Section IV – Urban sustainability: the Japanese experience, new concepts and the shift towards information technology

This section concludes the report discussing the concept of sustainable cities and topical concepts and tools in urban environmental management, such as urban ecosystems, ecological footprints, information technology, and "digital society." These concepts are discussed presenting the example of Japanese cities, which are already moving towards incorporating these issues into the environmental policy agenda. In order to understand the Japanese experience, the section starts with a description of this transformation in Japanese cities and then follows the discussion of the concepts cited above. Finally, overall closing remarks on urban issues are made.

1. Cities in industrial transformation and the Japanese experience

Japan is the first Asian country to introduce modern Western-style industry and attain the same development status as Western developed countries. Japan's record of successes and failures relating to urban development and environmental problems is rich with implications for the future of Asian cities.

After the Industrial Revolution, many cities around the world developed as industrial towns. In Japan, Osaka, Nagoya, Kawasaki, and Kitakyushu developed with the industrialization process. The classic environmental problems of modern industry − air and water pollution − appeared first in these industrial towns. Japan's history of modern urban environmental management also started in its industrial towns[1]. Air and water pollution arose in many cities, and were often considered as small problems compared to the benefits of economic development. Serious attention was first given to the environmental problems of modern industrial societies in the 1960s.

Expansion occurred in three major fields during the technological revolution after the Second World War − energy, raw materials, and information − and these brought about major changes in the nature of environmental issues. On the energy dimension, due to abundant oil supplies from the Middle East, coal was substituted by oil in many industries, backing the development of heavy industry to support the production of basic materials such as steel, cement, and plastics. Meanwhile, industrial towns became manufacturing bases and they grew by absorbing a large number of labourers from rural communities. However, along with the growing sophistication of industry, the city's role in industrial production began to decline. In pursuit of cheap labour, the industrial production bases moved overseas mainly to developing countries. And the core industries in Japanese cities shifted from heavy and chemical to electronics and machinery industries. Many of Japan's cities today focus on service industries. There are also examples like Kitakyushu City, as described in Section III, which aims to create new environmental industries while maintaining its traditional role as an industrial town.

Along with these industrial trends, changes in urban environmental problems as well as in the way they are managed are seen throughout history. In the shift toward heavy

[1] The history of environmental management in Kitakyushu City is described in Section III.

and chemical industries after the Second World War, it was Japan's cities that faced some of the world's most serious pollution problems. In the 1960s, Tokyo, Osaka, Nagoya, Yokohama, and many other large Japanese cities were industrial towns. Smaller cities located away from the big urban centres also eagerly tried to attract factories in order to promote local economic development. The result was industrial pollution − air and water pollution. From the 1960s through the 1970s, many of Japan's cities suffered air and water pollution problems, and to overcome these problems the country put major efforts into establishing laws and institutions, and introducing technological solutions. By the end of the 1980s, Japan had largely overcome the problems of industrial pollution. What emerged next, however, was a type of environmental problem brought on by mass production and its counterpart, mass consumption. People enjoyed wealthier lifestyles, but at the same time water consumption increased, as did domestic wastewater discharge. The result was serious pollution of the cities and surrounding water bodies. In addition, urban air pollution worsened due to an increase in vehicle traffic.

During the 1990s, the disposal of the massive amount of waste that results from mass consumption became a problem, and environmental policies to promote recycling of resources and to create a recycling-oriented society[2] emerged as important issues as presented in Section II. In addition, as global warming became a key issue internationally, urban environmental policies to create cities with low energy consumption and low greenhouse gas (GHG) emissions started to take centre stage. For instance, Tokyo has plans to take into account climate change concerns in its policies. Energy profile and GHG emissions of Tokyo as well as other Asian mega-cities were discussed in a case study in Section III.

Many cities in Asia are now on a path to experience the similar development processes as that of Japan's cities, but over a shorter period. This situation presents major problems, and at the same time great opportunities, such as the creation of "sustainable cities," which is discussed below. In order to achieve urban sustainability, several new concepts are being developed such as eco-efficiency in the urban management, urban metabolism, ecological footprints, and the use of information technology towards environment. Some of these concepts are also discussed along this section.

2. Sustainable cities

The concept of "sustainable development" was proposed at the UN Conference on Environment and Development, held in Rio de Janeiro in 1992 (also known as the Earth Summit). Consequently, the idea of "sustainability" − which suggests that actions are in harmony with the global environment − started to catch attention in governmental policies and corporate management, as well as in personal lifestyle decisions. Related to this, the term "sustainable cities" began to enter the vernacular when discussing cities.

