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From the Editor

This issue of *AJEM* includes articles from China, Taiwan, Malaysia, Pakistan, and Singapore. Wu Chengjian looks at Shanghai's future plans from the perspective of the present environmental situation and the types of infrastructure developments being planned to allow Shanghai to realize — what its planners see — as its rightful role among the major cities of the world.

Guo Huiguang and his colleagues are also looking to the future, but in this case are focusing on innovative solutions to Yunnan Province's pressing rural power shortages. They make the case that relatively small scale (3 megawatt) biomass-fired power plants have the potential for simultaneously addressing part of Yunnan's rural electricity shortages, while promoting environmental improvement. Their paper presents the findings of detailed pre-feasibility analyses to assess the viability of harnessing the biomass feedstock resources and technical expertise available at specific sugar mills and rubber plantations in Yunnan's remote areas.

Also writing on the topic of electric power, Khairulmaini Bin Osman Salleh assesses alternative routing options for a major power transmission line through peninsular Malaysia. His paper presents the results of his multiobjective modelling work on a number of specific alternative routing options so as to minimize 'total costs' in terms of environmental impacts, monetary expenditures and social impacts (e.g., relocating homes).

Gwo-Hshiung Tzeng and June-Jye Chen also deal with multiobjective decision making in their paper on Taipei's environmental quality. They draw on the findings of a survey of perceptions about the adequacy of environmental infrastructure in various districts of Taipei.

Stoll and Rahman review the situation with regard to industrial wastewater problems in Pakistan. The authors first review the basic problems and then propose a series of specific changes in the management system. One major point is the need to distinguish management systems appropriate for application to small-scale industry from those suitable for large-scale operations. They argue that the types of modification in managment they propose can lead to substantial improvements in overall environmental quality without needlessly severe impacts on Pakistan's industrial economy.

In each issue of *AJEM* we try to provide a balance of country-specific assessments with ones dealing with a regional overview. Briffett's paper on the role of environmental impact assessments (EIAs) in Southeast Asia, draws on surveys of practitioners to assess the effectiveness of EIAs in this part of the region. He notes that while EIAs clearly play an important role at this time, there are many ways in which they can be made a much more effective tool for decision making. He outlines recommendations in the conclusion to his paper.

This issue is completed with profiles of two institutions in the region — the *Faculty of Environmental and Resource Studies of Mahidol University in Thailand* and the *Yunnan Institute of Environmental Sciences, Yunnan Province, PRC.* Both institutions are active in applied research and in training in the field of environmental management. *AJEM* welcomes submissions of profiles from other environmentally active institutions in the region as well as those from outside the region which have a strong Asian environmental management focus.

In closing, we are pleased to note that part of the next issue of *AJEM* (November 1996) will be devoted to the results of *Planning for More Effective and Workable Environmental Law: An Asian Regional Workshop*, held in Hong Kong in March 1996, with representatives for most of the major economies of East and Southeast Asia, as well as persons and organizations from outside the region. This workshop brought together environmental management professionals from regulatory agencies, the judiciary, private business, voluntary groups and academia, to assess ways in which environmental law in East and Southeast Asia can be made more effective.

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The *Asian Journal of Environmental Management* (*AJEM*) invites articles on practical aspects of environmental management in Asia. Priority is given to papers involving (1) descriptions of efforts (or specific proposals) to *manage* problems associated with pollution or nature conservation, and (2) matters of concern to organizations involved in environmental management or public awareness (for example, environmental data, management tools, institutional developments).

The manuscript should be clear and concise. Where some of the material presented is highly specialized in nature, the text should include explanatory statements which convey its importance to a readership from different professional backgrounds. Submissions will be refereed by an international panel of experts in the field, and the referees will determine if the submitted papers are to be published as received, published following specific requests for revision, or not published. In keeping with *AJEM*'s goal of facilitating information exchanges, comments on published articles are invited and these will be published. Comments and rejoinders should be between 50 and 800 words.

