., buildings that do not use heating or cooling machines) had indoor comfort temperatures that varied with the outdoor temperature. This means that the energy needed to provide comfortable temperatures could be reduced by the use of people's natural adaptive ability in free-running buildings. Occupants in free-running buildings might adjust their clothing, open the window, or operate fans according to the outdoor temperature in order to achieve their thermal comfort.

In the decades since, the proliferation of air-conditioning systems has created artificial indoor climates that are controlled regardless of outdoor climate. Thus the influence of outdoor climate on indoor climate has weakened. At the same time, the influence of indoor climate on human thermal comfort has increased as modern people spend most of their time indoors, more than 90 per cent of their time. This has led people to adapt to a closely regulated indoor climate rather than a fluctuating outdoor climate. Therefore, people's natural adaptive ability has begun to be controlled by artificially air conditioned climates, not by their regional outdoor climate.

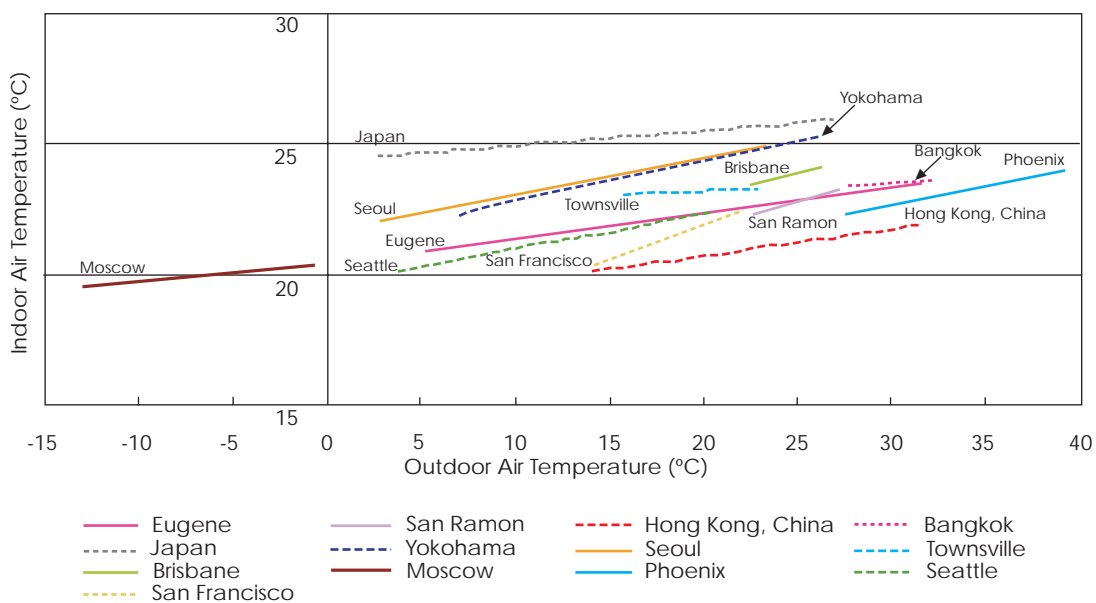
In one of our previous studies<sup>3</sup>, we collected indoor air temperatures of various buildings in a number of countries and compared them between cities. A plot of indoor air temperature against outdoor air temperature is given in figure 10. Rapidly industrialized cities located in hot and humid climates, such as Hong Kong, China and Phoenix, Arizona showed very low indoor temperatures compared to other industrialized cities in temperate or cold climates. This means that the popularization of air conditioning systems in hot humid cities made occupants want cooler temperatures, which requires more cooling energy in a very unsustainable manner.

Figure 9 A plot of indoor comfort temperature against outdoor temperature



Source: Humphreys, 1978. "Outdoor Temperatures and Comfort Indoors" in *Building Research and Practice*, Vol. 6.

Figure 10 A plot of indoor air temperature against outdoor air temperature



<sup>3</sup> Kim, Hyojin, 2006. *A Study of Human Thermal Adaptation State by the Comparison of Indoor Thermal Environments in Various Cities: Based on the Field Measurements in Korea, USA and Japan*. Dissertation, Yonsei University, Republic of Korea.

The operational conditions of buildings in much of the contemporary developed world resemble each other more and more since the present heating and cooling system has come into wider use. However, there are still cities in the hottest parts of the world where few buildings are air conditioned. If the buildings in these areas use conventional air conditioners in the near future and give up their traditional climate-appropriate designs, occupants would start the adaptation to cooler artificial temperatures, and their thermal preferences would change. Thus, indoor climates in entire tropical cities may become cooler than those in European or North American countries. They will then consume enormous amounts of energy for cooling and contribute to the heat island phenomena, which partly results from exhaust heat from air conditioners.

## 5. CONCLUSION

How can we change the direction of this rolling wheel? One of the answers is to define and promote Asia-Pacific climate-responsive building designs. This is the duty of the building and construction sector in order to realize sustainable development for our common future. Then what is Asia-Pacific climate-responsive design?

Most Asia-Pacific countries lie in temperate or tropical climate zones. They receive high levels of solar radiation and a heat surplus for a large proportion of the year, as well as higher temperatures and greater relative humidity. This means that the cooling demands in these regions are very high as compared to the heating demands in northern Europe and America. Therefore, we have to find the way through passive design to reduce heat in buildings. For example, when we plan the site, we should consider orientation, shading, and the microclimate of that site. Also, the promotion of natural ventilation and natural cooling will be important strategies. We can find many design tips from traditional architecture.

Next, in order to preserve natural human thermal adaptation, we must reconsider the popularization of air conditioning and develop an appropriate heating and cooling control method for Asia-Pacific. We also have to find ways to use the full ability of human thermal adaptation, if we want to avoid changing dynamic human beings into weak vegetation inside of green houses.

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# Engaging people in sustainability: NGOs' perspectives on the way to sustainable infrastructure development in the Republic of Korea

Yujin Lee  
Green Korea United  
Republic of Korea

## 1. SUSTAINABLE INFRASTRUCTURE DEVELOPMENT MATTERS

Sustainable infrastructure includes: (1) renewable solar and wind energy instead of nuclear and fossil fuels; (2) public transportation, such as rail, buses, and bicycles, instead of dependency on automobiles; and (3) Green gross national product (GGNP) or the ecological footprint instead of traditional gross national product. This paper will discuss how to implement these new tools in order to build a more sustainable infrastructure and promote green growth.

With this understanding, society should be able to move forward to actually change reality. However, the problem remains that we still hesitate to fully implement sustainable infrastructure development because we do not agree on how to convert our shared vision into a sustainable reality. The most intractable aspect about this problem is that we do not change anything as a result of this disagreement, and the conservative status quo continues to be dressed up as sustainable. However, can most people recognize the difference between sustainability in name only and sustainability in reality?

"Sustainable development" has been the answer to global development and environmental conflicts since 1987. *Our Common Future* (1987) defined sustainable development as "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable infrastructure development is also based on this basic definition. Keeping in mind this basic definition, the way towards sustainable infrastructure development is clear. This paper discusses the perspectives of NGO activists on infrastructure development in the Republic of Korea, specifically, three controversial cases of infrastructure development over the last decade. In each case, the stakeholders are the government, the Presidential Commission on Sustainable Development (PCSD)<sup>1</sup>, NGOs, and civil society.

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<sup>1</sup> In the 1990s there was a strong demand from civil societies and academia to establish a national organization for the implementation of sustainable development. As a result, some countries started to form National Commissions on Sustainable Development (NCSD). In the Republic of Korea, on 29 September 2000, the government's Presidential Commission on Sustainable Development (PCSD) was formed. It provides direct consultation to the president on major governmental issues and national politics. The role of PCSD was defined in Presidential Decree Article 1: "The mandate of the PCSD is to provide advice to the President on subjects related to sustainable and environmentally sound development, as well as the prevention and resolution of social conflicts."

