Section III – Case studies

1. Introduction

This section introduces two specific studies on urban environmental issues. The first part introduces the methodology of environmental management assets and its application to Kitakyushu City, Japan. Kitakyushu was chosen for this study because it witnessed earlier the transformations other Asian developing cities are facing currently: economic growth along with environmental degradation, which is being now followed by environmental revitalization. It is described in here how Kitakyushu City developed its assets on air quality, water and sanitation, and solid waste management and therefore overcome pollution.

The second is on energy consumption and greenhouse gas (GHG) emissions in selected East Asian mega-cities, viz. Tokyo, Seoul, Beijing, and Shanghai. The importance of studying urban environmental issues in mega-cities lies in the fact that the problems they are facing now could affect or are already affecting smaller cities. At present, reducing GHG emission is not a priority issue at local level in Asian cities. However, a better understanding of the structure and nature of GHG emission in cities are necessary in order to find the potential ways to integrate GHG consideration into local environmental management, especially in decisions that affect cities for decades to come.

In short, the first study focus on current issues in local environmental urban management: air quality, water and sanitation, and solid waste management, while the second addresses energy consumption and GHG emission, issues which are expected to grow in importance at local level in coming years. The first study looks mainly at problems that affect mostly the local and regional environment, the second, the global environment.

2. Evaluation of capacity of environmental management – Lessons from Kitakyushu

Environmental capacity means the ability of individuals and societies to respond effectively to environmental problems (OECD 1995). As a way to evaluate the environmental capacity of a city, the Urban Environmental Management Capacity Assessment system was developed (Kono et al. 2004). This assessment involves an inventory (qualitative, quantitative, or both) of the assets. It is recognized that while asset maintenance is important for creation of a sustainable society (Ekins 2003), the poor maintenance of institutions would reduce the assets. Comparing the “environmental management capacity assets” of different cities, for instance in the North and South, or with good environmental capacity and poor capacity, could give some indication of which aspects of environmental management could be improved although they are city dependent.

An inventory of the environmental management capacity assets was developed for Kitakyushu City in order to have this city as a model of environmental revitalization to other cities in Asia (IGES 2004).

2.1 Environmental Management Asset Approach

Initially the term "environmental assets" was related to the concept of natural environmental assets (or natural capital), such as clean air, clean water, forests, and so on, which provide environmental services to the population. Efforts have been made to systematically develop an inventory of these natural environmental assets and to conduct what is called "environmental resource accounting" as an attempt to evaluate the economic value of each asset (United Nations 1993, 2000, 2003). The concept of environmental assets was broadened and applied to urban areas. For cities, it is necessary to consider not only the natural assets, but also the human-made (artificial) assets such as parks, sewage systems, waste treatment facilities, as well as those assets without a physical form. These assets without a physical form, such as policies and measures, laws, governmental institutions, partnerships, and other elements of the urban environmental management, are designated as “environmental management capacity” assets. In short, the environmental assets can be broadly classified as physical (both natural and man-made) and non-physical assets or “environmental management capacity” assets.

The Urban Environmental Management Capacity Assessment broadened the idea of environmental accounting systems by considering the growth of environmental management capacity and analyzing the gaps of accumulation of environmental assets between developed and developing countries (Kono and Imura 2004, Kono et al. 2004). This system is innovative and practical for Urban Environmental Management: It focuses on the environmental management capacity of a city; it assesses the capacity of three stakeholders, viz. local governments, enterprises, and citizens; and it focuses on the local governance level, including supporting policies and actions from the national government and international cooperation (Kono and Imura 2004, Kono et al. 2004).

In this study, four types of assets are accounted for: (1) institutional assets, (2) social assets, (3) technological assets, and (4) environmental governance capacity. The focus is whether environmental management is using these assets in a comprehensively effective and efficient way.

(1) Institutional Assets

They represent the role and interventions of governments. They include plans, governmental institutions, laws and regulations, financial mechanisms, and so on, through which the role and capacity of the government is demonstrated.

(2) Social Assets

The roles of various stakeholders that make up society, including residents, corporations, and non-governmental organizations, are represented by social assets. They incorporate factors such as population’s environmental awareness, quality of the human resources, existence of appropriate technologies and sufficient funds, existence and conditions of the NGOs working for environmental protection, quality of research, and so on. In this study, the term “social assets” refers communally to residents, corporations and NGOs, etc., that have a role in protecting the environment while “social capital” refers to mutual trust, norms, and network among those stakeholders.

(3) Technological Assets

The primary definition of technological assets is the technological *know-how* that has been accumulated within the city, but it can also include the technology acquired from outside the city. Since obtaining technology from outside generally costs more than using internal technology, the more technology is available locally, the better is considered the environmental management capacity of that city. The technologies considered are those for monitoring, pollution removal, and other technologies to be used to prevent or mitigate environmental problems.

(4) Environmental Governance

"Environmental governance” is the capacity to comprehensively oversee and control the overall assets, including physical and non-physical assets. Good leadership towards achieving environmental targets is an indication of good environmental governance.

The categories and details of each asset are shown in Table 1. These individual elements will not function effectively if used independently. It is only when these various elements are effectively connected that outcomes are enhanced; it is particularly valid regarding social capital and environmental governance.

Table 1. Categories of environmental assets

<table>
<tr><th colspan="2">Categories</th><th colspan="2">Components</th></tr>
<tr><td rowspan="2">Physical assets</td><td>Natural environmental assets</td><td colspan="2">Air, rivers, seas, water resources, flora and fauna</td></tr>
<tr><td>Artificial assets</td><td colspan="2">Parks, sewer systems, waste treatment facilities, research facilities</td></tr>
<tr><td rowspan="4">Non-physical assets</td><td rowspan="4">Environmental management capacity assets</td><td>Institutional assets</td><td>Plans, laws and regulations, governmental institutions & organizations, funds, others</td></tr>
<tr><td>Social assets</td><td>Residents (with high environmental awareness), NGOs, corporations (human resources, funds, technologies), social capital</td></tr>
<tr><td>Technological assets</td><td>Technological know-how such as pollution prevention, environmental monitoring, recycling, etc.</td></tr>
<tr><td>Environmental governance</td><td>Leadership, political will and commitment to enforce laws</td></tr>
</table>

Source: IGES (2004)

2.2 Kitakyushu case study

2.2.1 Historical background

Kitakyushu city is one of the first industrial parks in Japan. Along the 20th century, Kitakyushu experienced both the prosperity brought by heavy and chemical industries, particularly steelmaking, and the serious pollution caused by them. In the context of the economic globalization and the transformation of industrial structure, the city is seeking to achieve sustainable development as an industrial city, while facing the challenges of declining manufacturing sector and a shrinking population. In response, the city has been making effort to foster new industries, especially those that are environmentally sound, trying to create a recycling-oriented society ,[1] and becoming a model for other industrial cities across Asia.

Kitakyushu is endowed with a rich natural environment, facing the sea on three sides (the Genkai Sea and Seto Inland Sea), and mountains on the fourth. However, during Japan's period of rapid industrial and economic growth after the 1950s, the sea and air became seriously polluted. Initially the image of a "grey city" was synonymous of prosperity and economic growth, but along the years the pollution started causing health-related problems and the need for a clean environment was felt. Starting from women groups' movements, and later involving local government and companies, actions were taken to clean up the city. Government, industry and citizens worked together in order to transform what was once a "grey city" into a "green city", with clean air and water and a better natural environment. This experience is now shared with cities in Asian countries such as China, Philippines, and Indonesia, through an international cooperation program.

These initiatives attracted international attention to Kitakyushu. The city received the UNEP Global 500 Award in 1990 and the UN Award for Local Governments in 1992. In September 2000, UN-ESCAP held its Fourth Ministerial Conference on Environment and Development in the Asia-Pacific (MCED4) in Kitakyushu and adopted the Kitakyushu Initiative for a Clean Environment. This is an implementation mechanism for a regional action plan to protect the environment in the Asia-Pacific region. It is based on considering the experiences of Kitakyushu to promote initiatives at the local level in ways that could improve the urban environment in this region, and seeks to strengthen international cooperation and collaboration among cities.

2.2.2. Air quality management

During the 1950s and 1960s, industrial air pollution was severe in Kitakyushu city and severe were the impacts on human health. Social assets, such as pollution control agreements, played an important role in lessening air pollution. In addition, technological assets enabled the introduction of Cleaner Production by companies.

[1] See section II on municipal solid waste management and sound material-cycle society.

The expertise acquired during this process of overcoming pollution problems became the base of the city's current international environmental cooperation.

In 1901, Yawata Steel Works was established leading to the creation of heavy and chemical industries, particularly steelmaking. After the Second World War, these factories were operating at full speed, along with the Japanese growing economy. By the 1950s, the smoke and dust emissions from the factories were causing problems for local residents. At that time, companies, government, and residents lacked adequate information about pollution sources and amount of emissions. Women's group activities provided the stimulus to start a movement demanding action. For instance, in 1950 the Women's Association of Nakabaru 36 District, based on their own research on pollution source and supported by relevant documentation, delivered a petition to the government demanding action to rectify the situation. They were able to prove that the closer to a factory, the worse the pollution was; then, negotiations towards establishing countermeasures against smoke started and finally the factory installed smokestack cleaners.

