

Integrating the Environment in Urban Development: Singapore as a Model of Good Practice

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7

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ACRONYMS

ALS	Area Licensing Scheme
ASEAN	Association of South East Asia Nations
BOD	Biological Oxygen Demand
CDB	Convention on Biological Diversity
CFC	Chlorofluorocarbons
COD	Chemical Oxygen Demand
COE	Certificates of Entitlement
DGP	Development Guide Plan
ENV	Ministry of Environment
EU	European Union
HDB	Housing Development Board
ICLEI	International Council for Local Environmental Initiatives
MRT	Mass Rapid Transit
OMV	The final price of a private car in Singapore consists of the manufacturer's price, insurance and freight costs (known as OMV)
PRD	Parks and Recreation Department
PUB	Public Utilities Board
URA	Urban Redevelopment Authority
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

How has Singapore managed rapid economic development while enhancing environmental quality for its citizens? The answer lies in a variety of good practices that the city-state has employed in both environmental planning and management. This working paper begins by reviewing three historical phases of environmental planning on the island. Then, the current approach to environmental management is presented, consisting of regulatory measures, planning controls, economic incentives, and encouragement of public awareness and participation. Next, specific sets of environmental good practice are elaborated in the fields of land use, transportation, water resource management, waste management, environmental health, air pollution control, nature conservation, noise control, and support for environmental businesses and regional co-operation. Finally, challenges for the future are identified and lessons for environmental planning and management are drawn.

PHASES OF ENVIRONMENTAL PLANNING

Environmental planning in Singapore can be divided into three phases. The first spans the period before the Ministry of the Environment (ENV) (from colonial times until 1972) that focused primarily on land use, environmental health and infrastructure issues. The second phase is the formative years of the Ministry of the Environment (from 1972 to 1992) when a top-down approach evolved that was based on awareness campaigns, land use planning, pollution monitoring, inspection, and strict enforcement. Finally, the “Green Plan” period (1992 to the present) introduced a strategic and participatory vision of environmental management beyond the classic focus on environmental health, infrastructure and pollution control.

CURRENT APPROACH TO ENVIRONMENTAL MANAGEMENT

Singapore currently uses four sets of instruments to manage environmental problem—regulatory measures, planning controls, economic incentives; and encouragement of public awareness and participation. Each set is briefly described in the working paper along with examples of their application. These stem from a post-independence philosophy of active government involvement in many sectors of the economy and society.

GOOD PRACTICES

During its experience with environmental planning and management, Singapore has developed a number of examples of “good practice” in the fields of land use, transportation, water resource management, waste management, environmental health, air pollution control, nature conservation, noise control, and support for environmental businesses and regional co-operation. These successful innovations are described in the working paper and include:

- Integration of environmental measures in land use planning to protect watersheds, manage facilities for waste collection, treatment and disposal, and ensure that new developments are properly sited;

- Transport-oriented settlement planning based on a hierarchical set of satellite centers linked by mass transit;
- A set of innovative measures to conserve and manage drinking water;
- Integrated efforts to minimize solid waste through recycling, purchase of recycled products and provision of waste audits;
- Effective protection of environmental health through an emphasis on food hygiene, vector control and infectious disease control;
- A range of measures to reduce air pollution by minimizing emissions at source and reducing exposure through careful siting of industries;
- An active greening and conservation program based on ecological value, watershed protection, and potential for recreation, education and research;
- Monitoring campaigns to detect and reduce excess noise; and
- Tax and other incentives to attract environmental technology companies.

CHALLENGES AND LESSONS

Singapore's environmental challenges are to meet rising expectations about environmental quality, reconcile environmental and economic needs, work with an environmentally-aware citizenry, accelerate introduction of clean technologies, and fulfil international environmental commitments.

Lessons for environmental planning and management include:

- Start with the basics;
- Coordinate planning in key sectors;
- Integrate environmental considerations in standard procedures;
- Get the politicians on board;
- Educate, monitor and then enforce;
- Manage through institutions with clout;
- Experiment and learn lessons;
- Combine regulatory with economic instruments; and
- Involve the private sector.

INTRODUCTION

■ Singapore is a highly industrialized and urbanized city-state with three million people. The city-state is located in Southeast Asia on an island of 647 square kilometers, nearly half of which is built-up. Road infrastructure covers another 11% of the island's landmass. Singapore's economy developed rapidly, growing from a GNP per capita of US\$1972 in 1971 to US\$32,940 in 1997. During the past 30 years, both the population and urbanized area of the island have doubled, housing units trebled, and industrial land grew six-fold (Tan, 1995). This rapid growth is largely attributed to Singapore's interventionist development strategy and replacement of corrupt with meritocratic governance (Quah, 1998). With the loss of the Malaysian domestic market, stagnation of the entrepot trade and withdrawal of the British military and independence in 1965, the Government focused on labor-intensive manufacturing for export. Multinationals were drawn in with investment incentives as the local private sector had little industrial experience. By the early 1970s, the city had become the regional service and refining center for the petroleum industry and a regional finance center. Gradually, capital intensive production such as, the electronics industry began to replace labor-intensive manufacturing (Murray and Perera, 1996).

Part of Singapore's environmental profile can be attributed to changes in its economic structure. In 1961, the natural resource-intensive and polluting sectors of food, printing and publishing, and wood products accounted for 40% of industrial employment. By 1991, these sectors had dropped to only 8% while electronics and electrical appliances had risen to 40% (Chiu *et al.*, 1997). Much of Singapore's environmental success, however, is due to its activist approaches to environmental planning and management.

STYLES OF ENVIRONMENTAL PLANNING

Environmental planning in Singapore can be divided into three phases. The first spans the period before the Ministry of the Environment (ENV)—from colonial times until 1972. Second would be the formative years of the Ministry of the Environment—from 1972 to 1992 and third, the “Green Plan” period—1992 to the present.