## 2. IS INFRASTRUCTURE DEVELOPMENT IN THE REPUBLIC OF KOREA SUSTAINABLE?

Based on this definition, two questions arise: Is current infrastructure development sustainable? And, what is the highest priority for infrastructure development? These are hot issues in the Republic of Korea because environmental and developmental concerns are confronting one another. Fierce debate over the controversial Saemangeum reclamation project, which was initiated by the government in 1991 without deep consideration of environmental issues, has caused a great amount of social loss and conflict. In addition, construction of nuclear waste disposal plants, high-speed railroad construction through Geum-jung and Chon-sung Mountains, and Hantan River dam construction have been the main debates within Korean society over the last two to three years. These are huge government-led infrastructure development projects. Environmental groups are requesting reconsideration of this often destructive national policy on development because these projects are harmful rather than healthy and forward-looking. These policies did not even help economic growth because of the cost of environmental destruction and restoration. Some experts worry that the Republic of Korea is following Japan's "construction-led development" system.<sup>2</sup>

The Republic of Korea's government submitted the "Evaluation Report on Implementation of Sustainable Development" in May 2002 to the United Nations. In that report, the government outlined the following accomplishments: an Agenda 21 national implementation plan in 1996, and forming the PCSD in September 2000. NGOs organized the Korean People's Network for Rio+10 (KPNR) in March 2002. The standing point of Korean NGOs was critical for the government's implementation of sustainable development: "*Despite civil society's efforts regarding sustainable development and some noteworthy outcomes in the past 10 years, Korean society still has not realized sustainability due to huge challenges, such as the dominant growth-centered developmental paradigm, social inequality and deepening poverty, violence of militarism, and threats against peace.*"<sup>3</sup> The government's pushing ahead of the Saemangeum reclamation project, dismantling of the green belt, and construction of nuclear power plants are the main examples of environmental degradation. The following are examples of infrastructure development and how these conflicts were resolved.

### 2.1 Land Use: Can the Saemangeum reclamation project be sustainable?

In 1991, the government began building a 33-kilometer (km) seawall to block the flow of seawater across the Saemangeum<sup>4</sup> mudflats and "reclaim" them for agricultural use. The project was one of the biggest land reclamation projects in history, covering about 400 km<sup>2</sup>—more than six times the size of Manhattan. However, after the Sihwa Lake contamination issue raised controversy, demands for a re-evaluation of the Saemangeum project's environmental impact were accepted, and a government-civilian joint investigation team was formed in May 1999. They submitted a comprehensive report in August 2000, although the team failed to reach a consensus. On 21 March 2001, the PCSD recommended to President Daejoong Kim to re-examine the controversial project to assess its negative impacts on the environment.<sup>5</sup> The chairman of the PCSD Moon-kyu Kang said, "*To settle the*

<sup>2</sup> Park, Taekyeon, 2005. "Participatory government caught in a trap of 'Gunseol-jok'", Seoul, Korea: Views.

<sup>3</sup> Korean Peoples' Network on Rio+10, August 2002. "Standpoint of Korean NGO", Seoul, Korea: Korean Peoples' Network on Rio+10.

<sup>4</sup> The Saemangeum tidal flats formed over millennia as the Mankyung and Dongjin rivers deposited silt at the shore of the Yellow Sea. Teaming with fish, shellfish, and invertebrates, the mudflats support small-scale fishermen and their families. Saemangeum also provides the most important feeding ground for hundreds of thousands of shorebirds that migrate between Australia and the Arctic. Famished and exhausted from flights of several thousand miles, shorebirds rest and feed at Saemangeum for weeks at a time, preparing to resume their 9,000-mile journeys. Among the globally endangered species at Saemangeum are the spotted greenshank (estimated world population is 700) and the spoon-billed sandpiper (estimated world population is 2,000). The Ramsar Convention defines as "wetlands of international importance" those used regularly by 20,000 shorebirds. Saemangeum is used by over 500,000 shorebirds per year.

<sup>5</sup> PCSD, 22 March 2001. Press release, p 7.

*controversial issues surrounding the plan, such as securing farmland, protecting mudflats, and facilitating local development, the government should thoroughly assess the value of the mudflats as well as the farmland.*"<sup>6</sup> Later that year, in August 2001, environmental civic groups filed an administrative suit against the government demanding an end to the project.

In 2003, religious leaders, including Roman Catholic priest Gyu-hyun Moon, Buddhist monk Soo-gyoung, Christian leaders, and Won Buddhist clerics performed *Samboilbae* from the Saemangeum tidal flat to Seoul. *Samboilbae* was developed as a unique form of protest involving three steps followed by a bow with knees and foreheads on the ground to humbly demand that the government reconsider its Saemangeum policy. It was a 305-km journey spanning 65 days, completed with sincere spirits. The aim was to suspend the Saemangeum reclamation project. Participants expressed atonement for humankind's destructive acts that have been committed in the name of development. In July 2003, the Seoul Administrative Court ordered the temporary suspension of the controversial project until a court decision could be reached. On 4 February 2005, the Seoul Administrative Court ordered the government to reconsider the controversial Saemangeum reclamation project.<sup>7</sup> The ruling forced the Ministry of Agriculture and Forestry to consider three options: discard the project, alter the project's aim of creating farmland and a reservoir, or appeal to a higher court. "*The project inevitably needs to either cancel or change the authorization for the development, as it had no economic accountability and has a high possibility of wreaking havoc on the environment*", the court said.

Finally, on 16 March 2006, the Supreme Court ruled in favor of the Saemangeum reclamation project, and the Ministry of Agriculture and Forestry completed construction of a seawall on 21 April 2006. As the project continues, it will likely devastate local ecosystems and communities. If the rivers and ocean are blocked, the Republic of Korea may experience an ecological disaster similar to Shihwa Lake again. This would be tragic because people lost their ability to fish in Shihwa Lake, in addition to immeasurable damage to shells and local ecosystems.

The Saemangeum reclamation project is illustrative for having provoked huge public debate in Korean society about economic and environmental values – though in the end, economic values seem to have won. In fact, the Saemangeum project has lost its original purpose, and it has not been environmentally or economically justified. Rather, it is a purely politically motivated development project dating back to Tae Woo Roh's presidential campaign promises to the Jeollabuk province people. It was supposed to be farmland, but the local government could not agree on how to use the land. In the meantime there has been no significant economic benefit to local people since 1991. In 1998, the Board of Audit and Inspection said it was possible the initial budget estimate was a fourth of what it should have been. The Ministry of Environment deliberately failed to account for water quality improvement costs in the budget estimate, and then it distorted the environmental impact assessment and exaggerated economic benefits. Government functionaries have gone forward with the project using unfounded budget estimates and feasibility studies, regardless of whether it wastes the people's hard-earned money.

## 2.2 Energy: Is nuclear energy sustainable?

Energy policy recommendations were submitted to the president in June 2004. PCSD recommended a target of saving 10 per cent in primary energy consumption by 2015, as well as supplying 5 per cent

<sup>6</sup> Soh, Ji-young, 22 March 2001. "Gov't Urged to Reexamine Saemangeum Project", Korea Times.