Submission of a manuscript will be taken to imply that the material is original and no similar paper has been published or currently submitted for publication elsewhere.

The manuscript should be between 3000 and 8000 words and the cover page must include the title (less than 15 words), the author's correspondence address, fax and telephone numbers, an abstract of 100 to 200 words, and a list of up to 10 key words. The typescript must be submitted along with a photocopy of original illustrations (for example, photographs, drawings). Indications of appropriate style for references, and other points of style, may be taken from the articles in this issue. Manuscripts must be submitted double spaced with wide margins on all sides along with a copy on a computer disk. (If requested, *AJEM* will return computer disks or printed material to the author.)

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Planning for a Cleaner Shanghai: The City's Current Environmental Status and Its Prospects

Wu Chengjian

ABSTRACT

Shanghai is facing a major pollution challenge due to historical neglect and recent economic development. However, as the city's prosperity increases, Shanghai is taking actions to improve the environmental situation. This paper describes the current situation with regard to environmental protection and the ambitious plans for future sustainable development in the city of Shanghai.

Keywords: *Shanghai, China, pollution, pollution control, environmental management*

INTRODUCTION

Shanghai, the largest city in China, has been experiencing a continuing economic growth at an average rate of approximately 14% for the period 1992 to 1994. Shanghai is fast resuming its position as one of Asia's major centres of business and finance. Yet, as clearly recognized by the local planners, if Shanghai is to once again take on this role of an international metropolis, its urban infrastructure and environmental quality must be consistent with that image. Therefore environmental protection has been regarded as one of the major concerns, both for protecting the public health of local inhabitants and for attracting foreign investors. The Shanghai Municipal Government has recognized the importance of a cleaner urban environment to harmonize economic growth and environmental protection, and therefore has been taking actions to control pollution with the aim of attaining an environmentally sound and sustainable urban development in the future. This paper draws on two recent comprehensive publications (*Shanghai Environmental Bulletin 1994*, and *The Shanghai Environmental Master Plan*) to present an overview of the environmental situation and plans for China's major city.

CURRENT STATUS OF ENVIRONMENTAL PROTECTION AND MAJOR PROBLEMS

Historical Review

Environmental pollution in Shanghai has existed for as long as the city itself, but matters began to get noticeably worse in the early 1920's. Suzhou Creek, one of the longest tributaries of the Huang Pu River, had been contaminated first owing to the direct discharge of untreated effluent from the factories along the creek as well as the sewage from some residential areas near by. Then, with population growth, urban expansion and industrialization process, water quality deteriorated to very unhealthy levels.

Since the 1960s, pollution problems have been

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handled by the Shanghai Municipal Government which set up a Special Office to address pollution control activities. Nevertheless, the pollution control activities lagged behind the increasing pollution loads which resulted from economic growth. As a consequence, the Huang Pu River has been badly contaminated since the late 60s. Meantime, due to the increasing energy consumption, particularly the numerous energy users with small-scale boilers and industrial furnaces scattered throughout the city, air quality also worsened.

In 1979, the Municipal Government established the Shanghai Municipal Bureau of Environmental Protection to control the ever-increasing pollution problems by: developing environmental planning, promulgating regulations and by-laws, strengthening enforcement and levying discharge fees on polluters, and other means. Guided by the national environmental policies, great efforts have been made in the past two decades and achievements in environmental protection in Shanghai have been remarkable. In the past ten years, gross national product (GNP) in the Shanghai region doubled, but total pollutant emissions were kept to the same level. Hence, greater economic prosperity has been attained without further worsening of the environment. In some areas, environmental quality has even been improved locally. However, because of the problems left from the past decades and the continuing rapid economic expansion, pollution control and infrastructure development are still not able to keep up with the requirements for an environmentally sound and sustainable urban development.

Status of Environmental Protection in Shanghai

Shanghai in the mid-1990s is already a super city with more than 13 million inhabitants, of whom about 8 million are living within the city proper. Yet this large population lives on less than 400 square kilometres. Such densities put severe strains on the environment.