Before the Ministry of the Environment

Prior to creation of the Ministry, a diverse set of actors focused primarily on land use, environmental health and infrastructure issues. Within a month of his arrival in 1822, Sir Stamford Raffles initiated measures to control flooding (building up a riverbank and filling a swamp), protect green space and biodiversity (setting aside 48 acres for a botanical garden) and regulate land use through a Town Planning Committee (Wurtzburg, 1954). Later, a body of Municipal Commissioners was created in 1856, which gradually took responsibility for health and sanitation problems. A Municipal Health Department was created in 1887 with a focus on controlling infectious diseases and inspecting food. The first water-borne sewerage network was completed in 1917. Efforts were initiated in the 1920s to manage solid waste and maintain drains. The net result of these activities was a visible improvement in public health by the 1950s.

Following self-government in 1959, many environmental services were combined. A Public Health Division in the Ministry of Health was given responsibility for all aspects of environmental health. The Ministry of National Development carried out sewerage and drainage. Water supply was the responsibility of the Public Utilities Board. In the early 1960s, these services participated in two projects that were keys to Singapore's future—the Jurong Industrial Estate (for promotion of industrial growth) and the Toa Payoh Satellite Town (the first of Singapore's planned new towns in its public housing program). Environmental health staff helped formulate approaches for controlling industrial waste from Jurong. The Ministry of National Development ensured that sewerage and sewage treatment were developed as part of the new satellite town.

After independence in 1965, environmental planning for the remainder of the decade focused on the following areas:

- Public cleansing, especially of drains and street vendor sites;
- Licensing and control of street vendors;
- Control of key disease vectors, especially for malaria and dengue fever;
- Flood control; and
- Expansion of the sewer network.

Despite these initiatives, Singapore at the end of the 1960s was faced with a number of environmental problems linked to urbanization and economic growth—air and water pollution, industrial hazards, dust, and noise.

In the early 1970s, environmental legislation and regulations became important tools for environmental planning. Laws were passed prohibiting smoking in specified public places, limiting emissions of air pollutants and making it easier to control food quality. Regulations were passed to allow for controlled discharge of industrial and commercial effluents into public sewers after necessary treatment. These were backed up by enforcement measures. The Public Works Department's Sewerage Branch was made responsible for identifying sources of industrial pollution and ensuring that industrial wastes were properly discharged into sewers. Air quality was monitored by an Anti-Pollution Unit in the Prime Minister's Office and applications to build new factories were evaluated to determine whether they complied with anti-pollution requirements.

Overall, Singapore's early environmental planning style had the following characteristics:

- An early and sustained focus on themes of environmental health;
- Attempts to integrate environmental features in major development initiatives such as industrial projects and public housing;
- Relatively clear, but changing lines of responsibility for environmental management;
- A relatively high level of priority attached to environmental protection, though less so to natural resource management;
- An increasing emphasis on regulatory and other command-and-control measures to deal with environmental issues;
- Very little island-wide integrated environmental planning; and
- Government-driven policy and implementation that involved relatively few stakeholders in decision-making.

Ministry of the Environment Era

Despite these efforts, the Government felt that a centralized organization was needed to deal with problems of pollution and environmental health. So, the Ministry of the Environment was created in September, 1972. The new Ministry was composed of two divisions, that is, Environmental Public Health for food inspection, epidemiology, quarantine, street vendors, vector control, cemeteries, research and Environmental Engineering for sewerage, solid waste disposal, drainage, public health engineering. During its first year of operation, the Ministry focused on enforcing industrial pollution control, mechanizing solid waste collection, combating an outbreak of cholera through upgrading hygiene food handlers, and planning a waste incineration plant.

Over the next 20 years, the ENV refined its approach to pollution control. Numerous examples of developments during this period are provided in the section on "Innovative Programs" below. Key characteristics of environmental planning during this period were as follows.

- Use of campaigns to focus resources and public attention on priority problems. The most significant of these was the ten-year clean-up campaign for the Singapore River and Kallang Basin (see the Water Resources Management section below).
- Using land use planning as a means of preventing pollution. Only new developments that are environmentally compatible with surrounding land uses were approved.
- Employing pollution monitoring as an important device for enforcing regulations. Monitoring also allows for early detection of deteriorating air or water quality.
- Inspection is also an essential element of enforcement. Pollution control equipment is regularly inspected to ensure that it is properly maintained and operated.
- Public education, beyond major campaigns, is an important management tool to create awareness and ensure compliance. Targeted programs were developed for schoolchildren, the private sector and NGOs on environmental protection and management.
- Political will was critical for supporting major environmental initiatives. It was the Prime Minister who challenged the Ministry to achieve full river clean-up within ten years.
- The predominant planning style continued to be top-down, with central decision-making and relatively little public consultation.

The Green Plan

During 1991, the ENV led development of a “Green Plan” intended to guide the city’s environmental planning and management through the year 2000 and beyond, that is, until the time, after 2020, when the city achieves a steady-state population of four million. In preparing the plan, the Ministry actively sought views of public and private organizations. Public fora were organized to get citizens’ ideas as well as feedback on a draft plan. The resulting plan contains an environmental vision for the city (see box below) and a set of objectives for environmental management and infrastructure, environmental education, international environmental programs, and environmental technology (Ministry of Environment, 1992). The Plan was intentionally prepared for and presented at the 1992 Earth Summit in Rio de Janeiro.

The long-term goals and environmental strategies of the Green Plan were then translated into specific recommendations. Work groups were formed to develop action programs in the priority areas of environmental education, environmental technology, resource conservation, clean technologies, nature conservation, and noise pollution. The groups were primarily made up of representatives from government ministries and statutory boards, with some participation from the private sector and non-governmental organizations. There were feedback sessions chaired by the Minister of the Environment and senior ENV staff, and draft documents were made available to the

THE GREEN PLAN'S VISION

“The vision is of a Singapore as a model Green City by the year 2000. It will be a city with high standards of public health and a quality environment. One which is conducive to gracious living with clean air, clean land, clean water and a quiet living environment. A city with people who are concerned for and take personal interest in the care of not just their immediate environment but of the global environment as well. A city which will also be a regional center for environmental technology.

The role of the public in achieving this vision is crucial. We will have to educate the people and to instill in every Singaporean a national commitment to protect and preserve the environment at home and globally. To be successful we need active public support. We will seek strong support, commitment and participation from the corporate sector, the media and non-governmental groups to develop a culture of proactive environmental awareness.