<sup>7</sup> Na, Jeong-ju, 4 February 2005. "Court Orders Government to Change Saemangeum Project", Korea Times.



of the country's total energy from renewable sources by 2011. The Republic of Korea is the tenth-largest energy consumer in the world and imports 97 per cent of primary energy from abroad. The country has 20 nuclear power plants; currently 40 per cent of electricity energy depends on nuclear power, and this is projected to increase to 46.7 per cent by 2015. In 2005, there were huge nuclear waste disposal-related conflicts. The government has been struggling for the past 19 years to pick a site to build a nuclear waste dump due to strong resistance from residents in all designated candidate sites. In February 2004, the Moo Hyun Roh administration announced a new bidding process in hopes of attracting new candidate sites. This was to replace the latest candidate site of Wido, an islet off the coast of Puan County in North Cholla province where more than half of the residents opposed a nuclear waste dump located in their area. Despite the government's proposed development grants in return for the construction of a nuclear waste dump, not a single regional authority submitted an application by September 2004.

Then on 27 April 2004, NGOs and the government established the "Public-Private Forum for Energy Policy" for consultations on a long-term policy on energy, including the nuclear waste dump issue.<sup>8</sup> However, 11 NGO forum members resigned because they said the government did not take their input into consideration and were not interested in long-term energy policy. Instead, NGOs believed the government actually only cared about designating the dumping sites. Environmental groups wanted to discuss the long-term policy implications of nuclear disposal before designating new power plants. Environmental groups insist that nuclear energy is not sustainable and can even be dangerous. They argued that there is a clear connection between disposal sites and long-term energy supply policy that requires deep discussion with all stakeholders—once we have nuclear disposal sites there is no turning back from nuclear energy. Truly renewable energy will not require nuclear plant construction or waste disposal, and so environmental groups recommend changing the nuclear dependence policy. This is the key issue that society should agree upon before building any nuclear waste dumpsites.<sup>9</sup>

PCSD studies ways to design an effective consultation process for building social consensus on the site and evaluates technical issues pertaining to nuclear waste disposal. PCSD tried to make a "consensus organization". The body was proposed by the ruling Uri Party to NGOs and agreed upon by the two sides in August 2004.<sup>10</sup> Efforts to establish a consensus organization lasted for one month until September 2004, but finally the process stopped because the prime minister decided "*to first construct a dump site for medium- and low-level radioactive waste by 2008, postponing the construction of a high-level waste site for the time being.*" The government confirmed that the construction of a high-level radioactive waste repository would be decided by the so-called consensus organization, consisting of civic groups, lawmakers, and government officials. The government has put off the plan for the high-level facility and planned to build a lower-level one, since the ministers agreed it would be easier for residents to accept the facility if the new dump will deal only with low-level waste.

However, environmentalists and NGOs said it is wrong for the government to unilaterally announce the methods of building and scheduling for a new nuclear waste facility, ignoring a

<sup>8</sup> KFEM, 10 May 2004. "Government should not promote old-fashioned way of nuclear waste dump site designation" statement.

<sup>9</sup> No Nuke Forum, 25 June 2004, "Resign from the 'Public-Private Forum for Energy Policy' and fight against nuclear dump site designation" Press release statement.

<sup>10</sup> Bae, Keun-min, 19 September 2004, "Two Nuke Repositories to Be Selected" *The Korea Herald*.

pre-existing consensus organization consisting of government and NGO representatives. The consensus organization was a public-private partnership between government and NGOs formed in August 2004, and ended in September 2004 when the prime minister unilaterally declared the nuclear disposal site designation plan. The fallout is that Koreans lost an opportunity to make a more sustainable long-term energy policy and a chance to stop our growing dependency on nuclear energy.

### 2.3 Water management: How many dams are enough?

The Republic of Korea has a total of 765 large dams, ranking seventh in the world. The government has focused on construction of 12 large dams in anticipation of future shortages in the water supply. Environmental NGOs are opposed to supply-oriented policy, and as a result, 9 out of the 12 dams seem to be behind schedule. Thus far, NGOs have been effective in arguing that dams are not part of a sustainable infrastructure for water supply. If the country continues along its planned path, it will soon hold the first ranking for dams per capita and per square kilometers, as well as incurring negative marks in terms of unsustainable management of water resources.<sup>11</sup> PCSD's policy recommendations to the president were submitted on 19 October 2005, recommending that the government shift supply-oriented policy to effective demand-oriented policy. Specifically, they set a target of conserving 10.6 billion cubic meters of water by 2016 with a 10 per cent water savings in agriculture and domestic use, and a 20 per cent water savings in industry. They also recommended strengthening water quality management, total pollution load management systems, and countermeasures to regulate non-point pollution sources. Other recommendations included diverse countermeasures on flooding; for example, to shift flood control from embankments to reservoirs for managing overflows and to regulate land-use in areas prone to flooding.

The case of constructing a flood control dam at Hantan River is a good example of how to consider different perspectives and come to a decision. On 19 December 2003, President Roh ordered the Hantan River dam construction issue to be solved through PCSD's conflict coordination process. In February 2004, PCSD organized a task force team composed of six committees to resolve the conflicts. On 11 May 2004, the small committee held a workshop and discussed the process of reconciliation with representative stakeholders through the committee's management method. The conciliation committee had 16 meetings and 5 technical meetings during a two-month period. Small committees held meetings 22 times, including 7 professional advisory meetings for the selection of 5 alternatives for flood protection in the Imjin River area. Through this process the small committee announced their decision in November 2004, which was to stop construction and redesign the disputed dam. The public-private co-committee prepared for one year, but the opposition side against dam construction refused to accept the result. They agreed that the PCSD decision to halt the current dam construction was due to many technical faults, but they did not agree with the committee's insistence on a new flood regulation dam. The debate raged on, since the need for a new flood regulation dam was not clear and the conflict was not resolved for over a year.

Finally, however, the government decided to build a new flood regulation dam in August 2006. Sang-hun Lee<sup>12</sup> wrote a report titled "An Estimation of the Extent of Institutionalizing Sustainability of PCSD: Focusing on the Case of Conflict Coordination of the Hantan River Dam Dispute". He

<sup>11</sup> Korean Peoples' Network on Rio+10, August 2002. Standpoint of Korean NGOs.

<sup>12</sup> Policy commissioner of PCSD.

analyzed the structure and process of the conflict coordination mechanism and evaluated the relevance of PCSD as a governance system. With respect to structure, he said there is an asymmetry of resources, such as information, power, and capacity among stakeholders. The government holds all the cards by having all the resources and experts, while NGOs and local people lack expertise, time, and money. Also, there are some limitations on the practical implementation between participants. With respect to the process, there is considerable efficiency, but relatively low effectiveness. Even if the decision-making process looks good and includes NGOs, there are limits on what NGOs can do when government holds the ultimate decision-making power. All participants agreed that the Hantan dam had problems, but the result was to go forward with the plan anyway.

Some say that PCSD is making the government's decision-making process more democratic and increasing civil society's participation in governmental policy.<sup>13</sup> PCSD is suggesting a new opportunity to the public. However, lessons from the Hantan River case highlight the inequality of resources, stakeholders' capital, time, and information. A question remains: can the PCSD be a fair "umpire" for resolving such conflicts?

### 3. LESSONS FROM CURRENT UNSUSTAINABLE INFRASTRUCTURE DEVELOPMENT

#### 3.1 Lack of social consensus about sustainability: Destructive development gets the benefit

Regarding future work, we should formulate an implementation plan for sustainable development and develop indicators to monitor and assess the implementation plan. NGOs asked the government to overhaul the decision-making process by putting priority on the environment. However, this is not easy work to do for various reasons. One reason is that the Saemangeum project was started for political reasons and has been pursued for political reasons. In 1987, then Democratic Liberal Party (currently the Grand National Party) presidential candidate Tae Woo Roh promised voters in the Honam region a land reclamation project. Once elected he did not put much effort towards fulfilling this promise, but then Peace and Democracy Party chairman Dae Jung Kim worked with him to expand the project so that it became bigger than it would have otherwise been. When current president Moo Hyun Roh was Minister of Maritime Affairs and Fisheries he opposed the project, but once he was president he changed his mind because many people from Jeolla Bukdo wanted to continue the project. They believe that the project will bring economic prosperity to their long-ignored region even though it does not give money to the people directly. Politicians cannot ignore their eagerness for the development. These destructive construction projects generate economic profits, while conservation and preservation does not seem to generate profit in the current economic system. Society is used to thinking that infrastructure development equals economic growth, and that any development will bring prosperity.