At that time, pollution-related health effects were not widely known and environmental countermeasures were considered less important than economic growth. It was in this context that the Women's Association studied the state of damage and pollution, called experts and university professors, approached the related institutions, raised broad support, and expanded their activities. In 1965, a group involving 6,000 women in 13 associations issued their report on air pollution entitled "We Want our Blue Skies Back". These activities of the women's associations were a trigger for women to tackle environmental problems and women's concerns from their own perspective, and they led to the creation of the Kitakyushu Forum on Asian Women (KFAW) and the Kitakyushu Municipal Gender Equality Centre "MOVE". In addition, the media took up pollution issues and played a role in spreading information about pollution impacts, as well as the responses by residents, government, and industry. The actions by the women's associations and the reports by the media brought the pollution issue to the forefront in society. This helped to raise the awareness of residents, government, and corporations about the environment, and led to stronger initiatives by governments and companies to address environmental issues.

This prompted the establishment of several initiatives involving institutional, legislative, financial, technological, and social aspects. Changes in administrative structure were taken, regulations were sanctioned, financial instruments for preventing pollution were created, monitoring stations were installed, and partnerships among government, companies, and civil society were established. These initiatives are described below and summarized in Table 2, which presents the assets regarding air quality management.

An office responsible for pollution issues was established within the Public Health Sector of the Health Bureau in 1963 to oversee pollution-related policies and establish inspections and air monitoring studies. The Pollution Prevention Council, established in 1964, consisting of representatives of academia, city councillors, residents' groups and corporations, was responsible for studying pollution countermeasures and proposing policies and specific measures for dealing with air pollution. To this day, the council still plays an important role in decisions on environmental policies.

Financing systems for small and medium-scale business were established to help companies to decrease their emissions by improving monitoring at plant level, by installing equipments for pollution control, or by relocating the industrial plants to other sites. These initiatives gave origin to the Pollution Prevention Funding System, established in 1968. In the 1970s, several industries starting adopting cleaner production measures instead of end-of-pipe technologies, with the advantage of saving energy or other resources while decreasing the emissions.

Based on the first recommendation of the Pollution Prevention Council, research was enhanced by establishing the Kitakyushu City Health Research Institute in 1965, which was later denominated Kitakyushu City Environmental Sciences Research Institute.

Decentralization of the decision-making and expansion of the rights of the city government were important in order to take specific measures to avoid pollution. One such example is the “Smog Alert Initiative”, through which the government could issue an order to industries to change temporally the fuel or halt the production in case of special weather pattern (e.g. inversions) that would lead to smog. In order to monitor for inversions the Mt. Sarakura Meteorological Observation Station was established to measure temperature at different altitudes while the Special Weather Information System was created to notify companies subject to regulation when a weather inversion had formed.

The Pollution Control Agreement involved a partnership between government and factories in order to have far-reaching outcomes than the temporary Smog Alert System. Finally, Kitakyushu City was able to overcome pollution by forming partnerships among residents, government, and companies through various activities that complemented legislation.

Table 2. Air Quality Management Assets for Kitakyushu City

Institutional Assets				Social Assets	Technological Assets
Plans	Organizations	Laws and regulations	Financial instruments	Citizens, NGOs, corporations, social capital	
"We Want our Blue Skies Back" The City of Kitakyushu Fundamental Plan for the Anti-Automobile Pollution Measures Environmental Pollution Control Plan	Kitakyushu Health Research Institute Pollution Monitoring Centre Group for inspections in industrial plants Pollution Prevention Council	Photochemical Smog Emergency Measure Implementation Guideline Pollution Control Ordinance Ordinance regarding special weather conditions Guidance Outline on NOx Emissions Regulation on Total Discharge of SOx Smoke Control Law	Pollution-related Health Damage Compensation System Pollution Prevention Funding System	The Environment Account Book Campaign Women's Association Pollution Control Agreement	Measurement of deposited dust Mt. Sarakura Meteorological Observation Station Smog Alert System (information system for special weather conditions) Cleaner Production

Source: Kitakyushu Environmental Asset Database (IGES 2004)

2.2.3 Bay recovery and water quality management

Dokai Bay was known as the "sea of death" after heavy and chemical industries caused water contamination with high concentrations of toxic substances such as heavy metals. Women's associations tackled this problem as they had done with air pollution, and their efforts were joined by Kitakyushu labour unions. Ultimately, the Polluter Pays Principle was applied, the contaminated bottom of the Dokai Bay was dredged out, and fish and shellfish were again found in the bay. Social assets created the impetus for decontaminating the bay and this process led to the creation of a variety of legal, institutional, and technological assets.

The shape of Dokai Bay has changed considerably along the years, especially during the 20th century (Figure 1). Its basic was wide and reaching deep inland, with the inner bay having a shallow depth of only 1.5 to 2.0 meters. The reclamation of Dokai Bay began during the 15th century to increase size of land for cultivation. In the 20th century, it was landfilled and dredged to function as a harbour for industry, turning it into a long, and narrow waterway stretching East and West. The shipping route was kept at a depth of about 10 meters, making it navigable by large ships. The waterfront was all dedicated to industrial or quasi-industrial zoning, and was artificially modified for almost its entire 44 kilometres, leaving almost no natural sections. Nowadays, there are efforts to make the bay waterfront more attractive to people. Although many clusters of heavy and chemical industry plants remain along the shore today, the water quality has improved remarkably. Along the shoreline, there is now some greening projects, such as the Dokai Biopark, the Dohoku Green Zone, and the Oku Dokai Bay Green Zone.

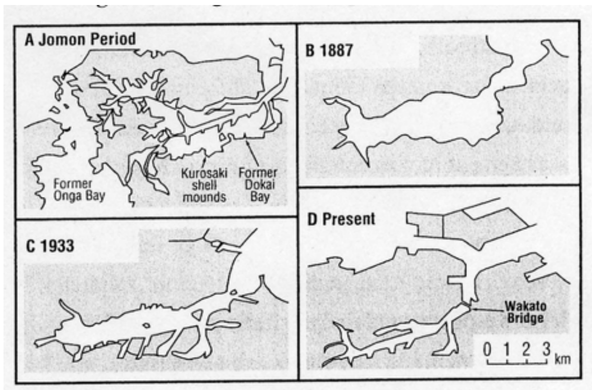

Figure 1. Shape of Dokai Bay along the years

Source: City of Kitakyushu (1999)

By 1930, the annual fish catch in Dokai Bay started to drop dramatically; by 1942, it reached zero. The number of workers in the fisheries was only a fraction of the number in industries; hence, they voluntarily abandoned their fishing rights. In 1968, the chemical oxygen demand (COD) reached as high as 74 ml/l, while in other large industrial cities like Kawasaki and Nagoya, it was 10 mg/l. In addition, cyanide, cadmium, arsenic, and mercury concentrations were the highest in Japan. These figures indicate that Dokai Bay probably had the most polluted coast in Asia at the time, but since fishery activities stopped in the area, no contamination by consuming contaminated fish happened as in Minamata City.

Since the Dokai Bay's shoreline became an industrial zone, it was somehow removed from the daily lives of the average citizen and hard to get a view of, except for passing ferry passengers. However, action towards remediation started after the activities of women's associations and a report by the Kitakyushu Region Labour Union in 1971 on the state of pollution. With the objective of cleaning it up, the Dokai Bay Cleaning Study Group was created by the Kitakyushu Bay Management Union, which at the time was responsible for Dokai Bay. The study group evaluated the bottom contamination as well as dredging methods that could remove sediments economically without causing further pollution. The dredging was performed based on the on the Pollution Control Public Works Cost Allocation Law, which is based on the Polluter Pays Principle. As shown in Table 3, the costs were shared according the proportion of pollution source between industry (71%) and government (29%). Additionally, companies installed wastewater treatment systems while the government started sewage treatment projects thus decreasing the water emissions into the bay. By early 1970s, COD levels reached values lower than 10 ml/l.

Table 3. Dredging costs of polluted sediment in Dokai Bay

Payer	Item	Proportion of burden		Net share (%)	Amount (billion yen)
		Suspended solids (%)	Toxic substances (%)		
Industry	Industrial effluent	54	87	71	1.28
Governments 1)	Household effluent 2) (portion for bankrupt companies)	46	13	29	0.52

Notes: 1) National, prefectural, and municipal governments
2) It includes the portion for bankrupt companies
Source: City of Kitakyushu (1999).

In order to avoid further pollution, appropriate technology was necessary for dredging the bay's polluted sediments and for treating and disposing them in safe way. It took significant effort to develop appropriate method for reclaiming the contaminated material without risks of leakage.

Regarding legal and regulatory assets, they were both used and further developed with the process of recovering the Dokai Bay. The dredging started with requests to the national and prefectural governments in 1966 based on the Water Quality Control Law and the Factory Effluent Control Law; i.e., laws were used to generate action. On the other hand, some inadequacies were found in some regulations, which were revised in the 1970s. Later, Dokai Bay became a 'designated water body', thus specific water quality standards were established for the site. In 1973, Dokai Bay

Stringent Standards were established allowing the prefectural government to apply standards[2] much stricter than in other areas.