We will support international efforts to protect the global environment and will play an active role in international conferences and seminars on environmental concerns. We will share acquired skills and expertise in environmental management and protection. We will make Singapore a regional center for environmental technology from which environmental engineering services can be provided to the Asia-Pacific region and beyond.”

Source: Ministry of Environment, 1992

public for comment. For the action programs, the work groups identified implementing agencies and recommended target dates for the completion of each activity through the year 2000. Then, public comment was incorporated before the action programs were finalized.

The following action programs were developed out of this process:

- Building Environmental Consciousness through creation of an environmentally pro-active society, create an information network, encouragement of green consumerism, provide awards and recognition, and the establishment of a National Council on the Environment.
- Corporate Responsibility and the Environment through action to change private sector attitudes, implement environmental auditing and involve the corporate sector in promoting public awareness.
- Conserving Resources through actions to contain CO₂ emissions, promote energy efficiency, support waste minimization and recycling, and reduce household as well as commercial and industrial waste.
- Environmental Management and Infrastructure for actions improving environmental public health, preventing pollution and reducing environmental noise.
- Nature Conservation to create an interconnected park network, develop nature appreciation, conserve coral areas, and selectively promote eco-tourism.
- Encouraging Clean Technologies with technical solutions for controlling sulfur oxide emissions, improving air quality, developing cleaner modes of transportation, introducing cleaner industrial processes, phasing out ozone-depleting substances, and encouraging research and development (R&D) for clean technologies.
- Environmental Technology through action to make Singapore a regional environmental business hub through incentives for foreign and local companies, human resource development and R&D.
- International and Regional Co-operation through action to maintain a global and regional environmental profile for Singapore (Ministry of Environment, 1993).

These actions, in 1993, were approved by the Cabinet as a national plan covering all concerned agencies. Progress is reviewed annually and a stocktaking is as scheduled in 1998/99.

The formulation of the Green Plan and subsequent action programs marks an important change in the style of environmental planning in Singapore. Previously, environmental problems were addressed on an issue-by-issue basis by government agencies without a strategic vision or much public participation. In contrast, the Green Plan addressed a broad range of environmental issues, involved government actors beyond the Ministry of the Environment as well as a limited set of other stakeholders, set out long-term goals (beyond the year 2020), and specified medium-term actions (through the year 2000). The Green Plan also encouraged a broader definition of environmental management beyond what had been the ENV's classic focus on environmental health, infrastructure and pollution control.

CURRENT APPROACHES TO ENVIRONMENTAL MANAGEMENT

Singapore currently uses four sets of instruments to manage environmental problems—regulatory measures, planning controls, economic incentives; and encouragement of public awareness and participation. Each set is briefly described below along with examples of their application. These stem from a post-independence philosophy of active government involvement in many sectors of the economy and society. As Former Prime Minister Lee Kuan Yew put it, “I am accused often enough of interfering in the private lives of citizens. If I did not, had I not done that, we wouldn’t be here today” (Murray and Perera, 1996, 20).

Regulatory Measures

Singapore employs a range of regulatory instruments to protect and manage the city’s environment. There are approximately forty environmental laws covering the following subjects—livestock, clean air, destruction of disease-bearing insects, environmental public health, food, hydrogen cyanide, infectious diseases, poison, smoking, and water pollution control and drainage. Emissions standards have been set for 17 types of air pollutants covering a wide range of stationary sources. Allowable limits have also been set for liquid effluent discharge to sewers and waterways. These include temperature, BOD, COD, total suspended solids, total dissolved solids, pH value, and 28 different chemicals. There are maximum limits have been set for transport of hazardous materials beyond which authorization must be obtained. Twenty-six categories of toxic industrial wastes are also subject to specific legislated controls. (Ministry of Environment, 1997a)

Singapore is known as a “fine” city partly because of its rigorous application of fines to enforce regulatory measures. Examples of fines that are applied to enforce environmental regulations include:

- Air pollution—violators of the Clean Air Act are subject to a maximum fine of S\$10,000 (US\$6666) plus S\$500 (US\$333) per day for continued non-compliance. Vehicles emitting smoke or visible vapor can be fined up to S\$500 as well.
- Water pollution—the maximum fine for violating the acceptable effluent limits is S\$5000 (US\$3333) per violation. Discharging oil into Singaporean coastal waters is subject to a maximum penalty of S\$500,000 (US\$333,333) or two years’ imprisonment.
- Solid waste—littering is punishable by fines up to S\$1000 (US\$666) per incidence. Serious and repeat offenders may also have to carry out public cleaning activities for up to three hours.
- Noise pollution—a range of fines have been set for vehicles, construction and other activities that exceed acceptable limits.

This fine structure has yielded revenues that range from S\$3.3 million (US\$2 million) to S\$4.5 million (US\$2.8 million) annually during the 1990s (Foo, 1996).

The ability to enforce regulations also depends on the existence of an effective monitoring system. Air pollution is measured through 12 monitoring stations and mobile sources must pass an emissions inspection before they can be registered. Water quality is measured on a monthly basis in 47 streams within watersheds and in 17 rivers in non-water catchment areas. Coastal water quality is measured regularly at nine sample points in the Straits of Johor and ten points in the Straits of

Singapore. The Pollution Control Department of the Ministry of Environment monitors individual sites by conducting over 50,000 inspections per year. Finally, the ENV responds to citizen monitoring by investigating several hundred complaints about air and water pollution each year (ENV, 1997c; Foo, 1996).

Planning Controls

Singapore's long-term development and land-use strategies are embodied in a Concept Plan. The most recent version was prepared in 1991 and is based on a time frame to the year X (beyond 2020) when the population will stabilize at four million. Spatially, the plan seeks to de-concentrate the existing central business district to four new regional centers. Environmentally, the Plan seeks to do the following things:

- Identify development constraints and land uses that affect the environment;
- Project land needs for environmental infrastructure;
- Identify areas for siting pollution-prone services and infrastructure;
- Locate areas for nature conservation; and
- Continue protection of water catchment areas.