However, if one is to attempt a discussion on the concept of sustainable cities, it is impossible to avoid one basic question: Exactly what is sustainable development and

[2] Recycling oriented-society or sound material-cycle society.

sustainability? There has already been much debate about the meaning of these terms, but it is not easy to offer a simple answer. First, there is a difference of opinion between developed and developing countries in terms of priority − should the emphasis be on improving human standards of living, or on protecting the environment? People in developed countries that have already achieved a certain level of material wealth might emphasize environmental protection, but for people in developing countries now seeking to improve their own material wealth, the emphasis on environmental protection may seem self-centred. On top of this, opinions are divided about whether or not humans should actually be managing the Earth's ecosystems. In short, there is a diversity of opinion when it comes to the topic of sustainability. Some hold the extreme view that unless modern materialistic civilization based on the factory is entirely rejected and return to agricultural societies, sustainable development will be impossible. Besides the issues above, there are socio-political challenges such as eliminating urban poverty, protecting the vulnerable people in society, ensuring equity, and securing public participation in political decision-making processes. The ways chosen to address these challenges are also important topics for sustainable cities.

In this context, when environmental impacts of urban activities and the sustainability of cities are considered, came the question of balance with the "eco-space" or the "carrying capacity" of cities. It is necessary to consider both the *absolute measures* of urban activity (for example, urban population, area, or resource consumption of the city), and the *intensity* of each item per unit of area. For example, because rivers have a self-cleaning function, if the concentration of pollutants discharged from urban activities is low, the river will clean itself up on the local scale. However, if the urban area is large, even if the environmental load is small on the local scale, the total load will be large and may exceed the environmental space of the region.

In particular, the most important to control the environmental burden is "growth management," which means the exertion of controls on the expansion of urban population and economic activity. Many difficulties arise, however, when attempting to achieve economic and environmental goals at once. One approach to reduce energy consumption is to concentrate the urban population and office districts, and so on, close together, in order to reduce the travel distances of people and goods., In other words, denser cities are more energy-efficient as reported in the case study on the mega-cities (Section III). If that can be accomplished, the horizontal movement of people and goods is minimized, which means that the length of roads and sewage lines can be reduced proportionally. If buildings are built higher, however, more conduits and elevators become necessary for vertical movement. One concept that has emerged to consider these factors is the "compact city." By promoting residential living in the city centre, work and residences are closer to each other, traffic volume decreases, and congestion is less likely to occur. In addition, it becomes possible to rationalize municipal solid waste collection for greater efficiency. However, can such compact cities really ensure a comfortable life for its residents?

Problems are thus complex, but one clear method to discuss urban sustainability is to look at cities as circulation systems of resources and energy. To support the activities that go on within them, cities can be seen as ecosystems that take in massive inflows of resources and release the resulting waste back into the environment (air, water, soil). If the scale of urban activities become excessive, the circulation of materials, energy and information stops functioning normally, creating a drag on further city's

economic development and generating a variety of environmental problems. In other words, the city suffers from problems with its circulatory functions. Measures of urban activity are therefore important indicators of the environmental impacts of cities.

Newman and Kenworthy (1999) see cities as ecosystems, and define the objective of achieving urban sustainability as managing cities within the local, regional, and global environmental space, by reducing a city's use of natural resources and the generation of waste, at the same time as raising its liveability. Meanwhile, the Organization for Economic Co-operation and Development (OECD 1998) has proposed the concept of "eco-efficiency" for corporations and households, but this concept can also be useful when discussing cities, and it has many common points with the discussion by Newman and Kenworthy (1999). These models are based on seeing cities − places where humans to live, play and work − as natural ecosystems. It must be noted, however, that the object of analysis here is the metabolism consisting of material or energy budgets; actually, many elements that make up a natural ecosystem − such as flora and fauna, climate, and hydrological cycle − are not fully considered. Very little analysis has been done of urban ecosystems by comprehensively considering such elements and virtually no debate has been conducted about sustainability based on such a comprehensive approach.