Environmental NGOs are opposed to the Saemangeum reclamation project. NGOs, however, could not suggest an alternative sustainable development vision for the Jeolla Bukdo area. Some environmental NGOs suggested marine ecotourism development in the area, but that suggestion came too late in the process to discuss and implement.

Local government and people's strong demand for development makes it hard to plan for sustainable infrastructure development. What are the desirable roles of central and local governments

<sup>13</sup> Lee, Sanghun, 2005. "An Estimation of the Extent of Institutionalizing Sustainability of PCSD: Focusing on the Case of Conflict Coordination of the Hantan River Dam Dispute" Seoul, Republic of Korea: Trend and Prospect: 64.

in planning, facilitating, and coordinating investment decisions in sustainable infrastructure development? To answer this, the following question must also be discussed: How many government officers know and understand the “sustainable development concept”? Many local and mid-level government officers do not even recognize the existence of PCSD and the meaning of sustainable development. The National Implementation Strategy for United Nations Decade of Education for Sustainable Development, a research group, presented the results of a poll about sustainable development. This poll was given to university students (317 people). In response to “Have you heard about ‘sustainability’ or ‘sustainable development’?” 256 students answered yes (65.6 per cent). But only 13.4 per cent of students answered that they understand it very well. As to the goals of “sustainable development”, 64.3 per cent of students said “environmental conservation”, 42.1 per cent said “reducing the gap between rich and poor”, and 22.8 per cent “economic growth”.<sup>14</sup>

The goal of unifying and integrating economic, social, and environmental issues in decision-making by bringing together governmental ministries, decision makers, as well as sectors of civil society still seems too far to be achieved in our society. This is mainly due to the lack of environmental awareness at the decision-making level and the lack of expertise on the topics covered by sustainable development.<sup>15</sup> The government should also make education and learning key strategies for sustainable development to build a sustainable society through practical actions on various levels, as the United Nations suggested in 2006 for their Decade of Education for Sustainable Development. There are no easy answers on how to develop economics, the environment, and society at the same time, but education will help build social consensus in finding a balance between the three. This means planning now and educating future generations to create a better world with sustainable infrastructure as a centerpiece, and in the meantime, being patient while this seed takes growth.

### 3.2 Systematization (institutionalization) of sustainability

The fact up until now is that people can still earn money in conducting economic activities, even if those activities destroy the environment and pollute nature. But who earns this money? Central and local government officials, construction companies, public corporations, and development specialists all depend on development of any kind to sustain their livelihood and profit. In other words, this “establishment” feeds a larger social problem that convinces people there is no incentive to wait for a better, sustainable way. They make it difficult to be patient by constantly urging and promoting development to the government, media, academics, and general public. Social and environmental factors are frequently sacrificed for economic results.

The construction business establishment has a system and lots of money behind it. Sustainability does not. Individuals advocating for sustainability also need organizational support, laws, budgets, and all of the accompanying institutional elements to build an “infrastructure” for the people whose job it is to pursue sustainability. Jenam Kim, former Secretary-General of Green Korea United, said, *“Still for us it is really hard to block all the destructive development plans, especially government or politically led projects. It is hard to even dream about this. Why is it so hard? Because the people who are talking about [business] development have the power to practice it, but we [sustainability people] don’t.”*

Building this power for sustainability advocates could be the role of PCSD. They currently stand as the most promising starting point for building a system, or “infrastructure”, of people,

<sup>14</sup> Lee, Sunkyoung, 2005. “National Implementation Strategy for United Nations Decade of Education for Sustainable Development”, pp. 123-125.

<sup>15</sup> Koh, Chu-hwan, 22 February 2004, “For a Democratic and Sustainable Korea” Korea Times.

resources, energy, money, and institutions that promote sustainability. This sustainable infrastructure would work on projects such as calculating and revising a Green GNP, ecological footprints, and green taxes.

### 3.3 Need for people's participation from the planning stages of all infrastructure development

The necessity of people's participation earlier in the infrastructure development process was made clear by the Saemangeum project. Too much was already done before people became aware of the various issues and could oppose it. This means that from the beginning, this project was not well-designed.

Infrastructure development is for whom? Developers need to listen to those people who are affected by the development; for example, those having to evacuate from their homes because of dam construction. Infrastructure development cannot be sustainable if people who will be affected by it are not included in the decision-making process. Hantan dam is a representative case in the country because the local people strongly opposed it and the government was unable to persuade them otherwise.

Society's specific vision, value, law, and institutions are all the result of interaction between various stakeholders' understandings and values about the environment, society, and economics. The "discussion" character of sustainable development requires social consensus in addition to the science and economics.<sup>16</sup> The process of consensus should be treated as a way towards sustainable development, beginning with the existing environmental review system that has been in place since 17 October 2000.

### 3.4 Developing a new model: Environmentally-friendly is economically effective

Being open to alternatives and good models from other parts of the world is very important. The government has historically been good at learning from and borrowing models from other parts of the world to increase economic growth—this could also be done to increase sustainable infrastructure. When borrowing models it is important to understand the context (history, meaning, and internal struggles) associated with it.

## 4. DEFINING ROLES IN SUSTAINABLE INFRASTRUCTURE

In examining the possible guidelines and political actions to take in order to encourage participation and partnership amongst various sectors, sustainability advocates should engage government policymakers and people on the issues. Many stakeholders play this role, and civil society should not be afraid of the conflict itself or hesitate to solve the problem. Opposition, debate, and alternative viewpoints are not destructive, but should be seen as constructive for all the stakeholders. There are various opinions, but the matter is how to harmonize all of them together while leading the way towards sustainability. This is everyone's responsibility and ensures that process itself is sustainable.

NGOs are considered "anti" groups in the Republic of Korea, but this is a misconception. The Green Transportation NGO, for example, worked with the Seoul City government to develop a new bus system modeled on Brazil's sustainable system in the city of Curitiba. The Korean Federation for

<sup>16</sup> Chung, Kyuho, 2002. "Research on consensus building under the city governance system for sustainability" Seoul National University Environmental Planning PhD thesis, p. 22.

Environmental Movement (KFEM) has also been promoting bio-fuels for automobiles. Green Korea United (GKU) investigated road construction in the country and found that the government over-constructed and over-invested. The government, in turn, adopted GKU's recommendations and saved government money. There are several more examples of NGOs proposing alternatives for sustainable infrastructure.

However, finding and suggesting alternatives is not just the NGOs' responsibility. People are often quick to demand that NGOs propose an alternative if they criticize a project, but meanwhile NGOs are working to support and enhance discussions so that an alternative is possible. This was the NGOs' strategy for Saemangeum, but unfortunately, it was not followed. Even as NGOs call for more discussion the government has not been open to it or included local people's viewpoints. NGOs need to ensure that they are prepared and have researched the issues carefully. They need to build their skills, expertise, and knowledge—capacity—in order to propose better alternatives.

NGOs and the government must work together on the process of building sustainable infrastructure, especially in dealing with conflict resolution. The government has increasingly placed the burden for conflict resolution on NGOs and especially the PCSD. Therefore, the government and NGOs need to first work out their own conflicts and then work together in including local people and alternative perspectives from the rest of the world on building infrastructure (highways, tunnels, bridges, transportation, energy, etc.) Local governments and PCSD working together can be the actors to accomplish this if both government and NGO representatives are honest and consistent with one another. Both are necessary for a strong and realistic vision for sustainable development. If the negotiation and compromise process between both sides is open and honest, and both sides apply consistent principles, then PCSD can realize its potential. This process, much like the discussion of sustainable development itself, needs clearer and more consistent standards and principles. For example, is there a way to develop a sustainable development index, much like there are indexes for corporate social responsibility and corruption perception? This would be a worthy project for the new "sustainable sector".