Because of these activities, Dokai Bay has become again a habitat for fish and prawns. Moreover, the leadership of local government and the cooperation with industries created the basis for international environmental cooperation activities nowadays. The experience of recovering the Dokai Bay continued to other activities, such as creating innovative organizations like the Kitakyushu International Techno-cooperative Association (KITA) and networks like the Kitakyushu Initiative for a Clean Environment.

Recently, new development initiatives started in the area around Dokai Bay. There are several local groups discussing action plans to transform the area, such as the "Wakamatsu Environmental Model Town" and the "Dokai Bay Charming Plan".

Table 4 presents the complete listing of management assets used for and created by the recovery of Dokai Bay.

2.2.4 River water quality management

The Murasaki River, which flows through the centre of the city, was polluted until the 1970s due to the lack of sewage and wastewater treatment facilities. During the post-war period, industrial wastewater was dumped into the river without treatment, which, along with untreated effluent from illegal dwellings along the riverbanks, led to water pollution and offensive odour. Citizens started activities towards cleaning up the river. Water quality of Murasaki River was improved by the construction of sewer systems and treatment facilities. Moreover, social assets like volunteer activities raised public's environmental awareness and created the foundations for the development of the "My Town My River Renovation Plan".

In 1963, citizens created a group called the "Council for Cleaning up the River" and launched volunteer efforts. The public's rising environmental awareness together with political will lead to the improvement of sanitation conditions by constructing sewer systems and treatment facilities[3]. From early 1970s, a pollution-related legal system was enacted, which included for instance the Water Pollution Control Law. When the Water Pollution Control Law came into effect, the authority for conducting inspections and regulating effluent from specified facilities as well as issuing directives for the improvement of facilities was transferred from the jurisdiction of the prefectural governor to the city's mayor. Around this time, the entire system for administration of pollution control measures[4] was reformed and the number of staff was increased from 22 to 47. In addition, between 1966 and 1980, the illegal dwellings that had contributed to the water pollution problem were removed; former residents of these areas were relocated to city-run public housing facilities.

[2] The Dokai Bay Stringent Standards covered six parameters: COD, suspended solids, N-hexane extracts, phenols, cyanide, and arsenic.

[3] By 2002, 98.5% of buildings were connected to sewer systems.

[4] Presently known as Environment Bureau.

Table 4. Water quality management assets related to the Dokai Bay recovery plan

Institutional Assets				Social Assets	Technology
Plans	Organizations	Laws and regulations	Financing mechanisms	Citizens, NGOs, corporations, social capital	
Wakamatsu Environmental Oriented Community Plan Dokai-bay Charming Plan	Aqua research centre The Environment Bureau Institute of Environmental Sciences	Water Quality Control Law Provincial Sediment Removal Standards Water Quality Conservation Law Dokai Bay Stringent Standards Factory Effluent Control Law Water Pollution Control Law Law Concerning Special Measures for Conservation of the Environment of the Seto Inland Sea	Polluter Pays Principle	Dokai Bay Cleaning Group Kitakyushu Region Labour Union The activities of women's associations	Dredging technology for sediments removal and disposal Water recycling plan Technology to monitor environmental endocrine disrupters Comprehensive ecosystem monitoring program

Source: Kitakyushu Environmental Asset Database (IGES 2004)

As a result of these types of measures, the quality of the Murasaki River's water was gradually restored. Citizens' activities have continued since the water quality improvement but now focusing on improving the city's amenities. New efforts have also expanded, including improving garbage collection system, releasing *ayu* (a local fish) into the river, conducting environmental education for children, and holding environmental conservation workshops.

The area around the Murasaki River is currently the centrepiece of efforts for urban renewal. In 1988, Kitakyushu was designated under the national government's "My Town - My River Renovation Project". This project does not seek merely managing the river flow for flood control; it is linked with planned redevelopment of the surrounding roads and urban area and it seeks to create an appealing urban space. Besides various measures for flood control, such as expanding the width of the river's lower reaches and dredging the river bottom, this project revitalized the area by construction of bridges, parks, a water museum, a commercial complex, among other amenities.

2.2.5 Sanitary management

Natural assets restoration is due to the installation of sewage system. Kitakyushu has achieved a sewage system covering 98.5% of the city, which puts it near the top of Japan's 13 largest cities. The well-developed *social assets* in terms of volunteer activities made the policy-makers aware of the need for better sewage systems from an early stage. Thanks to the expansion of the sewage system, the BOD levels in the rivers steadily improved.

The expansion of Kitakyushu's sewage system started in 1963 in Wakamatsu. Public awareness prompted the necessary political will leading to the development of the so-called Phase 2 of the Sewage System Improvement Five-Year Plan, with which the construction of the sewage system proceeded more rapidly.

Kitakyushu was able to reach a high level of sewage connection due to three main reasons as following: 1) its geography, the residential areas are relatively dense; 2) city's tax revenues from companies rose during the country's period of rapid economic expansion; and 3) a user-pay system was introduced in 1967, which gave the city a higher priority in receiving subsides from the Ministry of Construction.

Reflecting society's need for a clean coastal environment, the sewage treatment plants are operating with advanced treatment methods that reduce levels of phosphorus, nitrogen and other substances. Some treatment plants use the locally developed MAP (Magnesium Ammonium Phosphate) Method to remove phosphorus and reuse it as a fertilizer. At the Kogasaki Treatment Centre, the treated effluent is sent to the neighbouring Dokai Biopark, where the natural ecosystem (water lily, etc.) is used to remove nutrients such as phosphorus and nitrogen. The treated water is then reused to create an aquatic biotope for insects such as dragonflies. Moreover, the park is used as a place of environmental learning, recreation, and relaxation for residents.

About 200 tons (dry weight) of sludge are daily produced from sewage treatment. Until late 1990s, this sludge was disposed in landfill, but due to land shortage, the treatment method has changed. Half of the sludge is used in cement ("eco-cement") production and the other half is dried and incinerated with general waste. This process is being implemented with cooperation from the private sector and the city's incineration plants.

The City of Kitakyushu developed funding mechanisms for improving the sewage system and for integrating the larger number of residents to it. Costs for constructing facilities are mostly covered by subsidies from the national government and municipal bonds (long-term debt). Repayment of the bonds issued for sewage treatment is mostly covered by sewage treatment fees.

The City of Kitakyushu also offers loans and assistance to residents who start using the sewage system. Under the loan program, part of the construction costs are covered at zero interest when someone installs flush toilets, stops using a private sewage treatment tank and instead feeds into the public sewage system, or arranges for kitchen or bath wastewater to be used in the local residential area. Under the funding assistance program, people can receive grants if they convert from a pit toilet to a flush toilet, when they install common-use wastewater facilities, or when houses in low-lying areas use pumps in order to connect to the public sewage system.

Table 5 lists detailed information regarding the environmental management related to the Murasaki River water quality management and revitalization and the sewage system expansion.

2.2.6 Solid waste management

Kitakyushu City improved its solid waste management (SWM) along the years, from the 1950s, when waste collection was inefficient until now when the policies are concentrated on (1) addressing hazardous waste problems and (2) material recycling and promotion of sound material-cycle society. Improvements on waste management were achieved through to a series of actions, such as implementing changes on waste collection system, enacting specific legislation, developing or adopting new technologies, developing partnerships with the private sector, promoting public awareness and so on. All these activities and reforms, which can be classified as assets of urban management, led to the creation of proper conditions for (1) developing hazardous waste management strategies along with "risk communication" strategies and (2) promoting material recycling through the establishment of an eco-industrial park (Eco-Town Project).

The development of waste management in Kitakyushu city started with the launching of the national Public Cleansing Law in 1954, which made mandatory the cleaning of urban areas and the disposal of waste by municipalities; it also made the responsibility of residents to cooperate in local cleaning projects. This law received several amendments over the years; it was drastically reviewed in 1970, as the Waste Disposal and Public Cleansing Law, and in 1991, when the Law for the Promotion of Utilization of Recycled Resources was established. In 2000, the Waste Disposal Law was again amended and laws for promotion of recycling, including the Food Recycling Law and Construction Material Recycling Act, were established (Mendes and Imura 2004b).