3. Transportation and environment

As cities expand in area, high-speed transportation systems are needed that efficiently link parts within the cities and that link the inside with the outside. In European cities, networks of subways, trams, and buses were created for these purposes at the end of the nineteenth century. By the end of the twentieth century, however, as the automobile became the dominant mode of transportation particularly in countries like the United States and Australia, the "auto city" emerged, with a heavy dependence on private car ownership. In such cities, people live far away from the city centre in the suburbs in houses with large yards surrounded by fields. This type of urban development was praised for releasing people from the cramped living conditions in the city centres. However, such low-density, decentralized cities depend on massive levels of oil consumption for automobile use, and they are built on the assumption that energy prices will remain stable. The ascending gasoline prices during the oil crisis in 1973 alarmed cities built on transportation systems that depend so much on the automobile. During the 1990s, global warming caused by carbon dioxide from fossil fuel consumption emerged as a huge problem for humanity, forcing many people to reconsider their heavy use of the automobile.

As a result, two major trends have emerged since the 1990s. The first is the development of innovative automobile technologies aiming to improve significantly fuel consumption, and the second is a modal shift from private car ownership towards public transportation systems. In terms of automobile technologies, the development of small cars labelled as **"**eco-cars," as well as accelerated development of new technologies such as electric and hydrogen (or fuel cell) cars are observed. As for "modal shift" of transportation options, in Germany and other Western countries, cities have introduced park-and-ride systems, while trams and Light Rapid Transit (LRT) have obtained renewed popularity. While such trends have been evident in mature cities in the West, urban development based on automobile dependency has

been growing unabated in many young cities in developing countries. In other cases, cities are sprawling outward with no clear vision of urban development, and the number of automobiles on the road is expanding rapidly despite inadequate road infrastructure. Major reasons for these outcomes include a shortage of the funds needed for improving mass public transportation systems like subways, and the lack of vision in urban planning in the relevant central or local governments. Freedom of movement (in other words, mobility) is one of the basic human desires. Even in countries with relatively low incomes per capita, the number of automobiles on the road is exploding. Old cars in need of proper maintenance are also a large source of air pollution.

In Japan, it is noteworthy the large differences between large and small or medium cities in terms of their transportation systems. In large cities like Tokyo, Osaka, and Nagoya, mass rapid transit systems such as subways create a dense transportation network and the use of private automobiles for commuting is discouraged. In contrast, in regional small and medium cities it is not viable to move around without a car because public transportation systems are not well developed. Japan's history of motorization spans only about forty years, starting in the 1960s. Because of this short history, early policies emphasized improvements in road networks, and the major interests of transportation research were focused on construction of economically efficient road networks compatible with regional development and land use planning, as well as methods to relieve traffic congestion. In recent years, however, consideration of the global environment has been given greater emphasis, and research has paid more attention to the creation of transportation systems that have low energy consumption and low carbon dioxide emissions.

Low-density, decentralized cities in countries like the United States and Australia rely on massive consumption of gasoline. Newman and Kenworthy (1999) studied cities around the world to determine the relationship between population density and per capita energy consumption for personal transportation and plotted their findings. They found an inverse relationship between the two: higher the population density, lower was automobile usage and fuel consumption. Their chart shows that annual gasoline consumption was less than 100 litres per capita for residents of Hong Kong, which had the highest population density, at 30,000 people per square kilometre; in contrast, it soared to between 1,500 and 1,700 litres per capita for American cities like Los Angeles and Detroit with about 1,000 persons per square kilometre (1990).

4. Urban resources, energy metabolism and environmental impacts

Modern cities depend on the consumption of a wide variety of materials for the lifestyles of residents and the activities of businesses. They also depend on the consumption of energy such as in the form of electricity and natural gas − and they generate considerable amount of waste.

In physical aspects, a city consists of houses, offices, commercial buildings, and infrastructure, such as roads; these are brought to life by the activities done there and by the flows of people, goods, energy, and information. To support this activity, inside and outside the city, it is found a complex net weaved of roads, railway lines, water supply and sewage pipes, electrical and gas lines, and communications lines.

These networks, if compared to the human body, would be the equivalent of the blood circulation and nervous systems. The materials, energy, and information that flow through these networks would be the equivalent of the body's blood and nerve signals. The blood in arteries coming from the lungs would then take up waste material from each part of the body and become the blood in the veins. In the body, organs such as the liver and kidneys would deal with these waste materials. In the city, the equivalent would be environmental infrastructure such as sewage treatment and waste treatment facilities that handle respectively wastewater treatment and purification and municipal solid waste treatment and disposal.