Water Pollution

Approximately 5.5 million tons of wastewater are discharged daily in the Shanghai region; about two-thirds of the wastewater are industrial effluents from a wide spectrum of industries (Figure 1). It is reported that about 30% of the industrial wastewater is treated in individual wastewater treatment facilities owned by the wastewater generators. The remaining one-third, 2 million tons/day, is domestic wastewater, of which less than 20% is treated in the 16 small sewage plants around the city. While approximately 1.6 million tons/day of wastewater are collected and then discharged into the Changjiang Estuary by sewage interception projects, the remainder is directly discharged into the river .

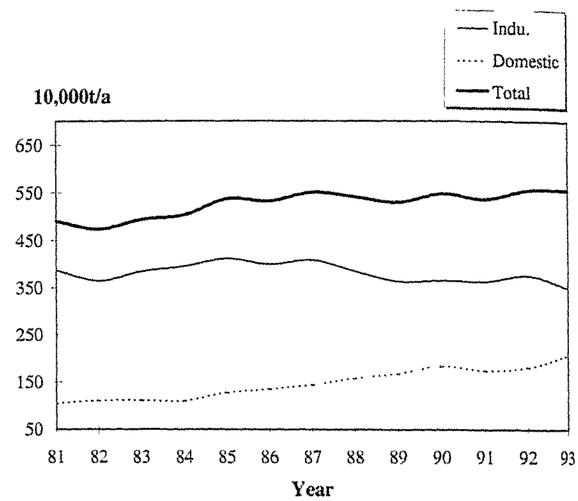

Fig. 1 Wastewater discharged in Shanghai (1981–1993).

Water quality is directly affected by this great amount of untreated waste. For example, only the Huang Pu River 'Water Source Protection Zone' — where the 2.3 million tons/day of drinking water for the inhabitants of the city proper are taken — was classified as 'Class 3' (i.e., drinkable) in 1994. In all other parts of the river, the water quality does not meet this standard and is considered contaminated (Figure 2).

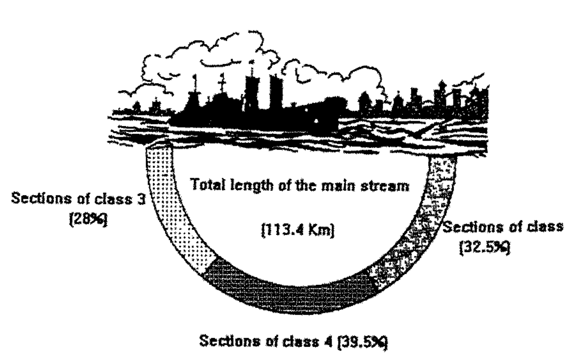

Fig. 2 Water quality of the main stream.

Air Pollution

Enormous coal consumption in Shanghai is the main reason for air pollution which is characterized by high levels of sulphur dioxide (SO_2) and total suspended particulates (TSP). In 1994, approximately 32 million tons of coal were consumed in the Shanghai region, of which over 40% was used for generating electricity in the twelve power stations around Shanghai. None of these plants had flue gas desulphurization (FGD) systems installed. In addition, tens of thousands of boilers and industrial furnaces are still burning coal. These sources are regarded as the most significant air pollutant sources to affect the ambient air quality in the city, in spite of the fact that most have dust removal equipment (e.g., filters or cyclones) installed.

Fig. 3 Coal consumption in China (1986–1993).

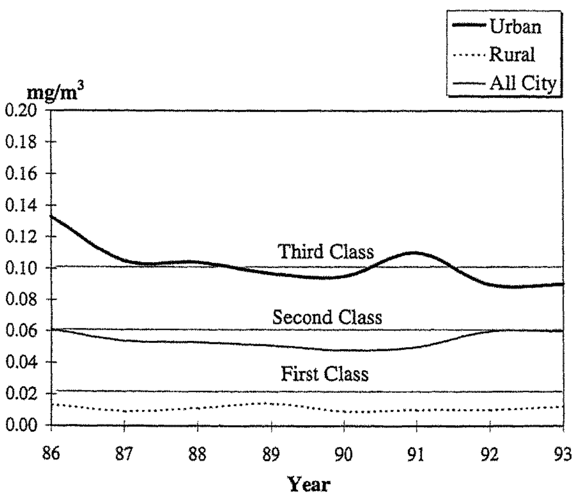

Fig. 4 SO_2 concentrations in Shanghai (1986–1993).