Table 5. Environmental management assets related to the river water quality management and wastewater management

Institutional Asset				Social Assets	Technology
Plans	Organizations	Laws and regulations	Financing mechanisms	Citizens, NGOs, corporations, social capital	
My Town - My River Renovation Project	The City of Kitakyushu Construction Bureau, Water Environment Section, Firefly Subsection Conference on Measures of the City of Kitakyushu Against the Use of Detergents Environmental Museum of Water	The River Environment Standard Water Quality Class Designation The Reduction Guideline Concerning Phosphorous and Its Compounds The City of Kitakyushu Small Business Discharge Water Quality Improvement Guideline		The Takamiya Mariner Environmental Preservation Foundation Association of the Murasaki River's Fans The Murasaki River M-CAP Network Association to Beautify the Murasaki River	Additive-free soap of Shabondama Soap Corporation Biological Water Quality Survey Anti Synthetic Detergent Measures
The Sewage Maintenance Project	Installation System for Sewage Pump Facilities on Low Land The Aqua Research Centre The Public Sewage Construction System on Private Streets The Purification Centre	Drainage Ordinance The Sewage Law	Sewage fee Subsidy scheme for the Installation of Common Drainage Facilities The Drainage Facility Designated Constructor Loan scheme Corporate bond Government Subsidy Subsidy to Convert to Flushable Toilet Subsidy Scheme for the Installation of Sewage Pump Facilities, etc. on Low Land	"Sewage Day" street campaign Distribution of Pamphlets and Videos The Flushable Toilet Mediation Committee System The Sewage Drainage System Construction Technician Sewage expedition bus tour Social Studies Supplementary Reader "Sewage and Our Lives" The Flushable Toilet Diffusion Advisor System	The Magnesium Ammonium Phosphate Method The Dokai Bio Park Biosolids as substitute raw material of cement

Source: Kitakyushu Environmental Asset Database (IGES 2004)

In 1963, the Kitakyushu Bureau of Public Health developed a master plan for the collection, transportation and disposal of waste and excrement, and the ward departments operated waste disposal and collection. Waste management was enhanced as waste incineration facilities were completed at this time. Until the 1960's, household garbage was disposed of in garbage cans on the street and periodically collected by the cleaning office; however, efficiency was low, working conditions for the workers were bad, and several problems, such as foul odours and flies, arose. Hence, the collection from plastic containers started in 1963, resulting in higher waste collection efficiency (City of Kitakyushu 1999). This and other measures resulted in beautification of the town and improvement of the living and working environment. In 1991, a more efficient collection method using plastic bags at collection stations replaced the plastic container collection. Separated collection of cans and bottles started in 1993 and PET bottles, in 1997. In order to encourage residents to reduce waste generation, a pay-system using designated bags was introduced in 1998. Within the first year, general waste generation declined by 12% and resource recycling increased by same rate. The profits generated from revenues from the designated bag program, minus the costs of bag production, cover around 12% of the costs for waste management. Since its implementation in Kitakyushu, other cities established similar system; currently, 60% of the Japanese cities adopt the designated-bag system. Other cities in Asia are also adopting the same program.

From the late 1970s, efforts to encourage recycling started to gain momentum, including the organization of public events to promote recycling as well as awareness campaigns. In 1995, the *City of Kitakyushu Ordinance on the Reduction and Proper Treatment of Waste* was passed, and the basic philosophy of waste management shifted from *waste treatment* to *recycling*. Kitakyushu is taking a systematic approach to enact and implement measures and plans that make the most of the city's characteristics and strengths, such as the existence of local technology and expertise, in order to improve waste recycling and treatment. Following the national laws and directives, the *City of Kitakyushu Basic Plan on the Treatment of General Waste* was passed in 2001, moving further ahead from simple recycling to the development of an integrated resource cycle-based approach[5]. It has been encouraging greater demand for recycled goods, such as the green purchasing policy (IGES 2004b, Mendes and Imura 2004b). Additionally, it has been using financing mechanisms to decrease waste generation and promote recycling such as using a subsidy program for the installation of organic waste composters, and offering a support grant for organizations that collect used paper. Around 26,000 households have compost equipment.

In 1997, the Japanese Ministry of Economy, Trade and Industry (METI) launched the "Eco-Town Project" to provide assistance to local governments, which were planning to achieve regional development through the promotion of environmental industry. Local governments, if their master plans were approved, received various forms of financial aid from the national government, including subsidies[6] to private companies that agree to construct recycling and other facilities, and financial support for the exhibition of eco-technologies. As a mature industrial city, Kitakyushu retains vast

[5] An integrated approach based on 3Rs (Reduce, Reuse, Recycle).

[6] Two types of subsidies are provided to Eco-Towns: 1) Assistance for *'Soft'* Projects (Subsidy for Resource-Recycling Local Stimulation Project Costs) which covers up to 1/2 of costs, and 2) Assistance for *'Hard'* Projects (Subsidy for Resource-Recycling Local Stimulation Facilities Improvement Costs) which covers up to 1/2 of costs or 1/3 of costs (METI 2005)

land areas that were once developed for the siting of industrial facilities, but are almost abandoned today. On the other hand, it has accumulated technologies for the processing of metals, chemicals, and other materials, which can be applied to the development of resource recycling and recovery technologies. Kitakyushu has been promoting a new urban industrial development policy to invite recycling and other eco-industries to its unused reclaimed land. It launched the first Eco-Town Project in Japan, which is based on the *zero emission* concept and involves an eco-industrial complex (or *"environmental kombinat"*) and a research centre for the development and assessment of recycling technologies. The city provides various benefits to small- and medium-sized companies for the development of diverse technologies. So far, recycling factories for PET-bottles, cars, electric appliances, and construction materials have started operation. The ultimate aim of the Kitakyushu Eco-Town is not only to develop recycling industries, but also to create a new industrial system in which resources are used more efficiently and that generates no waste (Mendes and Imura 2004a, Mendes and Imura 2004b). Several new technologies are being developed in the site, such as the development of biodegradable plastic and use of waste fibreglass-reinforced plastic (FRP) from fishing boats (IGES 2004).

Regarding industrial wastes, through good coordination with neighbouring communities among other actions, Kitakyushu aims for their proper treatment. The city also developed several plans and regulations towards better treatment and disposal, such as the *Kitakyushu Guidelines Concerning Appropriate Treatment* associated with the *Movement of Industrial Waste* (1988), the *Kitakyushu Guidelines Concerning Conflict Prevention and Mediation Relating to Establishment of Industrial Waste Treatment Facilities* (1991), and the *Kitakyushu Ordinance and Regulations Concerning Reduction and Proper Treatment of Waste* (1994). In addition, the city passed the *Ordinance Concerning Treatment of General Waste Together with Industrial Waste* (1993) in order to increase the effectiveness of waste treatment. To deal with dioxins, which represent a new type of pollutant on the regulatory front, Kitakyushu also passed *Guidelines to Limit Dioxins from Small-Scale Incinerators* (1999), and based on the national *Law Concerning Special Measures against Dioxins* (2000), environmental quality standards were set and emissions standards and monitoring became mandatory for designated facilities. Financing industrial waste treatment measures became an issue requiring attention; thus a new tax, the *Environment Future Tax*, was imposed on the landfilling of industrial waste, and revenues are being used to secure final disposal sites as well as to promote environmental industries (IGES 2004).

Kitakyushu also developed capacity on hazardous waste management. For instance, it is handling the treatment of polychlorinated biphenyl (PCBs) for 17 prefectures in West Japan. PCBs were widely used in the past as an insulator in electrical condensers and transformers, but after a cooking oil poisoning incident[7], production was halted in 1973, and companies with PCB products were required to store their own PCBs. Due to citizen's concern about PCB contamination and opposition against construction of treatment facilities in their communities, thirty years passed with the PCBs still in storage; however, there was evidence of PCB contamination in several sites. Kitakyushu started a process of risk communication and discussion with stakeholders in order to attend the request from national government to install a

[7] It became known as the *Kanemi Yusho* or *Kanemi cooking oil syndrome*, which occurred in Kitakyushu in 1968 (Niida 2005).

chemical treatment facility. In 2001, the *Kitakyushu PCB Treatment Safety Discussion Committee* was established; 450 people participated in events for discussions. In addition, the city government made several presentations for providing clarifications and debating safety guarantees and responsibilities. After discussions, the location of the PCB treatment facility was approved. It was proactive efforts for information disclosure and a system that allowed monitoring and oversight by residents that made it possible to reach the decision to locate the PCB treatment facility in Kitakyushu.

Table 6 lists the assets related to solid waste treatment and recycling. It is noteworthy to point out that Kitakyushu used and produced several assets in this sector, such as regulations, financing mechanisms and technology development and application.

2.3 Outlook

This section summarized the example of Kitakyushu through air, water, and waste management. Each issue was reviewed through the environmental management capacity asset approach, which was introduced in the line of new paradigm of environmental capacity building. The methodology applied in this study allows cities to develop their own self-evaluation of their environmental management capacity. Kitakyushu City environmental assets database can be an example to other cities across Asia.

Note: Text written by Dr. Mara Regina Mendes based on research and documentation produced by Ms. Noriko Kono and Dr. Hiroaki Shirakawa in a work commissioned by the City of Kitakyushu.