Overall, the Plan states that "Singapore will be cloaked in greenery, both manicured by man and by protected tracts of natural growth, with water bodies woven into the landscape" (Foo, 1996, p13).

Administratively, an Urban Redevelopment Authority (URA) implements the Plan. The URA has further subdivided the island into 55 planning areas, each with a local plan called a Development Guide Plan (DGP), to manage the development potential of each area (Hin *et al.*, 1997). Part of the environmental outcome of the URA's enforcement of the Plan and DGPs are location of industries primarily in proper industrial parks, requirement of a minimum of 0.8 hectares of parks and gardens per 1000 people, and control of tree cutting in designated areas. All land development proposals need to be submitted to the URA for approval before implementation. For construction, the Public Works Department approves building permits and considers technical requirements for environmental health, drainage, sewerage, and pollution control. Post-construction inspection is carried out to ensure compliance. Several thousand planning consultations are held each year on land use and factory siting that include a review of environmental impacts. Finally, while environmental impact assessment is not legislated, it is a mandatory administrative requirement for developers seeking to undertake large projects that are likely to have a major environmental effect (Foo, 1996).

Economic Incentives

The key economic instruments used for environmental management in Singapore are user fees, licensing, fiscal measures, and auctions. User charges are levied for wastewater collection and treatment. Households pay S\$0.15 and other users pay S\$0.32 per cubic meter of potable water consumed plus S\$3 annually per sanitary fitting. For solid waste disposal, businesses are charged according to the volume of refuse they generate while households and street vendors pay a flat monthly rate. Finally, street vendors, restaurants and port facilities pay fees to cover inspection costs. Revenue from these fees collected by the ENV can amount to a total of a third to nearly half

of the Ministry's total annual expenditure (ENV, 1998). Licensing is used especially to limit traffic congestion in the central area of the city (see section below on Traffic Management). Tax differentiation is used between leaded and unleaded fuel so that unleaded is sold at a lower price in order to encourage its use. There are also tax incentives to encourage the use of cleaner technologies. Finally, a Vehicle Quota System was introduced in 1990 that capped annual vehicle population growth at 3%. Vehicle purchasers must bid for Certificates of Entitlement (COE) that are issued in limited numbers for different categories of vehicles. The COE component of a car's final price can range from 30-40% for medium-sized cars and 15-25% for larger vehicles (Foo, 1997b).

Public Awareness and Participation

Public awareness about environmental matters is developed in Singapore through three major avenues—specialized campaigns, the education system and the “Clean and Green Week.” The first campaign, “Keep Singapore Clean,” was initiated in 1968. Since then, there have been focused campaigns to build public awareness about pollution, food hygiene, infectious diseases, waste management, sanitation, anti-spitting, anti-littering, river clean-up, and global environmental issues. Often, a campaign will precede introduction of an environmental or public health law. Public education is then followed up with strict enforcement. Schools are important conveyors of environmental information. They participate in the national campaigns, environmental material is included in the curriculum and students are encouraged to participate in environmental clubs and projects such as, beach clean-ups. Since 1990, Singapore has held a Clean and Green Week with a different theme each year. Activities include giving environmental awards to youths, other individuals and organizations, clean-up of specific areas, special seminars, school competitions, public exhibits, and dissemination of new publications. NGOs and the private sector are increasingly involved as sponsors of activities during the week (ENV, 1997a). The private sector is also promoting awareness about clean production technologies, waste minimization, environmentally-friendly products, energy and water conservation, and implementation of ISO14000 standards (ENV, 1997d).

Increased environmental awareness led to the development of environmental NGOs in Singapore in the 1980s and growing pressure for public participation in environmental decision-making. The oldest and most capable environmental NGO, the Nature Society, was established in 1954 (Mekani and Stengel, 1995). By 1990, an umbrella National Council on the Environment (now called the Singapore Environment Council) was established by the private sector to promote environmental awareness. The Council facilitates networking of environmental NGOs, encourages public environmental responsibility and develops environmental protection and management measures for both public and private implementation. Being a non-profit organization, it can receive tax-exempt donations from the public (ENV, 1997d). Neither the Council nor other environmental NGOs however, are regularly consulted on environmental policy. Public participation in developing the Green Plan and action programs was also relatively limited.

The DGP planning process is perhaps the most structured opportunity for the public to take environmental factors into account, though the process is not set up for the sole purpose of incorporating environmental comments. An initial Outline Plan that covers broad strategies must be made available for public comment before the DGP is further developed and adopted. The draft DGP

itself must also be available for public review over a period of two weeks before it can be finalized. During this exhibition period, the public can give their feedback and suggestions on the plans, including environmental issues. These are seen as wedges that may eventually open up the governmental process to more institutionalized stakeholder involvement (Mallone-Lee *et al.*, 1998). A form of unstructured public participation has been the involvement of citizens and local environmental organizations who complain about particular incidents of air, water and land pollution. These have been important sources of information for the ENV.

INNOVATIVE ACTIVITIES

During its experience with environmental planning and management, Singapore has developed a number of examples of “good practice” in the fields of land use, transportation, water resource management, waste management, environmental health, air pollution control, nature conservation, noise control, and support for environmental businesses and regional co-operation.

Land Use

Land use controls, described generally above, are a major means of environmental management in Singapore. The URA is Singapore’s land use planning authority. The ENV advises the URA on specific environmental measures that are needed in land use planning to protect watersheds, manage facilities for waste collection, treatment and disposal, and ensure that new developments are both properly sited and compatible with surrounding land uses. One way through which this is done is by providing advice in the development of DGPs so that these local plans use environmental factors to guide development activities. The URA also takes many other factors into consideration in the planning of DGPs in addition to the environment. Other public and private sector land developers also consult the ENV on needed environmental controls.

At the planning and building phases of new developments, the ENV checks development proposals and building plans to ensure the sufficiency of waste management, make sure that pollution control requirements are incorporated into designs and that measures are undertaken to mitigate negative environmental impacts. New developments must obtain occupation permits and completion certificates that are cleared by ENV’s Sewerage, Drainage, Environmental Health, and Pollution Control Departments (ENV, 1997c). This is done through the Central Building Plan Unit of ENV’s Pollution Control Department. The Unit is a “one-stop” service that is regularly consulted by private and public sector agencies with development proposals such as new housing estates and industrial facilities as well as alterations and additions to existing sites (Foo 1993).