## 5. ENGAGING PEOPLE IN SUSTAINABILITY FOR THE NEXT GENERATION

On 4 June 2005, President Moo Hyun Roh declared the national vision for sustainable development. The vision was to "*build an advanced country while maintaining balance between the economy, society, and the environment*"<sup>17</sup>. He suggested "*awareness on the limits of natural resources, precautions, and integration of policies, participation, and responsibility.*" Following these good words, PCSD prepared a follow-up plan to implement the vision and reported it to the Presidential office on 17 June 2005. They prepared the "guidelines for establishing the implementation plan for the vision" and provided it to the ministries on 9 September 2005. Nineteen ministries formulated the implementation plan for the vision. However, comparing this vision with the current environmental practices, there is a huge gap between vision and reality. In other words, President Roh was late in articulating a vision for sustainable development, and once he did, it was not realizable because it did not have specific guidelines, budget, or specified people to carry out the vision. Even Roh's most recent plan for the environmental sector included in *Vision 2030* does not clearly articulate measurable and attainable goals.

<sup>17</sup> PCSD, 2005. Workshop Proceedings of "The 2<sup>nd</sup> East Asia National Council for Sustainable Development Workshop", Presidential Commission on Sustainable Development, Republic of Korea.

Even though President Roh declared the national vision for sustainable development on 4 June 2005, environmental NGOs have criticized his destructive development policy. The increase in the number of golf courses, a special bill for “business towns”, and “easing of development regulations around Seoul” are the main reasons that environmental groups struggle against his administration. In November 2004, environmental groups strongly denounced his administration for adopting anti-environmental policies.<sup>18</sup> A total of 112 civic groups, including Green Korea, the Korean Federation for Environmental Movement, and the Citizens Movement for Environmental Justice, held an “emergency meeting for the environment” in the Sejong Center for the Performing Arts on 10 November 2004 to launch a joint campaign against the government’s harmful policies. They declared an all-out struggle against the government: *“In the name of economic stimulus, the government has recklessly adopted short-term development projects without taking the environment into consideration.”* Unfortunately, due to Roh’s persistent lack of vision and action for the environment, the country has been on an environmentally destructive path.

Koreans live in a small land compared to the population. When the environment is contaminated, the land’s natural purification ability is limited. Thus, we have to take sustainable development seriously. Awareness-raising is needed and should continue. The government has operated under a development-oriented policy for a long time. Although it will take a long time to change course, now is a key time when Koreans have to choose their development path for the future. Will society build for the future or mortgage it in order to support the present? NGOs should build their capacity, and the government should open their process in order to build for the future. This process will of course be difficult, but in the long run it is the only way to truly realize a more sustainably developed Republic of Korea.

## 6. CONCLUSION: EXPAND THE BOUNDARIES OF “INFRASTRUCTURE”

This paper has suggested several ways to realize a more sustainable Republic of Korea. NGOs and the government need to acknowledge their roles in the current destructive system. Will society support the construction business establishment or a new “sustainable sector”? The government should be more open to discussion and alternative viewpoints from more stakeholders, especially local people, while NGOs should build their capacity to provide well-researched and supported alternatives. If NGOs and the government collaborate through the existing institutional mechanisms of local government, Agenda 21, and PCSD, then the seeds of sustainable infrastructure have already been planted. Infrastructure does not just mean roads, water, energy, and building cities, but rather all the components of each of these – people, time, money, and creative ideas. The most important part of this infrastructure is patience: people have to accept and embrace the fact that the world cannot be changed in one day. Accepting this keeps hope alive and will allow us to realize sustainable development and infrastructure.

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<sup>18</sup> Moon, Gwang-ilip, 22 November 2004. “Development Projects Spark Strong Protests”, Korea Times.

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## Internet Resources

PCSD <http://www.pcsd.go.kr>

Green Korea United <http://www.greenkorea.org>

KFEM <http://www.kfem.or.kr>



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# ANNEXES

I: Agenda of the Seoul Initiative Policy Forum

II: Report of the Seoul Initiative Policy Forum

III: List of abbreviations

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# Annex I

## Agenda of the Seoul Initiative Policy Forum

First Policy Consultation Forum of the Seoul Initiative on Green Growth:  
“Promoting Sustainable Infrastructure Development”

6-8 September 2006

Ramada Seoul Hotel, Seoul, Republic of Korea

### TENTATIVE PROGRAMME

Wednesday, 6 September 2006

09:00-09:30 Opening session

Welcoming address by H. E. Mr. Lee Chi-Beom, Minister,  
Ministry of Environment, Republic of Korea

Opening remarks by Mr. Kim Hak-Su, Under-Secretary-General of the United Nations and Executive Secretary of ESCAP  
(to be delivered by Mr. Rae Kwon Chung, Director of Environment and Sustainable Division, ESCAP)

09:30-09:45 Lunch Break

09:45-11:00 Introductory session

Moderator: Mr. Boonam Shin, Director General, Office of the International Cooperation, Ministry of Environment, Republic of Korea

Green Growth and eco-efficiency: A regional strategy for environmentally sustainable economic growth in Asia and Pacific  
(Mr. Rae Kwon Chung, Director of Environment and Sustainable Development Division, ESCAP)

Implementation Plan 2006 of the Seoul Initiative on Green Growth

(Mr. Hee Chul Lee, Director of International Cooperation Division, Ministry of Environment, Republic of Korea)

Discussion

**11:00-12:00** Session I: Taking green into account  
*Moderator: Prof. Jong Ho Hong, Professor,  
 Department of Economics and Finance, Hanyang University*

Concept of environmental accounting  
*(Dr. Jongho Kim, Korea Environment Institute)*

Green Growth and environmental accounting: Importance of environmental accounting for Green Growth  
*(Dr. Sangin Kang, Director, Sustainable Development Division, Korea Environment Institute)*

Green accounting: China's practice  
*(Dr. Zhou Guomei, Director of Environmental Economic Division, Policy Research Center of Environment and Economy of State Environment Protection Agency, China)*

Discussion

#### POSSIBLE DISCUSSION POINTS:

- Why are green accounting and green GDP important for Green Growth?
- What are some initial steps to take in order to calculate Green GDP?
- Non-market benefits of nature: what should be accounted for Green GDP, why and how?
- What are the main challenges we face in introducing green accounting?
- What kinds of leadership are necessary for the implementation of green GDP policies/practices?
- What are the roles of the different governmental sectors (e.g. Ministry of Environment, Ministry of Economy, Ministry of Commerce, Industry and Energy, etc.) in promoting/implementing green GDP measures/calculations?