Table 6. Solid Waste Management Assets for Kitakyushu City

Institutional Assets				Social Assets	Technology
Plans	Organizations	Laws and regulations	Financing mechanisms	Citizens, NGOs, corporations	
Kitakyushu Renaissance 3rd Implementation Plan "For Creation of a Future Environmental City" (1999-2003) Basic Plan on the Treatment of General Waste		National Law Concerning Special Measures against Dioxins Guidelines to limit dioxins from small-scale incinerators Kitakyushu guideline on movement and treatment of industrial waste Kitakyushu Ordinance and regulation concerning reduction and proper disposal of waste Ordinance Concerning Treatment of General Waste Together With Industrial Waste Kitakyushu Ordinance and enforcement regulations regarding prevention of littering rubbish	Designated bag fund Support grant for organizations collecting used paper Subsidy program for the installation of organic waste composers	"Clean-up day" City of Kitakyushu Environmental Health Convention Green City Month	PCB treatment Power generation from waste and dried sludge from wastewater treatment plant
The Kitakyushu Eco-Town Plan	Environmental Industries Promotion Office Environmental Industry Promotion Council	Kitakyushu City's guidelines for granting of subsidies for development of industrial recycling facilities (Eco-Town Centre Ordinance)	Eco-tax	Recycling Industry Council Eco-Town Electricity Cooperative Union Practical Research Area Promotion Council Eco-Town Disaster Reduction Council	Medical Wastes Recycling Recycle of office equipment, household electrical appliances, cooking oil and fat, bean curd refuse and other food residues, paper, construction wastes, fluorescent lamps, automobiles, styrene foam, pet bottles and cans Research and development of Shochu (distilled spirit) lees recycling technology Recycling of food wastes to produce bio-degradable plastics

Source: Kitakyushu Environmental Asset Database (IGES 2004)

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3. Energy consumption and GHG emissions in selected East Asian mega-cities

The trend of urbanization, especially in Asian developing countries, which was described previously, will increase energy use since per capita commercial energy uses in cities are higher than that of the rural areas. This will further contribute to worsen local as well as global environmental problems in the future from energy use.

One of the major factors driving clean energy debate today is due to increasing concerns for air pollution and climatic changes. The United Nations Framework Convention on Climate Change (UNFCCC), which was adopted in 1992, sets an ultimate objective of stabilizing GHG concentrations in the atmosphere at a level that would prevent dangerous human-induced interference with the climate system. It urges the parties to protect the climate system in accordance with their common but differentiated responsibilities. Within the Asian region, the significant increase of energy consumption and GHG emissions is expected to take place in mega-cities, which have rapidly expanding populations that enjoy higher living standards and material affluence than that of rural areas and smaller cities. Increasing demand for passenger mobility and freight transport will be reliant upon increases in the number of vehicles, which not only create problems such as traffic congestion, urban heat islands, air pollution, and noise but are also a major cause of increasing energy consumption and CO_2 emissions. The carbon sink within the mega-cities, primarily urban greenery, is insufficient to absorb emitted carbons.

Nowadays cities in the rapidly industrializing regions of Asia are confronted with multiple tasks for economic development and environmental protection. They tend to give priorities to immediate local issues and to regard global warming as a long-term and distant issue. Moreover, the nature of energy use and GHG emissions from cities is not well known in Asia. Municipal policies to reduce energy consumption may bring multiple benefits to the community. It will help to solve air pollution, urban heat island, and traffic congestion problems, and will facilitate the reduction of CO_2 emissions. Energy management at the city level was neither a priority, nor an important topic until recently because local energy related decisions are mostly made at the national level in most of the Asian countries with few exceptions. Recently, due to the growing concerns of climate change, efforts are being made to understand such phenomenon at the city level in more detail. City policy makers are under growing pressure to incorporate GHGs, especially CO_2 emissions into consideration while planning. However, any policy measure solely for CO_2 reduction is a distant possibility for cities in Asia with the exception of selected and relatively developed cities. Integrating energy consideration into policies, either by integrating energy concerns to overall urban development or by synergizing measures to reduce air pollution and CO_2 emissions, is therefore important.

In this context, apart from a broader picture and discussions, this chapter examines the linkages between energy use and CO_2 emissions and their other environmental implications, mainly air pollution and urban warming (popularly known as urban heat island[8]), in selected East Asian mega-cities, namely Tokyo, Seoul, Beijing and

[8] Urban heat warming is a phenomenon in which temperature of an urbanized area becomes significantly higher than its surrounding areas. Often, the term “heat island” is used to describe this phenomenon. In earlier times, higher latitude cities, mostly in Europe, experienced this

Shanghai. The sub-section also discusses a direct and indirect energy-CO_2 scenario and their sectoral performance in these cities. Based on the results, it provides a broader perspective on why some cities are more energy efficient than others. Further, this sub-section discuses these barriers and potential opportunities to reduce CO_2 emissions from energy use.

The four mega-cities in this study, Tokyo, Seoul, Beijing, and Shanghai, share common characteristics in terms of population, population density and they are the most important cities in their respective countries. However, they present differences on income level, development level, governance, and institutional capacity among others. In this case study, the so-called “city”, or the geographical boundary for Tokyo, Seoul, Beijing, and Shanghai are respectively Tokyo-to (Tokyo Metropolitan Government administered area), Seoul City, Beijing, and Shanghai. Beijing and Shanghai are far greater in area than Tokyo and Seoul. However, the boundary of the core ward areas (built-up areas at the centre of ward areas) in Beijing and Shanghai are comparable to Tokyo and Seoul, although their city-boundaries have changed over time.

3.1 Urban energy use and its context

A compact city may have smaller per capita energy consumption due to compact transportation and distribution infrastructure; at the same time, the city may have smaller per capita building floor space, thus further reducing energy use. In Japan, the pattern of energy consumption shows that the per capita energy consumption in urban areas, which are denser, i.e. more compact, is lower than that of non-urban areas and this phenomenon is common in developed countries (Ichinose et al. 1993). In developing countries such as China and Thailand, the opposite trend is reported (Ichinose et al. 1993). The income gap between urban and rural areas is smaller in developed countries such as Japan, and therefore, the effect of urban density can be visible. In developing countries, the income gap is “large,” whose effect surpasses the “effect of density” for commercial energy uses (non-commercial energy uses are not considered in many studies).

In general, energy consumption in Tokyo, Seoul, Beijing, and Shanghai is increasing in last three decades, with the exception of Beijing and Seoul (after the 1997 Asian financial crisis). Beijing seems to have followed the national trend, which reports that energy consumption and more specifically CO_2 emissions decreased after 1996. However, there is an ongoing controversy whether this reduction in China is real or has resulted due to accounting problems. In Beijing, the total energy consumption has increased by 15% in 1998-2002 (Wu 2004).

The per capita energy consumption of these cities is consistently increasing and is converging towards a common point in recent years (Figure 2). This means that

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phenomenon in winter times. Today it affects major cities in the world (Kubo 1997). Anthropogenic heat discharge due to energy uses is one of the major factors for urban heat island (Dhakal 2002). Other factors are linked to land use changes, which affect the characteristics of ground surfaces such as evaporative capacity, specific heat capacity, surface reflectivity and others. Apart from direct energy use and their heat discharges, urban built up structures also create imbalances in storage and release pattern of heat, and wind obstruction by which heat island become more phenomenal in late afternoon or evening hours (Dhakal et al. 2003a; Dhakal et al. 2004).

developing cities such as Beijing and Shanghai are rapidly approaching and even surpassing developed cities such as Tokyo and Seoul (Since 1998, Seoul's per capita energy consumption decreased due to the financial crisis in 1997. It is currently recovering).

In Tokyo, energy consumption has increased to about 85% in the last three decades (1970-98). Oil, urban gas, and electricity are major energy sources and coal has almost been eliminated. Electricity use, in particular, is rising compared to other fuel types both in terms of share and absolute volume and oil is decreasing. Industry has a nominal share in Tokyo in recent years (about 10%; national share is about 40%), unlike Beijing and Shanghai, where it contributes over 65% and 85%, respectively. Most of the energy use in Tokyo is by transportation and commercial activities. Within the commercial activities, offices consume a majority of the energy, followed by restaurants whose gap has significantly widened in last two decades due to increasing share of offices. Energy consumption by restaurants has decreased since 1995, most likely due to the economic recession (Dhakal et al. 2002, Dhakal et al. 2003b, and IGES 2004).

Seoul is very distinct in its high share of oil use; in recent years, coal has been eliminated and substituted with gas and electricity. Residential households consume the majority of energy in Seoul, followed by transportation. The provision for district heating is rapidly expanding. In 2001, over 350,000 households used district heating which is expected to increase to over 430,000 households by 2007 (Jung 2004).

The structure of energy use in Beijing and Shanghai has not changed significantly. The major characteristics of the energy profile in these cities are: (1) electricity share is somewhat increasing, (2) coal dominates energy use, and (3) the share of transport sector is between 5-10%. Despite high economic growth, the primary industry is shrinking in Beijing and Shanghai; significant economic growth is coming from the tertiary sector, which balances the energy profile to some extent so that per capita energy consumption does not overshoot. In Beijing for example, coal consumption of the secondary industry is growing in total final consumption, which is consistent with the economic growth trend of the secondary industry. Beijing replaced small coal-fired boilers to gas-fired boilers in residential sectors, and accordingly, coal consumption in this sector has reduced from 4.0 million tons in 1995 to 2.8 million tons in 1999 (BSY 2001). The use of natural gas has risen dramatically in Beijing and Shanghai in recent years but still accounts for a very small share. In Shanghai's energy structure, 6-7% reduction in coal shares has taken place from 1995-2000, which is largely substituted by oil. A rapid change in energy structure has taken place after 1998.

Table 11 in the Appendix presents detailed information about the four mega-cities.