Particular attention is paid to developments in water catchment areas and to industrial siting. Industries are classified as clean, light, general, and special (high pollution potential), and separate land use rules are applied to each category. This integration of environmental features into land use planning has resulted in: proper siting of industries with separation of residential and industrial areas, rational provision of environmental infrastructure, encouragement of industries to use cleaner technologies, and effective protection of watersheds (Ministry of Environment, 1997b).

One of the largest developers in Singapore has been the government's Housing and Development Board. It has constructed over 600,000 units which house an impressive 86% of the city-state's population. The HDB, guided by an earlier Concept Plan, helped to build 20 new or satellite towns around the central city to channel new development to areas that were both economically and environmentally appropriate, improve infrastructure planning and reduce congestion. The center of each new town is also the terminal point for public transportation and most residents are within five minutes' walking distance from their neighborhood center. Finally, the industrial development in each new town, accounting for about 20% of land area, was restricted to light, non-polluting facilities (Field, 1992).

Transportation

The goal of transportation planning in Singapore is to provide an efficient and reliable system for the mobility of people and goods. According to Singapore's Land Transport Authority, this should be achieved through the following strategies:

- Integrated and co-ordinated land use and transportation planning;
- Increasing the capacity of Singapore's roads;
- Improving the public transport system;
- Effective travel demand management; and
- Improving traffic management (Foo, 1997a).

To implement these strategies, it employs four innovative approaches that help minimize the environmental side-effects of traffic congestion—transport-oriented settlement planning, the Area Licensing Scheme, demand management through the Vehicle Quota System, and the Park-and-Ride scheme. These innovations are reinforced by the existence of an affordable, efficient and integrated public transportation system consisting of mass rapid transit, local and trans-island buses, and taxis.

In 1971, a 20-year strategy for the country's physical development was approved, known as the Ring Plan. It was based on the development of high-density housing, industrial estates and commercial areas around a ring around an urban center that would be linked by a transportation network. The Plan then guided construction of new towns, roads and highways, and the Mass Rapid Transit (MRT) system. Transport-oriented settlement development is currently guided by the Constellation Plan which changes the emphasis from ring development to a hierarchical set of satellite centers, but still linked by mass transit. From an environmental perspective, the new plan envisages a vehicle-free central business district where mobility is achieved by mass transit, moving sidewalks and green pedestrian pathways. New towns will be designed to encourage transportation other than by automobile, and will be linked to one of four satellite CBDs by mass transit (Cervero, 1998).

Next, the Area Licensing Scheme (ALS) is a system of road pricing to manage demand for road space that is highly congested during peak hours. In 1975, the Government designated an area of 725 hectares comprising the central business district plus the most important commercial and shopping corridor (Orchard Road) for intensified traffic management. Currently, there are 33 entry points into the area; these are marked with signs and lights and are policed during restricted periods.

Motorists must purchase a special license and display it on their windshields if they want to enter the restricted area during peak periods. Peak times are 07:30–19:00 Mondays–Fridays and 07:30–14:00 on Saturdays. Fees are progressively higher for motorcycles, private cars and company vehicles, and licenses can be purchased for monthly, daily or part-day use. At present, charges range from S\$1–\$6 (US\$) for a daily license and S\$14–120 (US\$) for a monthly license. Ambulances, fire engines, police vehicles, and public buses are exempted from licensing (Foo, 1997a). In 1998, an Electronic Road Pricing system was introduced using in-vehicle smart cards and road sensors to automatically charge users entering the restricted area. Electronic surveillance cameras photograph the license plates of vehicles without cards or with insufficient funds and violators are fined by mail (McNulty and Parker, 1998). Road pricing has also been extended to three expressways during peak morning commute hours (ENV, 1997d).

The ALS has played an important role in reducing central-city congestion during peak hours. The number of vehicles entering the morning peak period (07:30–10:15) averaged 46,000 in May, 1991 compared to 74,000 in March 1975 which was before the scheme was implemented. This is even more remarkable considering that Singapore's vehicle population doubled during the same period. There was also an important shift in modal split after implementation of the ALS. In the pre-ALS period, 56% of trips to the CBD were by car and 33% by bus. By 1983, this had reversed and 69% of trips were by bus and only 23% by car. Environmentally, accidents in the restricted area dropped from 4405 in 1978 to 3382 in 1982 while there were average decreases in total acidity (-11%), smoke (-32%) and NO_x (-8%) in the same period (Foo, 1997a). Most recently, the Land Transport Authority estimates that traffic volume has dropped a further 17% in the CBD since introduction of the electronic road pricing system. The average speed during peak hours in the CBD has increased from 50 to 61 kph. This compares favorably with London where the average speed is 16 kph, or slightly slower than horse-drawn vehicles at the turn of the century (McNulty and Parker, 1998).

The cost of vehicle ownership in Singapore is intentionally high in order to reduce growth of the vehicle population and to raise revenues to cover the social costs of motorization. Under the Vehicle Quota System (VQS), long-term growth in the vehicle fleet is set at 3% per year through issuance of Certificates of Entitlement (COE). Vehicle owners must bid to purchase a COE through the Government's before the vehicle can be used on the road. The final price of a private car in Singapore consists of the manufacturer's price, insurance and freight costs (known as OMV), an additional registration fee, currently set at 140% of the OMV, import duty (currently 41% of the OMV), a S\$140 registration fee, an annual road tax (ranging from S\$0.70–S\$1.75 per cc of engine capacity) and other costs such as, retailer's costs and profits. With COE costs typically ranging from 15–40% of total vehicle cost (Foo, 1998), a 2000 cc vehicle with an OMV of US\$20,000 might end up costing a Singaporean over US\$75,000. This and other measures to discourage car use have resulted in a relatively low level of car ownership in Singapore (85 cars per 1000 people) (ICLEI, 1995) and have reduced vehicle population growth from 6% to 3% annually.