**12:00-13:30** *Lunch Break*

**13:30-15:15** Session II: Sustainable infrastructure:  
 What is it? Why is it important?  
*Moderator: Mr. Rae Kwon Chung, Director of Environment and Sustainable Development Division, ESCAP*

Concept of sustainable infrastructure and how it can contribute to Green Growth (introductory presentation on sustainable infrastructure)  
*(Prof. Vilas Nitivattananon, Assistant Professor, Urban Environmental Management, School of Environment, Resources and Development, Asian Institute of Technology)*

Sustainable infrastructure: What is it? Why is it important? (Concept and definition of sustainable infrastructure, European experiences)  
*(Dr. Rolf André Bohne, Faculty of Engineering Science and Technology Department of Civil and Transport Engineering, Norwegian University of Science and Technology)*

Sustainability and public infrastructure investment: Korean experiences  
*(Prof. Jong Ho Hong, Professor, Department of Economics and Finance, Hanyang University and Mr. Yong-Shin Park, Director, Citizens' Coalition for Environmental Justice)*

The World Bank's approach to sustainable infrastructure development  
(Mr. Ben Eijbergen, Infrastructure Sector Coordinator, The World Bank, Manila Office)

Sustainable infrastructure, doing more with less: Applying eco-efficiency principles  
(Dr. David Ness, Office of Major Projects and Infrastructure Department for Transport, Energy and Infrastructure and Adjunct Research Fellow, University of South Australia  
(To be presented by Ms. Aneta Nikolova, ESCAP)

Discussion

**POSSIBLE DISCUSSION POINTS:**

- What are the impacts of infrastructure in improving eco-efficiency to pursue Green Growth?
- How should the concept of eco-efficiency be applied in infrastructure development (design, construction, operation, maintenance, and disposal of infrastructure)?
- What are the factors affecting the eco-efficiency of infrastructure?
- What are the issues and challenges in promoting sustainable infrastructure development in the region?
- What are the other characteristics and externalities of infrastructure and how can we overcome this problem?
- How should sustainable infrastructure development be approached as a policy framework or as a system?
- What is the current status of the sustainable infrastructure development in Asia-Pacific region?
- Eco-efficiency of infrastructure: what must be considered in order to support sustainable development in Asia-Pacific region? What are the possible policy tools and guidance available/ needed?

15:15-15:30 Break

15:30-18:00 Session III: Improving eco-efficiency of transport infrastructure  
Moderator: Mr. Chan Woo Kim, Senior Coordinator for Environmental and Scientific Affairs, Ministry of Foreign Affairs and Trade

Environmentally-friendly transport policy in Asia  
(Improving Eco-efficiency of Transport Infrastructure and Urban Settlement)  
(Dr. Shinya Hanaoka, Assistant Professor, Transportation Engineering, School of Civil Engineering, Asian Institute of Technology)

UNCRD's initiative on EST towards the promotion of Green Growth in Asia  
(United Nations Centre for Regional Development (UNCRD))

Urban rail transportation development in Bangkok Metropolitan, Thailand  
(Mr. Padet Praditphet, Policy and Plan Analyst, Office of Transport and Traffic Policy and Planning, Ministry of Transport, Thailand)

Seoul's challenge for eco-efficient transport  
(Dr. Gyeong Chul Kim, Senior Research Fellow, Seoul Development Institute, Seoul Metropolitan Government)

Sustainable urban design-climate measures in transportation policies-  
(Ms. Maki Nakamura, Section Chief, Minister's Secretariat General Affairs Division,  
Ministry of Environment, Japan)

Transportation policy towards eco-efficiency in the Republic of Korea  
(Dr. Junhaeng Jo, Korea Transport Institute)

Road transport emission control in Pakistan  
(Mr. Syed Tanvir Hussain Bokhari, Chief (Transport and Communications), Planning and  
Development Division, Government of Pakistan)

Air quality management through sustainable transport in Indonesia  
(Mr. Dana A. Kartakusuma, Assistant Minister, Technology and Sustainable Development,  
Ministry of Environment, Indonesia)

Discussion

**POSSIBLE DISCUSSION POINTS:**

- What are the challenges in promoting sustainable transport in the region?
- Are the adverse external effects of transport infrastructure and congestion being comprehensively and adequately assessed in Asia-Pacific regions? If yes, what step should be taken?
- What are the environmental and economic impacts of traditional transportation infrastructure?
- How can we improve the eco-efficiency of the transport sector as a whole?
- What are the social costs of traffic congestion? What policies should be taken to minimize the cost?
- What are the external costs and benefits of other modes of transportation (e.g. walking, cycling, and public transportation, including rail)?
- What are some of the cultural and national differences of the various transportation modes in Asia-Pacific, and what are some ways to achieve sustainable national transport systems?
- What are some existing strategies and policies relating to sustainable transport infrastructure planning and broader matters of urban planning and population density? What are some related government policies at local, regional, and national levels?

18:30-20:00 Reception hosted by Ministry of Environment, Republic of Korea

Thursday, 7 September 2006

09:00-12:00 Session IV: Promoting eco-efficiency of water supply, wastewater and solid waste management infrastructure  
Moderator: Mr. Young-Woo Park, President, Business Institute for Sustainable Development, Republic of Korea

Introductory presentation  
(Prof. Vilas Nitivattananon, Assistant Professor, Urban Environmental Management, School of Environment, Resources and Development, Asian Institute of Technology)

Promoting eco-efficiency of water infrastructure investment  
(Mr. Ti Le-Huu, Sustainable Development and Water Resources Section, Environment and Sustainable Development Division, ESCAP)  
(To be presented by Mr. Jung Kyun Na, ESCAP)

Rainwater harvesting: A new paradigm to meet MDG and maintain sustainability  
(Prof. Mooyoung Han, Director, Rainwater Research Center, Seoul National University)

Sustainable groundwater resources management in Asia - from case studies of 5 Asian cities  
(Dr. Yatsuka Kataoka, Policy Researcher, Institute for Global Environmental Strategies (IGES))

Water supply and sewage management systems in the Republic of Korea  
(Dr. Dae Young Joo, Deputy Director, Water Supply and Sewerage Policy Division, Ministry of Environment, Republic of Korea)

Water resource of the Mongolia  
(Mr. Chandmani Dambabazar, Director of Mongolian Water Institute)

10:30-10:45 Break

Water supply, wastewater and solid waste management infrastructure in Bangladesh  
(Mr. Touhid Uddin Ahmed, Deputy Secretary, Ministry of Environment and Forest, Bangladesh)

Small water impounding project: A small scale eco-efficient infrastructure in upland communities of the Philippines  
(Mr. Samuel M. Contreras, Chief Agriculturist, Bureau of Soils and Water Management, Department of Agriculture, Philippines)

Promoting eco-efficiency of solid waste management infrastructure in Thailand  
(Mr. Solos Khankhrua, Senior Environmental Scientist, Department of Environmental Quality, Ministry of Natural Resources and Environment, Thailand)

Solid waste management problems in Russian Federation  
(Dr. Vladimir Maksimov, Advisor, Ministry of Economic Development and Trade, Russian Federation)

Infrastructure strategic plan towards sustainable development in Indonesia  
(Mr. Mochammad Amron, Director, Strategic Research Centre, Ministry of Public Works)

Discussion



**POSSIBLE DISCUSSION POINTS:**

- What are the issues surrounding sustainable water infrastructure in the region?
- How can we improve the eco-efficiency of water infrastructure (water leakages, water recycling, water pricing and water savings)?
- What are the environmental impacts of sewerage and wastewater treatment?
- In what critical areas might economic activities be comprised by pollution from wastewater facilities?
- Are there any possible “cultural solutions” in respect to human waste and water usage? What are they?
- What are the possible policy guidelines for eco-efficient water infrastructure?