3.2 Carbon dioxide emissions from cities

Commercial energy use and income are expected to have direct correlations. Accordingly, the per capita energy use has increased in these East Asian mega-cities. Interestingly, the trend of per capita energy is converging in these cities in between 1.3 and 1.6 TOE/person as shown in Figure 2. In contrast, per capita CO_2 emissions in Beijing and Shanghai are rapidly diverging from Tokyo and Seoul (Figure 3). In 1998, per capita CO_2 in Tokyo was 4.84 tons, which was 1.3 times higher than Seoul;

Beijing and Shanghai were respectively 1.3 and 1.6 times higher than Tokyo. Economic recession in Tokyo in the mid-1990s did not reduce CO_2 emissions because in Tokyo they are affected more by lifestyle factors which are resistant to changes. The 1997 Asian currency crisis shows a visible impact on Seoul as emissions reduced drastically from previous year in 1998. In contrast, Beijing and Shanghai transformed from "smaller economic growth" and "higher emission growth" phase in the 1980s to the "higher income" and "lower emission growth" phase in the 1990s as shown in Table 7. Several factors contributed to this transformation such as technological advancements, increases in market competitiveness, reform of inefficient state enterprises, emergence of a strong tertiary sector and massive energy efficiency improvements (IGES 2004, Dhakal et al. 2002, Dhakal et al. 2003b, Wu et al. 2005).

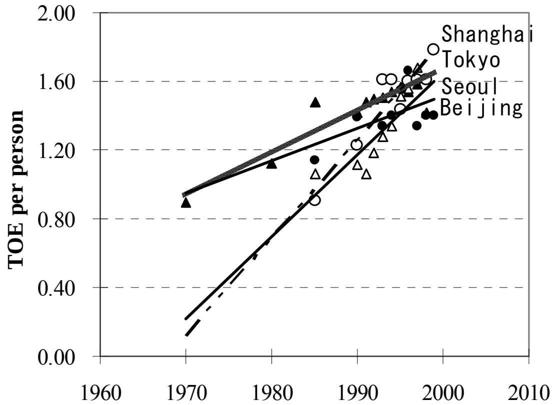

Figure 2. Trend of per capita energy consumption

Source: IGES (2004)

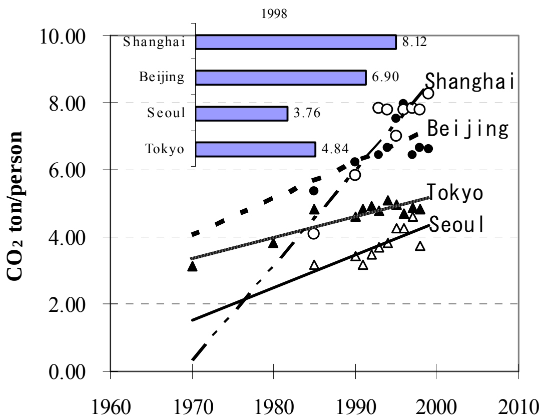

Figure 3. Trend of per capita CO_2 emission from energy use

Source: IGES (2004)

The differences in the sources of CO_2 emissions are quite contrasting in these cities. Tokyo is dominated by commercial and transport sectors where the share of industry's CO_2 emissions has diminished to less than 10% now from 35% in 1970. On the contrary, the household and transport sectors are dominant in Seoul. Most of the emissions in Beijing and Shanghai are dominated by industry, where the role of the transport sector is smaller (about 5-6%). Despite the fact that the role of transportation is smaller, it is growing rapidly with a rate of over 10%. Future growth is also expected to follow this trend in urban transportation due to continuous economic growth, financial market liberalization (availability of more credit mechanisms to buy vehicles) and WTO accession (Zhou and Sperling 2002, He et al. 2004a, He et al. 2004b). Since transportation related air pollution is already serious, such vehicle growth is alarming to local policy makers.

On the fuel side, structural changes in the share of fuel types in CO_2 emissions have been low in Beijing and Shanghai over the last two decades. However, ambitious plans exist in these cities to tap clean energy from the Three River Gorge Dam Project and from the national government's massive natural gas pipeline plan. In the case of Tokyo and Seoul, coal has been almost eliminated in recent years and electricity is playing a greater role. Oil significantly dominates the market in Seoul due to its massive district heating and cooling systems which is essentially lacking in Tokyo.

Table 7. Economic and CO_2 emission transitions in cities

City	1970-80	1980-90		1990-1998	
		1980-85	1985-90	1990-97	1997-98
Tokyo	High economic growth (8.5%) Moderate emission growth 2.5%	High economic growth (6.3%) Moderate emission growth (2.3%)		Negative economic growth (-0.4%) Low emission growth (0.7%)	
Seoul				High economic growth (5.9%) Moderate emission growth (4.5%)	Negative economic growth (-16.3%) Negative emission growth (-19%)
Beijing			High economic growth (7.5%) High emission growth (6.5%)	High economic growth (14.5%) Low emission growth (2.7%	
Shanghai			Low economic growth (2.3%) High emission growth (11%)	High economic growth (20%) High emission growth (5.6%)	

Definition for high and low is subjective, over 5% is taken as high in this table for comparison purpose.
Source: IGES (2004)

The comparison of emissions between these cities with other OECD and major non-OECD countries based on per capita and per unit of economic activity shows that Tokyo is outstanding in its performance (Dhakal et al. 2002, IGES 2004). All these four cities have failed to perform better in terms of per capita but their performance is better in terms of per unit economic activities as shown in Figure 4.

3.3 Perspectives on indirect emissions of cities

In contrast to direct emissions, emissions embedded in consumption goods are often neglected in CO_2 debates. The true environmental load of a city, especially in case of location-nonbinding emissions such as CO_2, needs to be clarified to explore alternative urban development pathways. This essentially reduces the burden to upstream production processes and natural resource extraction. To extend such an approach, a detailed analysis of the consumption activities of urban dwellers is necessary. However, with the lack of such studies, industrial Input-Output Table based studies can provide at least some perspective on the extent of such loads. Such analyses show that the indirect emission of CO_2 in cities such as Tokyo and Shanghai could be over three times than that of direct emissions. However, cities do not always "consume" − it also exports goods which should be deducted; with that argument, the CO_2 emissions for which Tokyo, Beijing and Shanghai are "responsible" (responsible emission = direct emissions from energy use + indirect emissions embedded in input materials – emissions embedded in exported materials) could be about 70% of total (direct and indirect) emissions (Kaneko et al. 2003). Although such estimation may not actually reflect all consumption-related indirect emissions, it essentially provides a sound basis to show and argue that indirect emissions from mega-cities are large and policy makers should consider it as an issue.

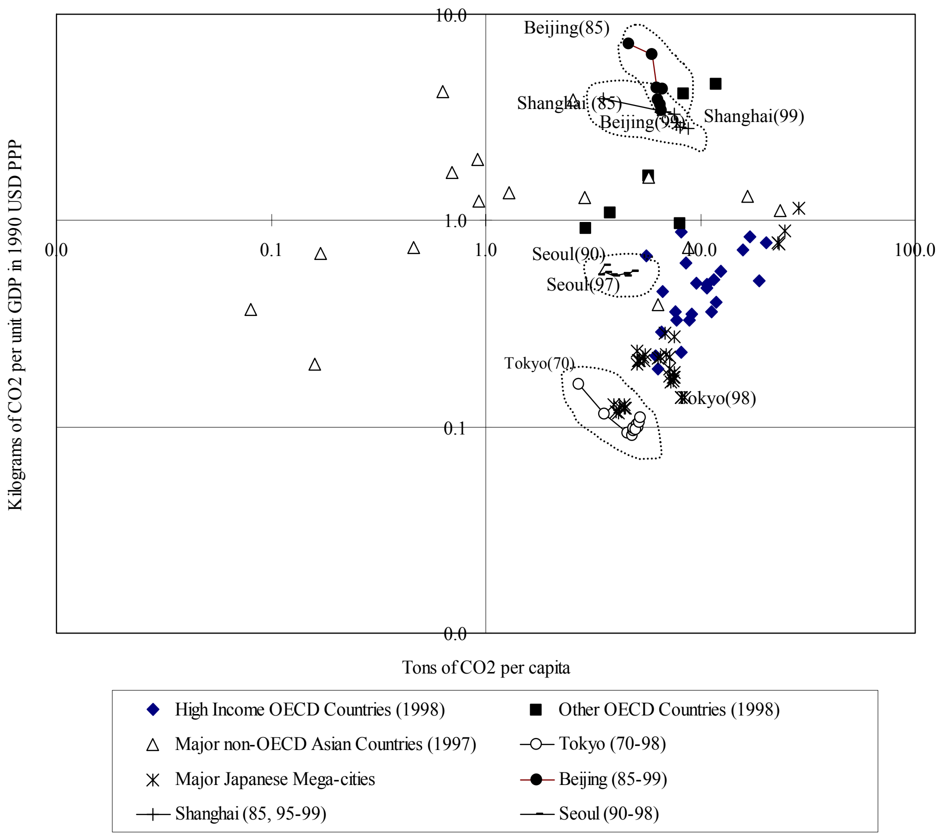

Figure 4. CO_2 emission in per capita and per unit GRP/GDP (in log-log scale)