Finally, the goal of the Park-and-Ride Scheme (PRS) is to alleviate congestion in the CBD during peak hours. Since it was first introduced in 1975, the PRS has gone through several incarnations. It began as a series of peripheral parking lots where drivers could leave their vehicles and board buses into the CBD. Following completion of the MRT network in 1987, it evolved into a system where the lots were linked to rapid transit stations. In the current enhanced PRS system, there are

19 parking lots. Eight are located near both MRT stations and bus stops, another eight are only near MRT stations and three are near bus stops. Drivers purchase monthly tickets for S\$72 (US\$) that enable them to park at a specified lot and use mass transit or a bus to commute to the CBD (Foo, 1997b).

Average sales of monthly tickets have risen from 15 in 1991 to 572 in 1996. However, there are over 2900 spaces available in the 19 parking lots, indicating that only about a fifth of capacity is being used. In 1996, just over 1% of motorists who regularly drive into the CBD were diverted into the PRS system. User surveys indicate the following problems: parking hours are too restrictive, parking lots are not available at all MRT stations, lots are too far from the stations, monthly tickets are restricted to only one lot, and monthly tickets are too expensive (Foo, 1997b). Thus, the PRS is an innovative approach to traffic demand management that has not yet achieved its potential due to a number of operational constraints.

All of these transport innovations are bolstered by the existence of one of the world's cleanest and most efficient public transportation systems. Singapore has an integrated system consisting of city buses, suburban-city center express buses and the Mass Rapid Transit railway. The MRT is a 67 km system that carries more than 560,000 passengers a day. TransitLink, a public corporation, was established in 1987 to operate and integrate all modes of public transport. Commuters can travel between trains, subways and buses using one pass. Buses carry half of all road passenger traffic and 65% of commuter trips are by public transit (ICLEI, 1995).

Water Resource Management

As an island, water management is critical for Singapore. The city-state has been an innovator in drinking water resource management, wastewater and water pollution control, river clean-up, and flood control. Each of these areas is more fully described below.

Singapore's water catchment areas meet less than half of residential, commercial and industrial demand for clean water. The remainder must be imported from Malaysia. Thus, drinking water management has been not only an economic and environmental issue for Singapore but has also been perceived as a national security issue. Some of the innovative measures to conserve and manage drinking water include the following:

- Protection of water catchment areas through the land use planning measures described above as well as nature conservation activities described below;
- Collection and treatment of urban stormwater as a source of raw water;
- Water audits and technical assistance for industries and commercial users to help them conserve on water use, re-use wastewater and substitute non-potable for potable water where feasible;
- Mandatory installation of water-saving devices in private commercial establishments and new public apartment buildings;
- Metering of all water consumption and setting of water charges to recover costs and discourage excessive levels of consumption;
- Use of a sophisticated monitoring system to measure and model water distribution, pressure and leakage;

- An apprentice plumber program whereby people seeking to become plumbers must apprentice in an apartment building, conduct regular inspections and seek to minimize leaks and water wastage within the building; and
- Imposition of high standards for waterworks as well as residential and commercial plumbing in order to ensure efficient functioning of the water delivery system and reduce maintenance costs.

The Water Department of the Public Utilities Board (PUB) primarily administers these measures. In many low-income Asian cities, half of the water in the municipal system is unaccounted for. In Singapore, largely because of these measures, the city has increasingly achieved a level of unaccounted-for water approaching the theoretical minimum loss of 5% (PUB, 1996).

Water pollution is controlled through several different measures. Polluting industries are generally sited in industrial estates that are located outside of water catchment areas and are served by public sewers. Industries must install pre-treatment facilities to handle their liquid effluents which exceed discharge limits. Pre-treatment plants must be installed prior to commissioning of new factories (ENV, 1997c). For household effluents, most of the island is sewered. There are now 2500 km. of sewer pipeline, six large sewage treatment plants serving an equal number of catchment areas and 130 pumping installations. A deep tunnel sewerage system is planned that will require only two centralized treatment facilities, less land as buffer zones and eventually no pumping stations (ENV, 1997e).

In 1977, the Singapore River and Kallang Basin catchments, covering a fifth of the island, were heavily polluted by organic and inorganic discharges, stench pervaded the watercourses and the rivers supported little or no marine life. The then Prime Minister, Lee Kuan Yew, challenged ENV to improve the watercourses and ENV responded with a report the same year outlining priority problems and options. Over the next ten years, an action plan was implemented. This involved development of housing, industrial workshops, sewerage, and food centers, massive resettlement of squatters, cottage and other industries, and farmers out of sensitive areas, re-siting of street vendors into food centers, phasing out of polluting activities, and turfing and landscaping of riverbanks. Work was implemented by various departments and agencies under five Government ministries, all of which were co-ordinated by ENV. Financing came from central government revenues at a cost of S\$200 million (US\$125 million), not including the costs of public housing, food centers, industrial workshops, and sewerage. These measures resulted in cleaner water, a return of aquatic life to the River and Basin, and an aesthetically pleasanter waterfront (ENV, 1987).

Singapore is a small island with one of the highest rainfall rates in the world yet flooding is a thing of the past. Innovation in the field of drainage for water management has included the use of pre-cast box culverts to cut drains on busy roads overnight in order to minimize construction time and traffic disruption, computer modeling to optimize canal design, incorporation of special engineering and landscaping features to retain a river's natural features as well as its flood control role and jet grouting to stabilize riverbanks while limiting disturbance to surrounding areas. These innovations have reduced the size of flood-prone areas in Singapore from 3000 hectares in the 1970s to 300 hectares at present (ENV, 1997e).

Waste Management

Limited land area combined with rapid economic growth and industrialization has led Singapore to adopt several novel approaches to solid and hazardous waste management. Incineration is the main method for disposing combustible wastes. An offshore landfill has been prepared for disposal of non-burnable wastes and incineration ash residues. Efforts have been stepped up to minimize waste generation and there is strict management of hazardous wastes.