12:00-13:30    *Lunch Break*

13:30-15:00    Session V: Eco-efficiency of energy infrastructure and human settlements  
*Moderator: Dr. Kwang Kyu Kang, Director, Office of Planning and Coordination, Korea Environment Institute*

Eco-efficient energy infrastructures: Towards an eco-energy strategic plan  
*(Dr. Woodrow W. Clark II, Managing Director, Clark Strategic Partners (Former Senior Energy Policy Advisor – renewables, technology and finance), Governor’s Office, State of California, the United States of America)*

Strategies for new and renewable energy development in the Republic of Korea  
*(Dr. Kyungjin Boo, Korea Energy Economics Institute)*

Green building system: Eco-efficient construction strategy adapted to the climate of Asia and the Pacific  
*(Prof. Chung-Yoon Chun, College of Human Ecology, Yonsei University)*

Promoting eco-Friendly and sustainable urban settlements- the Indian experience  
*(Mr. Pankaj Jain, Joint Secretary, Ministry of Housing and Urban Poverty Alleviation, Government of India)*

Sihwa tidal power plant project: To promote the use of renewable energy  
*(Mr. Jong lee Shin and Mr. Jong Deug Kim, Korea Water Resources Corporation (K-Water))*

Discussion

**POSSIBLE DISCUSSION POINTS:**

- Energy security: what are the challenges with energy supply and consumption in this era? Why? And what are the possible national responses to overcome these challenges?
- What are the economic and eco-efficiency aspects of energy security issues?
- The impact of decarbonisation: the pressure to move towards a much lower level of carbon intensity in energy system in Asia-Pacific region?
- How much of a switch towards renewable technologies/resources is likely in response to international pressure to reduce GHG emissions?

- What are the possible strategies for constructing eco-efficient buildings and urban settlements relating to the unique climate and cultural characteristics of the participating nations? What are some strategies that increase the efficiency with which buildings and their sites use and harvest energy, water, and materials?

15:00-15:15 Break

15:15-18:00 Session VI: The role of the public and private sectors in promoting sustainable infrastructure development

*Moderator: Prof. Hyun-Hoon Lee, Director of Asia-Pacific Leadership Center, Professor of International Economics, Kangwon National University*

Introductory presentation

*(Prof. Vilas Nitivattananon, Assistant Professor, Urban Environmental Management, School of Environment, Resources and Development, Asian Institute of Technology)*

Private sector involvement in sustainable infrastructure: The ADB's approach to sustainable infrastructure development

*(Mr. Woochong Um, Director, Energy, Transport and Water Division, Regional and Sustainable Development Department, the Asian Development Bank)*

The role of public and private in developing infrastructure

*(Ms. Junglim Hahm, Infrastructure and PPP Specialist, Finance and Private Sector Development Division, World Bank )*

The current state and future perspective of private investment project in the Republic of Korea

*(Dr. Geun Ung Choi, Director, Department of Private Investment Promotion, Korea Environmental Management Corporation)*

Government policies and institutional framework of infrastructure development in India

*(Mr. Narendra Hatwar Hosabettu, Director, Impact Assessment Division, Ministry of Environment and Forests, Government of India)*

Private participation in infrastructure (PPI) initiatives in Cambodia

*(Mr. Sopheap Chan, Head of General Policy Office, Ministry of Economy and Finance, Cambodia)*

Presentation by Malaysian delegation: Infrastructure and utilities development in Malaysia

*(Ms. Maznon binti Abdullah Hashim, Principal Assistant Director, Infrastructure and Utilities Section, Economic Planning Unit, Prime Minister's Department, Malaysia)*

Engaging people in sustainability: NGO's perspectives on the way to sustainable infrastructure development in the Republic of Korea

*(Ms. Yoo Jin Lee, Green Korea United)*

Presentation by Viet Nam

*(Mr. Xuan Bao Tam Nguyen, Deputy Director General, International Cooperation Department, Ministry of Natural Resources and the Environment, Viet Nam and Mr. Ta Dinh Thi, Ministry of Natural Resources and the Environment, Viet Nam)*

Discussion

POSSIBLE DISCUSSION POINTS:

- What are the financial challenges in promoting sustainable infrastructure development in Asia-Pacific region? Why are they challenges? What can be done about them?
- What are the desirable roles of central and local governments in planning, facilitating and coordinating investment decisions in sustainable infrastructure development?
- What kind of investment strategies would best support implementing sustainable infrastructure?
- How should risks be shared between government and the private sector for sustainable infrastructure development? What are some suggestions for possible guidelines?
- What are the possible guidelines and political actions to take in order to encourage participation and partnership amongst various sectors?

18:30-20:00 Reception hosted by Korea Environment Institute

Friday, 8 September 2006

09:00-11:00 Concluding session

*Moderator: Mr. Rae Kwon Chung, Director of Environment and Sustainable Development Division, ESCAP*

Policy direction for sustainable infrastructure development

*(Prof. Vilas Nitivattananon, Assistant Professor, Urban Environmental Management, School of Environment, Resources and Development, Asian Institute of Technology)*

Summary of the Forum

*(Mr. Rae Kwon Chung, Director of Environment and Sustainable Development Division, ESCAP)*

Discussion

Closure of the Meeting

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# Annex II

## Report of the Seoul Initiative Policy Forum

First Policy Consultation Forum of the Seoul Initiative on Green Growth:  
“Promoting Sustainable Infrastructure Development”

6-8 September 2006

Ramada Seoul Hotel, Seoul, Republic of Korea

### POLICY DIRECTIONS AND RECOMMENDATIONS FOR SUSTAINABLE INFRASTRUCTURE DEVELOPMENT IN ASIA

#### BACKGROUND

1. The First Policy Consultation Forum of the Seoul Initiative on Green Growth: “Promoting Sustainable Infrastructure Development”, held from 6 to 8 September 2006 in Seoul, Republic of Korea, was jointly organized by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and the Ministry of Environment, Republic of Korea in cooperation with the Korea Environment Institute with the generous funding from the Government of the Republic of Korea.
2. It was attended by about 100 participants from Ministries of Environment and relevant ministries responsible for infrastructure development, public works, transport, energy, economic development and planning of 17 ESCAP member states, representatives of the United Nations organizations and international financial institutions, NGOs, private sector, and research institutions.
3. The Policy Consultation Forum reviewed various options and policies to promote eco-efficient and environmentally sustainable infrastructure development focusing on water, waste, energy and transport infrastructure in Asia and the Pacific. The Policy Consultation Forum also took stock of a vast range of experiences, successful national examples and models, as well as lessons learned in the area of eco-efficient and environmentally sustainable infrastructure.
4. To incorporate the concept of sustainable infrastructure into the various stages of infrastructure development, there is a need to deliver the message of the Policy Consultation Forum to high level decision makers of relevant ministries responsible for infrastructure development. This “Policy Directions and Recommendations for Sustainable Infrastructure Development in Asia and the Pacific” is the summary of the findings and conclusions of the Policy Consultation Forum.

#### IMPORTANCE OF SUSTAINABLE INFRASTRUCTURE

5. Infrastructure is a key element for realizing sustained economic growth and sustainable development to achieve the Millennium Development Goals (MDGs), and in particular,

MDG 1 (Poverty Reduction) and MDG 7 (Environmental Sustainability). The unmet demand for social and physical infrastructure to support the delivery of housing, transportation, energy, water services and to overcome the deficiency of food limits economic opportunity and is therefore a major barrier to the achievement of MDG 1.

6. Patterns of infrastructure development determine the environmental sustainability of “green” economic growth. In turn, eco-efficiency should be one of the key criteria for the development of sustainable infrastructure. Eco-efficiency of infrastructure has long-term and significant impacts on both economic and environmental sustainability.
7. Currently, many developing countries are at the crossroads of developing and further expanding their infrastructures in support of robust economic growth. This is an opportune time for them to adopt and apply the eco-efficiency concept in their infrastructure development.