A variety of resources are being consumed to support the lifestyles and activities of the average Japanese resident, including 1.4 kilograms of food per day, 320 litres of water, and the equivalent of 2.4 kilograms of crude oil (the total for the household and private car). As a result, a variety of pollutants and waste are generated, including 1.1 kilograms per day of domestic waste, 320 litres of sewage water, and the equivalent of 8.8 kilograms of carbon dioxide. These are the amounts associated with the materials and energy directly consumed by individuals; not counted here are the amounts resulting from industrial and commercial activities. The industrial and commercial portions ultimately support all economic activities, and are essential for realization of affluent lifestyles, so it can be considered that these amounts are being consumed indirectly for individuals. If these amounts were included in the calculation, the values above would be much higher. This individual-based accounting of resource and energy consumption can also be applied for cities, which are in essence gatherings of people.

To protect the environment, it is important for individuals to account for their own resource and energy consumption and the resultant environmental burdens, and by improving their lifestyles, to continue making an effort to actually reduce the parts that can be reduced. Household environmental budgets are one way to accomplish this. Besides evaluation of activities at the individual level, it is also important to evaluate and devise strategies for collective activities at the regional level. For global environmental protection, responses are also necessary at macro levels like the entire human race or country level. It is at the level of the micro-economic entity (i.e., the individual/household or corporate level), however, where concrete measures are implemented. The sum total of the behaviour of micro-level entities is reflected in macro-level effects. For micro-level entities, however, it is certainly not easy to ascertain the effect of one's own small behaviour on the macro system. It is more important to determine the effects by community unit or by region, and give this feedback to the micro-level entities. For this is necessary to quantify the environmental burden arising from resource and energy consumption, and to quantify the effects of countermeasures, at the proper level, i.e., the city or community level.

The "metabolism" of the input and transformation of resources and energy associated with urban activities closely resembles that of natural ecosystems. Nevertheless, whereas the metabolism of the natural world forms a perfect circulation system, the metabolism of modern cities has only a one-way flow, with resources and energy brought in from outside and then generating waste that is hard to dispose. In recent years, more attention has been going into efforts to reform urban circulation systems by learning from the natural world. Many of these are initiatives to promote resource recycling. As one example, as discussed in Section II, the government of Japan has enacted the Law for Establishment of a Sound Material-cycle Society (2000).

Cities are heavily dependent on outside resources to support their activities. Taking as an example the food ingested by residents, it is mainly brought in from outside the city, and to support the affluent urban food lifestyle a significant consumption occurs − of land, water, fertilizer, machinery, fuel and so on. Rees and Wackernagel (1996) defined "ecological footprint" as the total amount of land required to supply food and timber products to cities, plus the land required for forests to absorb the carbon dioxide generated from the city. As one example, Girardet (1999) calculated London's ecological footprint. London covers an area of 1,580 square kilometres, but its ecological footprint is 125 times that, equivalent to 80% of UK's entire land area.

In the case of Japan, which imports more than half of the food it consumes, the country is using a huge amount of land and water resources overseas for production of food and timber. Japan's production and consumption activities depend heavily on natural resources collected from Japan and overseas. It should be noted that the resources used here include those that are priced and transacted on the market and those that are not. The former consists of resource flows that can be counted as economic goods, and these are recorded in economic statistics such as Input-Output tables as the "material flows" associated with economic transactions. In contrast, the latter are not recorded and simply neglected in economic accounting. These are the "hidden flows," and these include, for example, the soil dug up during construction, the discarded rocks and tailings from extractive mining, the soil that is eroded from cultivated land, and the trees inadvertently cut in clear-cut logging, and so on (Environment Agency of Japan 1998). These hidden flows have also been called the "ecological rucksacks."

A calculation of Japan's overall material flows in 1996 indicated that the "surface flows" of resources that are inputs into Japan's economic activities amounted to 2.01 billion tons, but the hidden flows within Japan amounted to 1.15 billion tons, while the hidden flows overseas were 2.53 billion tons. The impacts of human activities on the environment are intimately related to the amount of resource consumption, but these cannot be fully known just by describing the surface flows. As shown above, to properly evaluate the environmental impacts of the construction and maintenance of intensive human activities in cities it is also necessary to include the hidden flows.