Existing dump sites began to fill up in the 1970s. In response, Singapore decided to opt for incineration as a means of reducing the volume of final waste that required disposal. Three incineration plants have been constructed since 1978, located in the central, northern and western part of the island. Much of the city's solid waste is generated in the east, centralized at a transfer station, compacted into containers and then hauled to incineration plants in the north and west. Of the 7600 tons of solid waste generated per day, 70% is incinerated. The remainder of the waste is disposed at a landfill site. Incinerators have pollution control equipment and emissions are monitored on a regular basis (ENV, 1997e). A fourth plant is scheduled for completion in 2000; it will be one of the world's largest with a capacity of 3000 tons per day at a cost of S\$1 billion (US\$666 million) (ENV, 1998).

The present landfill site is expected to be full by 1999 and no additional sites are available on the main island. Thus, an offshore landfill is being constructed adjacent to the island of Pulau Semakau. This will be a 350 hectare site that is anticipated to meet landfill needs beyond the year 2030. A marine transfer station is also being built that will receive and process non-combustible waste and incineration ash before it is barged to the offshore landfill. Works will cost an estimated S\$840 million (US\$525 million) and should be completed by 1999 (ENV, 1998).

The magnitude of investments for new landfill and incineration facilities has convinced the Singapore government of the need to minimize the generation of waste before it requires disposal. ENV undertakes the following waste reduction activities:

- Sets aside land for the private sector to operate recycling activities;
- Creates in-house recycling centers in hotels, apartments buildings, factories, and other large establishments (1255 centers set up by 1995);
- Establishes public recycling centers in partnership with a private sector sponsor (58 created by 1995);
- Encourages Government agencies to use recycled products, issues a "Green Label" to inform consumers about products that are less damaging to the environment; and
- Provides free waste audits for promote better waste management (Foo, 1997c).

In 1997, 1.79 million tons or 39% of the 4.59 million tons of solid waste generated in the country were recovered for re-use. The highest recovery rates are for ferrous metals (92%), non-ferrous metals (84%) and construction debris (60%). The lowest rates are for food waste (2%), wood/timber (12%), glass (14%), and plastic (18%) (ENV, 1998).

ENV controls the collection, treatment and disposal of hazardous wastes in Singapore. Private

companies are licensed to establish treatment and disposal facilities in industrial estates. By the end of 1997, 116 such companies were licensed. That year, they collected 65,820 cubic meters of toxic industrial wastes such as used oil, waste solvents, spent etchants, and chemical wastes. 80% of this was recovered for re-use and the remainder was treated and rendered safe for landfill disposal. Hospital and clinic waste is separated into color-coded plastic bags and placed in special containers. Two licensed companies then collect the biohazardous material for disposal in special high temperature incinerators (ENV, 1998).

Environmental Health

There has been a historical focus on improving environmental health in Singapore for over a century. Beyond proper solid waste management, the main innovative features of the city's approach to environmental health include the following:

- Food hygiene—over a period of fifteen years (1972-1986), street vendors were relocated to over 150 markets and food centers in order to improve sanitary conditions as well as facilitate inspection. All food handlers are registered with ENV, inoculated against typhoid, given X-ray examinations if they are older than 45, and must pass a basic food hygiene course. Finally, all food establishments are regularly inspected and hygiene standards are strictly enforced.
- Vector control—mosquitoes, rats and other disease-bearing pests are kept in check through public education campaigns, vector control programs and engineering measures like an anti-malarial drainage system.
- Infectious disease control—ENV integrates services like Quarantine and Environmental Epidemiology in order to both control entry of infectious diseases into the island and effectively trace outbreaks if they occur.

The outcome is that Singapore has one of the lowest food poisoning rates in the world (despite its tropical climate) and the island was declared malaria-free by the World Health Organization (WHO) in 1982 (ENV, 1997a,e).

Air Pollution Control

The key principles of air pollution control in Singapore are to minimize emissions at source and to reduce emissions exposure through careful siting of industries. Efforts to minimize the emission of air pollutants have included the following measures:

- Control of fuels used by industries and commercial enterprises;
- Requirements that industries install air pollution control equipment to comply with emissions standards;
- Regular inspection of stationary sources to ensure that control equipment is properly maintained and operated (nearly 50,000 in 1996);
- Source emission tests required by over 100 industries to regularly monitor pollution (initiated in 1997);
- Promotion of unleaded fuel for vehicles;
- Gradual tightening of emissions standards for vehicles;
- Regular mandatory emissions inspections for vehicles;

- Prohibitions on the open burning of wastes;
- Ban on the importation of CFCs;
- Use of auctionable permits for the consumption of ozone-depleting substances;
- Regular monitoring of air pollutants throughout the island; and
- Rapid response to citizen complaints about stationary and mobile sources of air pollution.

Overall results are that measured levels of pollutants are almost always within the World Health Organization long-term goals and United States Environmental Protection Agency (USEPA) standards. Unleaded fuel now accounts for 70% of petrol sales since its introduction in 1991 (ENV, 1997a,c). Standards may not be met at all times, such as during the experience with regional haze that affected the area in 1997 and 1998 from fires in Kalimantan and Borneo in Indonesia.

Urban Greening and Nature Conservation

In 1963, the then Prime Minister Lee Kuan Yew launched a tree-planting campaign for all roads, vacant plots, reclaimed land, and other new development sites. This evolved into the Garden City campaign in 1967 to promote greening throughout the island. The campaign began by accelerating the tree planting; by the late 1970s, lush greenery was prominent across the island. During the 1980s, the campaign sought to add dashes of color by planting free-flowering trees and shrubs. At the same time, park development was emphasized. Existing parks were improved and many new ones were developed. Singapore currently has 337 parks and open spaces covering 1934 hectares (Parks and Recreation Department, 1992); development is guided by a standard of 0.8 hectares of parklands per 1000 population (Lee, 1995).

Proposals for the protection of the natural environment initially stemmed from an NGO. The Nature Society of Singapore, in its 1990 Master Plan for the Conservation of Nature in Singapore, identified 28 sites that had sufficient nature conservation to warrant permanent protection. These included the Bukit Timah primary forest and the Central Catchment mature secondary forest. Tidal mudflats and mangroves, freshwater marshes and wetlands, and some undeveloped offshore islands were also listed (Briffett, 1990; Wee in Briffett and Lee, 1993).