#### ASIA-PACIFIC SITUATION

8. So far, discussions on infrastructure development have been focused mainly on financing issues and engineering aspects in the region. Mainstreaming environmental aspects and incorporating the eco-efficiency concept into various stages of infrastructure development have not been considered as much as they should have been.
9. Improvement in the awareness of eco-efficiency concepts is urgently needed among policy-makers, planners and decision-makers. However, the criteria applicable to, and measures for developing eco-efficient and sustainable infrastructure are yet to be fully identified.
10. In many cases decisions for the development of infrastructure are dependent on political decisions, which sometimes are not scientifically and environmentally sound.
11. A systematic or holistic approach was not sufficiently considered for infrastructure development in the past.
12. Strategic Environmental Assessment (SEA) and life cycle assessment, taking into account the long term impact of infrastructure use, have not been widely applied in infrastructure development in the region.
13. The discussions have pointed out the lack of comprehensive statistical data and valuable information to understand the current eco-efficiency levels of existing infrastructure (including the long-term environmental impact of usage and life cycle of the infrastructure) and future development plans.
14. Buildings account for 50 per cent of the total fossil fuel use in developed economies. Most building environmental control systems were developed for cooler and less humid climate zones, such as North America and Europe. These are not appropriate for the hot and humid climates in the Asia-Pacific region.
15. Countries in the region are not taking full advantage of partnership building opportunities and multi-stakeholder consultations when developing infrastructure projects, such as partnerships between environment and transport sectors, transport management plan between road and rail infrastructure, and private and public transport.

## POLICY DIRECTIONS AND RECOMMENDATIONS

16. After discussing various experiences and policy options of infrastructure development, the First Policy Consultation Forum concludes that:

- It is necessary to develop sustainable infrastructure development policies and strategies, taking into account the eco-efficiency concept that includes all aspects of infrastructure and also seeks to merge and combine such systems, such as transportation and energy;
- A holistic approach is needed in infrastructure development, considering both consumption and production aspects, physical and non-physical aspects, different stages of infrastructure development, different levels of organizations, and roles of different stakeholders;
- Conventional Environmental Impact Assessment (EIA) is not enough to reflect the long-term environmental impact of infrastructure development. Thus, Strategic Environmental Assessment (SEA), which takes into account the long-term ecological impact of infrastructure, can be an important policy tool in promoting sustainable infrastructure;
- Green GDP can be a useful tool in promoting green growth in that it makes it possible to measure pollution costs. However, it has also a limitation as the valuation of environmental degradation is difficult and it does not cover the social cost resulting from inefficient use of resources;
- The technical expertise of the private sector in development of infrastructure will definitely be beneficial. However, the private sector participation does not automatically guarantee the promotion of sustainable infrastructure. The private sector participation in infrastructure development needs to be carefully evaluated and scrutinized;
- It is necessary to develop strategies for attitude change, including education, awareness raising, and ensuring decision making processes that give conscious attention to environmental and social objectives;

### Water

- There is a need to apply the eco-efficiency concept in water infrastructure development. Not only efficiency of infrastructure investment but also the eco-efficiency of operation and maintenance of water infrastructure need to be improved;
- Opportunities for improving eco-efficiency in water infrastructure include reducing water demand by increasing public awareness, applying integrated water resource management, increasing water recycling, and minimizing water loss;
- A new paradigm for rainwater management is required in order to maintain environmental sustainability and to mitigate flooding and drought. Rainwater could be the main source of water supply with less energy input;

### Energy

- There is a need for developing countries in the region to include a goal such as “enhanced energy independence” in their infrastructure development plans so that local and renewable energy resources may be used to generate power for buildings and fuel for transportation. Two key components are the need to diversify energy supplies so that one source does not dominate and hence control the market demands. The other is to start investing in development of renewable and sustainable energy resources now rather than later;
- Climate responsive building design codes applicable to each country need to be developed. This could reduce the cooling demands in the countries, which most likely

- will increase in the years to come. Such climate responsive building design code will have the goal to reduce heat gain, while using natural ventilation and natural cooling;
- Eco-efficient and effective air-conditioning systems need to be developed, taking into account the climate of the countries and the use-side of energy efficiency;
  - It is necessary to develop energy efficiency strategies that will increase awareness regarding housing and building design and householder behavior (e.g. insulation, choice and use of heating systems, dryers, lighting, and hot water);
  - The energy sector is a good example of how “agile energy” infrastructures can be created that combine “central grid” and local “on-site distributed” energy from renewable energy transmission over lines from long distances to local green building complexes that use energy conservation, efficiency and solar energy;

### Transport

- It is necessary to work towards improving the eco-efficiency of the transport sector by developing and realizing an appropriate vision of eco-efficient and sustainable transport firmly rooted in the concept of green growth;
- A regional approach to promote eco-efficient and sustainable transport is needed, in such areas as regulation, technology, and innovation. In order to move towards eco-efficient transport systems, it is necessary for the countries in the region to develop guidelines for eco-efficient and sustainable transport based on local traffic and land use conditions.

## THE WAY FORWARD

17. The secretariat of the Seoul Initiative Network on Green Growth (SINGG) and ESCAP in collaboration with the United Nations and international agencies will continue working in the area of sustainable infrastructure through the network of experts created during the First Policy Consultation Forum of the SINGG. To follow up overall progress on sustainable infrastructure issues in the region and to address the needs of the country senior officials and experts, the secretariat of SINGG and ESCAP will consider the opportunities for further analytical and policy work as follows:
  - Carrying out in-depth studies of regional experiences on eco-efficiency project development, compilation of good practices, organization of capacity building programmes, and development of pilot or demonstration projects;
  - Furthering the work on the eco-efficiency indicators to include eco-efficiency indicators for sustainable infrastructure development, while considering existing indicators such as water loss rate, solid waste generation rate, and energy use rate/intensity in transportation;
  - Dissemination of information on the importance and good practices of eco-efficiency in sustainable infrastructure development among decision-makers, planners, academics and related stakeholders;
  - Developing conceptual methodologies to improve eco-efficient infrastructure, such as congestion cost estimation to include not only time delay and oil consumption, but also environmental cost;
  - Developing guidelines for achieving eco-efficient infrastructure development in the region using existing information as much as possible, considering potential policy tools (such as economic incentives, life-cycle cost saving, and strategic environmental assessment) and strategies that are appropriate to different sectors, development stages, urban and rural conditions.

# Annex III

## List of abbreviations

3R	reduce, reuse and recycle
ADB	Asian Development Bank
AIT	Asian Institute of Technology
ALTID	Asian Land Transport Infrastructure Development
BRT	bus rapid transit
CDM	clean development mechanisms
CH <sub>4</sub>	methane
CIDA	Canadian International Development Agency
CO	carbon monoxide
CO <sub>2</sub>	carbon dioxide
CUTA	Canadian Urban Transport Association
CVM	contingent valuation method
DSM	demand-side management
EIA	environmental impact assessment
EMS	environmental management systems
ERP	electronic road pricing
ESD	ecologically sustainable development
FTZ	free trade zone
GDP	gross domestic product
HFCs	hydrofluorocarbons
IBRD	International Bank for Reconstruction and Development
IEA	International Energy Agency
JICA	Japan International Cooperation Agency
KEI	Korea Environment Institute
LCA	life cycle assessment
LFA	logical framework analysis
LOS	level of service
LRT	light rail transit
MDGs	Millennium Development Goals



MPIS	material input per unit of service
MSW	municipal solid waste
NGO	non-governmental organization
NO <sub>x</sub>	nitrogen oxides
ODA	official development assistance
OECD	Organization for Economic Co-operation and Development
PPP	public-private partnership
SCBA	social cost-benefit analysis
SEA	strategic environmental assessment
SID	sustainable infrastructure development
SMEs	small and medium-sized enterprises
SOE	state-owned enterprises
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
VMT	vehicle mile travelled
VOC	volatile organic compounds
VQS	vehicle quota system
WB	World Bank
WBCSD	World Business Council for Sustainable Development
WHO	World Health Organization

#### Units of Measure

ha	hectare
kg	kilogram
km	kilometre
kph	kilometre per hour
l	litre
m <sup>3</sup>	cubic metre