5. Urban environmental infrastructure

Technological systems to deal with urban sewerage and waste collection, incineration, and disposal are essential parts of the urban resource and energy metabolism. Even in a modern city like Tokyo, as recently as 1965, sewage systems serviced only about 10% of the population, and there were no modern waste incineration facilities. This urban environmental infrastructure has since then been more or less completed thanks to huge investments over the past forty years, which were covered by fiscal programmes. It can be said that because the economy was in a period of growth this achievement could be realized. Meanwhile, a huge amount of investment will be needed in the coming years in many Asian cities for sewage and waste treatment, particularly for the construction of facilities. Moreover, some countries first need to complete the necessary water supply systems as pointed out in Section II. How to address the financial burden for those items is a serious issue for cities in developing countries. The funds of national and local governments may be limited, and there are

limits to how much a country can rely on assistance from aid organizations. Thus, new approaches attracting attention include "public private partnerships" and "private financial incentives" which entrust construction, maintenance, and operations to the private sector.

6. Information-based societies and the shift toward participatory decision-making

Cities of the 21st century are being transformed into advanced information-based societies due to remarkable advances in communications and information technologies, including both hardware and software. As a sign of this, terms like "information superhighway" have also entered the language. Until now, roads railways, water supply, and sewage systems have been considered as the main urban infrastructures, but cities of the future will place greater importance on information and communications networks as well.

The construction, use, and maintenance of roads and railways require many resources and land, causing pollution and noise, particularly in the case of road transportation. In comparison, information and communications networks appear − at least initially − to be more energy efficient and better at resources conservation. If the use of information technologies can replace the movement of people, it might be possible to significantly reduce the required time and energy as well as the environmental impacts related to it. Despite the development of information technologies, the paper and energy consumption in offices have been rising. It has also been pointed out that information equipments contain hazardous substances, and that their disposal requires special management. Thus, there has been much debate about the environmental impacts of advanced information societies, but so for no clear conclusions have emerged.

The direct and indirect effects of the information age are many. In particular, the indirect impacts have been called the "rebound effect," and some argue that the time and income saved through greater efficiency from the better use of information have shifted to other economic activities, so that the overall environmental burden actually increases. "Teleworking," in which people use information technologies to work at home or commute to satellite offices, has attracted interest as it has the potential to replace the movement of people with the better use of information. A number of estimates have been made on the interesting question of how much energy consumption is reduced by requiring less movement.

The development of transportation and information/communications systems also brings about enormous changes to social networks − the inter-linkages between various entities that make up the city. When serious environmental problems emerged from Japan's rapid economic growth, the mass media were a major force in raising the public's awareness of problems and pressing corporations and governments to take countermeasures. In particular, it was news coverage by television, which was at the time spreading rapidly through households that played an important role in national and local environmental policy-making. Today, the Internet is playing a similar role. The Internet is making it increasingly easier to obtain

information on a wide range of environmental problems. Meanwhile, another major trend is increased information disclosure by central and local governments.

Through advances in "physical networks," the structure and functions of "social networks" have changed significantly and as a result the individual roles and interactions of each entity in measures to tackle environmental problems are also in the process of changing. For example, even a small residents' group in a local city is now able to spread information worldwide through the Internet and attract the world's attention to a local issue. Similarly, any person can participate in Internet discussions about environmental issues in their free time independent of the type of job they have. In addition, one can also find many websites carrying success stories of environmental measures around the world. Information systems are expected to facilitate participatory decision-making at various levels including international, national, and local levels. Moreover, information systems are changing market systems and this will affect the environment through changes in people's purchase behaviour.

7. Concluding remarks

Cities in Asia are diverse in terms of size, economic development, industrial activity, cultural background, and so on. There are "expanding" and "mature," poor and rich, industrial and service-oriented, small and large, compact and sprawled cities. These different cities face different challenges and are at different stages of development; therefore the responses for these challenges must be oriented to their unique conditions. Moreover, Asian cities are facing rapid transformation. All this make urban environmental management a challenging task, one which requires attention from both local and national policy makers.

Less developed cities are in need of strengthening their institutions and legislations, creating monitoring schemes and financing urban infrastructure. Mature cities face problems due to mass consumption and must address these problems, moving towards resource conservation and eco-efficiency. In Japan, policies for these issues are under the umbrella of promoting of sound material-cycle societies. This concept is spreading to other Asian countries like South Korea and China. In addition, information and communication technologies are expected to decrease the burden on urban infrastructure, especially transport, thus decreasing environmental impacts, as well as increasing public awareness and participation.

The Japanese experience of overcoming pollution can be valuable for other Asian cities. Therefore, international cooperation between Japanese cities and other Asian cities has been encouraged in order to transfer the experiences in managing the urban environment.

Note: Text written by Prof. Hidefumi Imura, affiliated to the Department of Urban Environmental Studies of Nagoya University, and Director of the Kitakyushu Office of IGES.

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