Source: Dhakal et al. (2002)

3.4 Driving forces for CO_2 emissions

A number of factors influence energy use and resulting CO_2 emissions from cities. Among them, some major factors are compactness of urban settlements, urban spatial structure, and urban functions, nature of transportation systems, income and lifestyle, energy structure, energy efficiency of key technologies, industrial processes, building technologies, climate, and waste disposal methods. A decomposition analyses of CO_2 emissions of four factors (namely, emission per unit energy use, energy use per unit economic activity, per capita income and population) for 1970 – 1998 shows that the impact of the population on CO_2 emissions is very low in Tokyo, Seoul, Beijing and Shanghai (Dhakal et al. 2002, Dhakal et al. 2003b, IGES 2004). Income and lifestyle changes are the most influential factors in these cities in 1970-98. Improvements in energy intensity (energy use per unit economic activity), which shows the direction of technological change and higher productivity of energy use, have played the most important role in reducing energy use and associated CO_2 emissions in general. The contributions of fuel quality improvements and fuel switching for reducing CO_2 emissions has become important in Seoul in recent years but their effect has been very low in Beijing and Shanghai over the last two decades. Most of the CO_2 related benefit has come from energy efficiency improvements in Beijing and Shanghai. In the transport sector, a rapid increase in vehicle number is the major reason for CO_2 emissions. The role of mass rail networks in Tokyo is a key factor for stabilizing emissions, but increases in the number of large cars is a primary cause of the increase in emissions (Dhakal 2003). In the household sector, household income is mostly responsible for the increase in emissions in cities. It was noted that the decreasing size of household, and consequently, the increasing number of households are primarily responsible in Seoul for increases in emissions in the household sector (Dhakal et al. 2003b).

The choice of waste treatment methods affects GHG emissions; for instance, CO_2 is emitted by incineration plants while methane is emitted by landfilling. While waste reduction at source avoids GHG emissions as shown in Table 8. Despite significant differences in income, Tokyo, Seoul, Beijing, and Shanghai have small differences in per capita waste generation (1.13, 1.06, 1.11, and 1.04 kg/person/day, respectively) (Yoon and Jo 2003a and 2003b). With prevailing open dump and landfilling and lesser efforts to reduce waste at source, GHG emissions from Beijing and Shanghai would increase dramatically.

Table 8. Net GHG emission from source reduction and MSWM options

Material	Source reduction	Recycling	Composting	Combustion	Landfilling
Newspaper	-0.91*	-0.86	NA	-0.22	-0.23
Office paper	-1.03	-0.82	NA	-0.19	0.53
Aluminium cans	-2.98	-3.88	NA	0.03	0.01
Glass	-0.14	-0.08	NA	0.02	0.01
PET	-0.98	-0.62	NA	0.24	0.01

Note: Emission counted from a waste generation reference point in MTCE/ton
Source: USEPA (1998)

Even under the most optimistic scenario, it has been found that the CO_2 emissions from these cities will not decrease (IGES 2004, He et al. 2004b, Matsumoto et al. 2003, Wei and Matsumoto 2003). The results from bottom-up models show that the vehicle population in Beijing and Shanghai is about one-tenth that of Tokyo in year 2000, but their total fuel consumption is only about one-third to one-half that of Tokyo because of lower fuel efficiency and larger vehicle mileage travel, among others (He et al. 2004b). As a result, a much smaller vehicle fleet in Beijing and Shanghai emit a larger amount of local pollutants and CO_2. In particular, light duty gasoline vehicles are expected to significantly contribute to the increase of CO_2 in the future in optimistic scenarios, and a more than twofold increase in fuel consumption from road transportation is expected in Beijing from 2000-2020. Policy measures to intervene in lifestyles and appliances will be the most important measures that would reduce the maximum volume of emissions from households and businesses in Tokyo (IGES 2004, Dhakal 2003).

The better performance of Tokyo for CO_2 emissions even at higher income level compared to other cities is attributed to a number of factors. These factors are divided into three groups. The first group of factors is geo-physical in nature, mainly location of cities and their climate in which Tokyo's location is favourable than other cities. The second group of factor is physical in nature mainly density of settlements, transportation infrastructure, industrial structure, automobile dependency, type of energy supply, technological efficiency of appliances and processes (for Shanghai see Table 9). In particular, a well-developed mass-transportation network, high commuting population and small contributions of industries in the city (city is commercial in nature) made Tokyo efficient. The third group of factors is non-physical in nature and is related to policies and institutions mainly level of awareness, institutional capacity, technology, and resources availability for interventions. Socio-cultural factors (household size, cultural preference, etc.) may have been responsible partly which could not be confirmed.

Table 9. Comparison of energy efficiency in Shanghai and in OECD countries, 1998 (Indicative)

	Unit	Shanghai	OECD countries
Coal-fired electricity production	(GJ el/GJ fuel)	0.38	0.40–0.44
Primary steel production	GJ/ton	20–25	18–20
Oil refining	GJ/GJ	0.03	0.03–0.07
Coal-fired industrial boilers 4–10t steam/ hr	(GJ steam/GJ fuel)	0.65	0.7–0.75
Passenger cars	L/100 km	10	8-14
Colour TV	Watts	100-150	70-120
Air conditioners	KW cold/KW el	3.6-4.4	3.8-5.5

Source: Gielen and Changhong (2001)

3.5 Local concerns and options for air quality and urban heat island

Apart from CO_2 emissions, several local air pollutants are already above healthy limits in some of these cities. Local experts suggest that the existing countermeasures in Beijing are not likely to meet WHO guidelines by the 2008 Olympic Games. Further increases in energy use in these cities would tremendously increase the health risks posed by local air pollutants.

The trend of air quality shows that Tokyo was successful in reducing the concentration of SO_2 drastically between the mid-1960s to the early 1970s, and Seoul after 1988 (Figure 5). Beijing and Shanghai suffer from higher concentrations of sulphur dioxide and particulate emissions compared to other cities as shown in Table 10. Rising emissions of air pollutants would further aggravate air quality. Since coal continues to dominate the energy sector in Beijing and Shanghai and the economy is growing at rapid rate, the development and implementation of serious policy efforts are necessary to bring these parameters into the acceptable limits.

Table 10. Air quality in selected cities, in micrograms per cubic meters

City	Particulates (1997), mg/m^3	Sulphur dioxide	Nitrogen dioxide
Beijing	377 (TSP)	71 (2000)	126 (NOx, 2000)
Shanghai	229 (TSP)	46 (2000)	91 (NOx, 2000)
Tokyo	45 (ward, SPM)	20 (ward 1997)	94 (city centre), 64 (ward) (NO_2 1998)
Seoul	72 (TSP), 68 (PM10)	31 (1997)	62 (NOx 2000)

TSP: Total suspended particles
Source: Compiled from statistical yearbooks of cities (cited in IGES 2004)

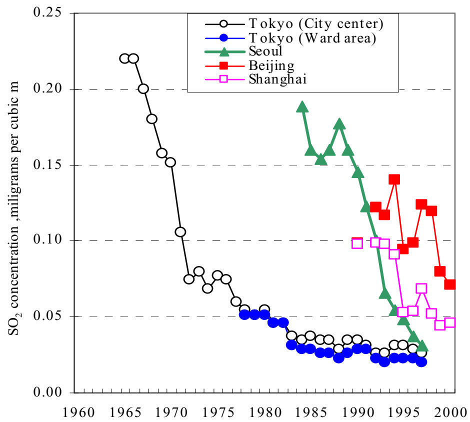

Figure 5. SO_2 concentration trends
Source: IGES (2004)

Although Tokyo has been successful in reducing concentrations of key industry-related air pollutants in the last three decades, which includes dust, carbon monoxide, and sulphur dioxide (SO_2), it has been struggling considerably to control suspended particulate matters (SPM), nitrogen oxide (NOx) and photochemical oxidants. Most are essentially emitted by businesses, households and lifestyle related activities. Therefore, a number of other problems other than GHGs are of the highest priority in Tokyo. Most Japanese cities, including Tokyo, suffer from SPM and NOx problems (Figure 6). Diesel vehicles were responsible for almost all particulate matters and about 70% of NOx emissions in Tokyo in 2003 (TMG 2003). A past estimation shows that automobiles were responsible for 67% of total NOx emissions, of which 73% was contributed by trucks and buses in 1995 (TEW 1997).

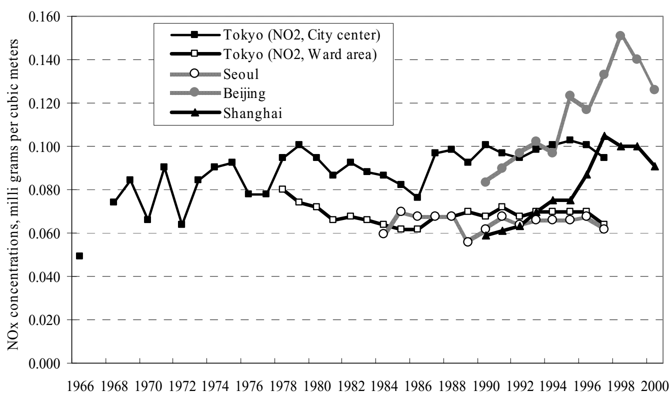

Figure 6. NOx concentration trends
Source: IGES (2004)

In Seoul, SO_2 and PM10 are not a major concern because they are within the WHO recommended guidelines, and in last two decades, their level has been decreasing with an increasing supply of clean fuel, better road pavements, and so on. However, the level of NOx (especially NO_2) and ozone are increasing, primarily due to the increase in volatile organic compounds (VOCs) and slowing road traffic flow (Jung 2004).