Although the number of automobiles (370,000 in 1994) is low compared to other major cities in the world, they are an increasingly important source to air pollution in Shanghai. Due to traffic congestion and the inferior automobile manufacturing quality, local emissions of hydrocarbons (HCs), carbon monoxide (CO) and nitrogen oxides (NO_x), in a number of busy traffic areas, are very high and present an increasing near-term health concern.

Moreover, the economic boom is reflected in a construction boom; dust from more than 20,000 construction sites scattered over the central part of the city significantly adds to the deteriorating air quality.

Solid Waste Management

In a large, densely populated city, domestic solid waste is always a thorny problem. In Shanghai, approximately 9,000 tons of garbage are generated every day. Currently, there is no incinerator for burning domestic solid wastes. About two-thirds of the solid wastes are properly disposed of in a huge coastal landfill site with leachate collection and a treatment facility. However, the remainder is dumped in various uncontrolled sites without any pollution prevention measures.

As for the nightsoil, the current practice is believed to be adequate only in a few of the new residential areas where nightsoil is directly linked to the sewage system. In most older residential areas where septic tanks are widely used, the traditional way of using nightsoil as fertilizer has been changed since the farmers are no longer willing to use it. This results in the difficult question of how to dispose of nightsoil.

As a major industrial base for China, industrial solid waste management in Shanghai is surely an important issue. However, one fortunate consequence of the lack of local natural resources is that comprehensive utilization (reuse, recovery and recycle) has been emphasized in Shanghai for the past two decades. More than 80% of about 10 million tons of industrial solid waste generated in the city are reported to have been reused, recycled or recovered. For example, annually 2.5 million tons of fly ash from power stations are used in building materials.

Nevertheless, hazardous waste management is a weak point of the waste management system. The current practices of handling hazardous wastes are far below international standards and present one of the more serious long-term problems for Shanghai. It is estimated that at least 50,000 tons of the hazardous waste needs to be safely treated or finally disposed of each year.

Noise

In Shanghai, as in other large, very densely populated urban centres, noise is always a problem. Normal problems encountered anywhere in the world are often made worse in Shanghai in some of the older, poorly-planned areas, where some noisy industries still exist inside residential areas. Indeed, dealing with the complaints from residents disturbed by their noisy neighbours is often a major part of the daily work of some local environmental authorities.

After ten years of efforts in organizing a campaign of *Quiet Districts*, that required noise makers to take measures to control their activities, the noise level in the city from stationary sources has been kept stable. Based on the monitoring results of environmental noise in the city in 1994, the average equivalent sound levels during the daytime and late at night, were 60.7 decibels dB(A) and 55.7 dB(A) respectively. However, traffic noise has exceeded the standard because of the ever-increasing number of vehicles, the narrow streets, and the mixing of pedestrians and bicycles which encourages the frequent use of horns.

SHANGHAI URBAN DEVELOPMENT AND ENVIRONMENTAL TARGETS

Urban Development

As defined by the city's Master Plan, the Shanghai urban development can briefly be described as follows:

> Shanghai is the largest centre of economic activity, culture, science and technology in China and is one of the major international economic and trade centres of the world. It is the 'Dragon Head' of the Changjiang Delta Economy.

The overall layout planned for Shanghai envisions a structure of multiple-centres, openness of landscape, and 'multiple levels and combinations' within the greater urban area of 6300 km^2. A metropolitan core, a number of surrounding sub-centres and six secondary cities will comprise the multi-centred urban area. Industrial structure is set to change to high-technology, investment-intensive industries, led by automobile manufacturing, iron and steel, telecommunication equipment, electrical appliance manufacturing, petrochemical processing and biochemical processing.