Singapore's nature conservation policy has a goal of setting aside 5% of its landmass for preservation. Currently, 19 areas, comprising 3130 hectares, have been designated as natural sites and are managed by a Natural Parks Board. They include a wide range of habitats such as primary and secondary forests, marshlands, and mangrove swamps. Sites were selected because of their ecological value, for watershed protection, or because of their potential for recreation, education and scientific research. The DGPs are being drawn up for these sites and they will serve as management tools for the future. A 360 km. Park Connectors Network is being implemented so that flora and fauna corridors will link many of the sites (ENV, 1997d). Urban greening has also been actively promoted. Over one million trees have been planted since independence and all public areas as well as new private developments must meet high standards for landscaping (Hin *et al.*, 1997).

Noise Control

Singapore is tackling noise problems through government actions. An Environmental Noise Management Unit was established in 1994. The Unit is supported by an Environmental Noise Advisory Committee consisting of industry, professional, academic, and government representatives. Together, they have developed noise action programs for monitoring, control of road traffic and MRT train noise, indoor noise for future residential buildings, control of noise from indoor and outdoor entertainment, boundary noise limits for factories, promotion of good management practices for noise reduction at construction sites, and planning guidelines for noise control. An environmental noise monitoring system has been set up which conducts twice-yearly, week-long measurements at 21 representative sites around the island (ENV, 1997a,1998).

ENVIRONMENTAL BUSINESS AND REGIONAL CO-OPERATION

Singapore is actively seeking to use its experience and comparative advantages to both attract environmental businesses and to develop itself as a regional center for environmental co-operation. Over 100 environmental technology companies are currently located on the island. New local, foreign and joint-venture environmental enterprises are being encouraged through tax incentives and by touting Singapore's role in the regional market, its existing stock of human resources, research and development facilities, manufacturing support, and the island's quality of life (ENV, 1997f).

Singapore is seeking to become a regional center through project activities, institutional development and agreements. Environmental firms provide technical assistance and equipment for investments in other countries in the region. Consortia involving Singaporean firms have helped develop four industrial parks, including environmental controls, in Indonesia and China. Institutionally, the Government and the European Union (EU) have established a Regional Institute of Environmental Technology to facilitate the transfer of technical expertise from the EU to the region, ENV has a Center for Environmental Training which serves as a regional training agency for environmental engineering and public health, and the ENV's Institute of Environmental Epidemiology as provides regional assistance (ENV, 1997f). Finally, Singapore has concluded a regional environmental co-operation agreement with ASEAN and bilateral agreements with Indonesia, Malaysia and Vietnam (Ministry of Environment, 1997c).

CHALLENGES AND LESSONS FOR THE FUTURE

Singapore has enjoyed many successes in urban environmental planning and management. All the same, there are several areas for improvement. Critics have noted the following:

- Environmental impact assessment of projects is not required in Singapore and it would be advantageous to do so (Briffett, 1992);
- Public participation in planning decisions is nascent and greater involvement would improve the quality and outcome of planning decisions (Mallone-Lee *et al.*, 1998); and
- The recycling rate is well below that of a similarly land-constrained, densely populated country (Japan's rate is over 50%) and a number of additional approaches are warranted (Foo, 1997c).

In addition, the predominant style of environmental planning and management has been top-down and more reliant on regulatory instruments. Environmental protection could be more efficient and effective through participation, some decentralization and greater use of economic incentives in combination with command-and-control approaches. Finally, ENV may not always have sufficient knowledge, commitment or clout to fully protect the environment in planning and investment decisions.

In the eyes of the Government, Singapore faces the following environmental challenges:

- Meeting rising expectations about air and water quality, cleaner surroundings and public health that come with economic development;
- Continuing to reconcile environmental needs with the demands of economic growth and competitiveness;
- Ensuring the co-operation of an environmentally-conscious population;
- Accelerating the introduction of clean technologies; and
- Fulfilling international and regional environmental commitments (ENV, 1997e).

In conclusion, several lessons can be drawn from Singapore's impressive experience with addressing and resolving environmental issues.

- **Start with the basics**—Singapore pursued a phased approach to tackling problems, beginning with environmental health issues (sanitation, vector control, food hygiene) and highly visible problems such as river and basin pollution.
- **Co-ordinate planning in key sectors**—the integration of land use, public transportation and motorization plans and policies has allowed Singapore to reduce the environmental impact of the private automobile.
- **Integrate environmental considerations in standard procedures**—environmental protection is an integral part of land use planning, industrial siting and building controls, largely negating the need for an environmental impact assessment process.
- **Get the politicians on board**—political will has been an essential force behind successful planning and implementation of environmental measures, including the Prime Minister's support for tree planting, the Garden City campaign and river clean-up, and the Cabinet's endorsement of the Green Plan.

Singapore teaches the following lessons about urban environmental management.

- **Educate, monitor and enforce**—environmental regulation has been so successful in Singapore because public awareness of new environmental measures is followed by monitoring and inspection with strict and consistent enforcement of serious penalties.
- **Manage through institutions with clout**—the ENV provides strong environmental management because it integrates important functions like infrastructure and environmental health, and because it has real enforcement powers.
- **Try and try again**—a willingness to experiment, learn and evolve have benefited both institutions such as the ENV and programs like the various incarnations of Park-and-Ride.

- **Combine economic instruments with regulatory measures**—traffic management, one of Singapore’s biggest successes, is a good example of how rules can be complemented by economic incentives such as road pricing, the high cost of vehicle ownership and, of course, fines.
- **Involve the private sector**—Singapore has made effective use of the private sector for implementing environmental policies such as partnerships to sponsor recycling centers and licensing for hazardous waste collection and treatment.

Overall, Singapore has had a strong government that exercised power in a pragmatic and forceful way. Its small size, concentrated economic development and compact state government have assisted in achieving tight controls. The compliant population has generally learned to accept government leadership as it is responsible, largely uncorrupt and sincere in attempting to meet the needs of the community. A committed top-down approach has combined flexible responses with rapid action for environmental management. The main challenge now, with increasing education, higher aspirations for environmental quality and a desire for more public involvement, is that new strategies for planning and management are in order.

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