3.6 Policy challenges

Traditionally, energy management has not been a priority agenda for municipal policy makers. Major energy related decisions are usually made by national governments. Accordingly, no comprehensive policy framework exists for energy issues at the city level. Interventions in energy related policies at the local level emerge primarily from either energy security or environmental impacts, namely air pollution. Even for urban environmental management, a comprehensive policy framework is lacking in general and environmental policy response is often fragmented into different sectors and actors without proper coordination in developing Asian countries (IGES 2004).

Developed nations of Annex-I[9] of UNFCCC are still struggling to formulate response strategies at national levels. Such expectations from cities now are minimal. There are many challenges regarding energy and environment in cities; some of those core challenges are as following:

- lack of awareness among local policy makers on global issues;
- lack of scientific studies, inventories of energy and CO_2 emission, and related information;
- financial, human and technical resource limitations even to tackle urgent local air pollution;
- priority questions in resources allocation; and
- public awareness.

Despite such limitations, mega-cities, especially in Northeast and South-East Asia, are aware, to some extent, of the need to reduce CO_2 emissions. In a mega-city such as Tokyo, the volume of CO_2 emissions exceeds that of many nations (TMG 2002).

Less awareness and less priority of local governments to global issues impede the efforts of GHG mitigation, as resources are limited and existing challenges for local environmental management are tremendous in cities. With the exception of Tokyo, the other case study cities do not have explicit policies to reduce GHGs. Existing policy measures in Tokyo jointly tackle urban warming and GHG emission issues and intervene mostly in the building sector, voluntary information disclosure system and others, principally, in energy efficiency improvement programs (Dhakal 2003). Implicit considerations of GHG mitigation, through the implementation of local air

[9] Annex I countries agree to reduce their GHG emissions to target levels below their 1990 emissions levels. If they cannot do so, they must buy emission credits or invest in conservation.. The list includes most OECD member states and some countries from central and eastern Europe and the Commonwealth of Independent States that are undergoing the process of transition to a market economy.

pollution measures and energy sector restructuring, have been observed in other cities (IGES 2004). However, measures to improve air pollution do not necessarily contribute to the reduction of GHG emissions. Broader policy agendas, such as emissions trading and mandatory reductions in the corporate sector, do not exist in any of the cities. The market mechanisms in cities are less effectively used in the process. Consensus building is a major challenge for local policy makers to formulate plans to influence powerful stakeholders, such as the corporate sector. Institutional barriers exist in mainstreaming the concerns of GHGs in the overall policy agenda even in developed cities such as Tokyo, where mandate and role of the responsible unit is limited not only due to local priority issues but also due to institutional structure (Dhakal 2003, IGES 2004).

3.7 Towards sustainable development of Asian cities

IGES (2004) noted that a gap of about twenty years persists in major infrastructure and energy-emission related indicators amongst Tokyo, Seoul, and Beijing. This phase-gap may assist Beijing to learn from the past successes and failure of Tokyo and Seoul. Therefore, sharing of experiences amongst the cities is essential. Such sharing of experiences would be bi-directional amongst developing and developed cities. Promoting forums that can facilitate information exchange, inter-city cooperation, creation of an information base, and sharing lessons and best practices is essential. In particular, empowering the local authorities is essential; their role is limited and jurisdiction is often narrower in environmental management in general, especially in South and South-East Asia. Building their capacity is essential. As these authorities have fewer experiences, an improved local-national coordination mechanisms and concrete national support is essential.

Past experiences tells that policies and policy instruments might have been successful in intervening per unit activity such as emission efficiency of economic activities, and emission per unit vehicles travel, but they have largely failed to control the scale of activity and structural shift of environmentally adverse choices. For instance, in the transportation sector, existing standards based on emission per km alone are not sufficient; standards based on average emission of vehicles fleets for corporate sector and auto sellers is also necessary. In addition, existing policies usually intervene from sectoral viewpoints; a transition from such sectoral planning to urban level integrated planning is essential. Urban planning practices have serious challenges to deal with metropolitan growth, denser population, denser infrastructure and urban activities, and a new way of planning is essential which can accommodate energy efficiency and CO_2 concerns.

Promotion of mass transportation and energy/emission efficient transportation infrastructure is essential. This can be achieved through a number of ways depending on city situations, such as promoting bus networks, restricting private cars, providing bus lanes, developing rail-based mass transportation and others. From the investment side, it could be challenging, but new financial mechanisms such as Public-Private Partnership schemes and Foreign Direct Investment can bear such costs with the government if the government can facilitate a good working environment from a regulatory, institutional, and financial viewpoint. Asian cities, especially mega-cities, are rapidly developing and constructing massive infrastructure. Once construction is completed, the cities will be in no position to significantly alter or change the infrastructure. Therefore, policy makers should incorporate the concept of energy efficiency and should consider of the environment during the construction of these infrastructures in order to avoid future "lock-in." It is not too late for policy makers to develop visionary policies to make energy-efficient-cities, in terms of infrastructure, although such windows are rapidly closing.

Due to priority questions, explicit GHG policies cannot be expected in the cities of developing countries at this time. Promoting integrated approaches, i.e., promoting those measures that can reduce GHGs without seriously compromising air pollution priorities is a promising strategy for addressing GHG emissions at local level. The synergy and conflicts between such measures have been poorly evaluated in the past. Even in those cases where it is evaluated, this has not been reflected in policy implementation due to the lack of serious consideration given to the issue. Such integrated approaches, to some extent, have gained interest in industries and power plants from the viewpoints of Clean Development Mechanisms and other financial/pollutant benefits. However, fewer efforts have been made in the evaluation of these benefits in the transportation sector. Therefore, finding barriers and opportunities at different scales of environmental governance is necessary and lobbying at the national and international level to extend support for integrated approaches is important, especially to bilateral and multilateral funding agencies and in their capacity building efforts.

Indirect CO_2 responsibility needs to be addressed in mega-cities, as they are focus of consumerism, income growth, and lifestyle changes. As more mega- and medium-size cities will grow in Asia, this issue will become more important in the future. At present, it may not be possible to have explicit polices however this should be addressed from other viewpoints, such as material and waste management and creation of a society with a sound material-cycle[10]. This contributes not only to emission reduction, but also reduces the consumption of precious natural resources. Drastic campaigns and awareness raising are necessary on the part of policymakers, non- governmental organizations (NGOs) and other concerned organizations, such as media.

Note: This article, written by Dr. Shobhakar Dhakal, is based on a research carried out within the Urban Environmental Project of Institute for Global Environmental Strategies under the theme "*Urban policy integration of energy related environmental issues in selected Asian cities.*" For further details, see a book recently published by the Project titled "Urban Energy Use and Greenhouse Gas Emissions in Asian Mega-cities: Policies for a Sustainable Future."[11]

[10] This concept is quite advanced in Europe and is penetrating into Japan and Korea, as discussed in Section II.

[11] The book is available for download from http://www.iges.or.jp/en/ue/report2.html

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3.9 Appendix

Table 11. Comparison of city attributes

Cities	Tokyo	Seoul	Beijing	Shanghai
Status	Matured city, well developed in terms of infrastructure and income	Thriving to catch up Tokyo	Rapidly developing	Rapidly developing
Population	Stabilized to 12 million since 1970, downtown population decreasing	Persistent population growth till 1990; decreasing population after 1990, about 10 million in 1999	About 11 million, growing rapidly, especially after 1980	Over 13 million, growth rate lower than Beijing
Passenger vehicles per 100 person	36	22	7	3
Modal split of passenger transportation volume	Majority of travel by rail and subway. Bus insignificant	Strong share of subway, bus and car. Less role of non-motorised mode.	Rapidly rising car's share since 1990. In 1990-98, 87% increase in number of buses but only 22% increase in passenger traffic	Majority of motorised transportation by bus. Highest level of non-motorized travel.
Vehicle population per road length in kilometre	200 (stagnant after 1990)	300	350 (rapidly increasing after 1990)	130
Rail network	250 km subway (Tokyo metropolitan regions are connected with 2,143 km of railway)	220 km subway	55 km subway (plans exist for over 250 km by 2008)	65 km subway
Share of tertiary sector (value added)	67% in 1980 to 78% in 1997	81% in 1997	26% in 1980 to 56% in 1997	21% in 1980 to 48% in 1997
Fuel structure	Oil, electricity and gas dominated	Oil and electricity	Heavily coal dominated	Heavily coal dominated
Share of industry sector in energy demand	10%	16%	64	85
Energy efficiency of major technologies	High	High	Low	Low

Note: Data mostly corresponds to year 1998 or 2000.