Environmental Targets

Based on the Master Plan, an ambitious environmental objective of Shanghai has been set. Despite economic development, Shanghai is to maintain a satisfactory ecological environment. According to the Master Plan requirements, Shanghai will set up a planning framework for an environmentally sound city by the year 2000, conform to the international practices by the year 2010, and be ranked as one of the major international metropolises with clean environment and sound urban infrastructure in the year 2020.

MAJOR MEASURES FOR REALIZING THE ENVIRONMENTAL OBJECTIVES

To realize the goal of environmental protection in Shanghai, tremendous efforts must be made which include municipal engineering projects, pollution prevention and control strategies as well as regulatory improvements.

Municipal Engineering Projects

The shortage of municipal engineering facilities is one of the major constraints in dealing with Shanghai's adverse environmental situation. The construction and improvement of Shanghai's municipal infrastructure will be of great advantage to the city's environment. Several important projects are described below.

Phase II of Upper Huang Pu Water Supply Intake

The Huang Pu River is the water supply source for domestic, industrial and agricultural uses. In the 1980s, the water supply intake was relocated to Linjiang, about 15 km upstream of the old water intakes. But the raw water quality at that point is now below drinking standards, sometimes due to flood tides. For example, the biological oxygen demand (BOD), chemical oxygen demand (COD) and nitrogen (NH3-N) levels are all below Class 3 Criteria for National Surface Water Quality Standards. Therefore, relocation of the water supply intake to Da Qiao, where the water quality is within the ground water quality Class 2–3 Criteria (at least at present) will be undertaken. The designed capacity for the water supply will be 5,000,000 cubic metres per day (m^3/day).

Phase II of the Combined Sewage Project

Phase I of the Combined Sewage Project was completed in 1994 for collecting approximately 1.4 million tons of wastewater that used to be discharged into the Suzhou Creek. This water is now discharged into the Changjiang Estuary through a deep outfall. Phase II is now on the agenda. This project is designed to serve a total area of 322 km^2. The planned sewerage capacity is 5 million tons/day. The project will construct three trunk lines in the northeast, middle and southern parts of Shanghai. Bai Long Gang, 10 km south of the Phase I sewerage discharge point has been chosen as the location for this second discharge point. The project will be implemented in several stages due to the huge scale and funding needed.

Maintenance and Dredging Projects for Urban Canals and Rivers

To change the conditions of the heavily polluted urban waters, comprehensive measures must be taken to clean up the major canals and rivers in the Shanghai area. The dredging of Suzhou Creek is of particular importance, both to increase the land value along the river as well as for the city's environmental image.

Long-term Strategies for the Protection of the Water Environment

By the year 2000, a complete drainage system within the inner urban area will be established. By the year 2020, the total area to be covered by the urban rainwater runoff collection system will be some 500–600 km3, with the overall capacity of the drainage system being 2000–2500 cubic metres per second (m^3/s). At the same time, the drain design standard will be increased from a capacity of handling the expected maximum flood for a one year period to that of a cumulative two-three year period.

Construction of the Centralized Heating System

One of the components of Shanghai's air pollution control strategy is to promote central heating systems, and eventually to eliminate small and middle-size boilers which are making a major contribution to air pollution. Meanwhile, high efficiency combustion boilers and pollutant removal equipment, as well as higher exhaust gas stacks, will greatly improve the local air quality condition. In some development zones, particularly in the Pu Dong Area, district heating systems are under construction or being actively considered, and co-generation technology has already been adopted by the power stations and more are planned.

Gas Supply for Domestic Users

More than 80% of the city inhabitants have been using coal gas or liquid propane gas (LPG) for cooking. However, the remaining 20% mostly use coal, which results in serious public health problems due to both indoor air pollution and local ambient air pollution in these neighbourhoods. In order to change this situation, two major gas supply projects are under construction to provide coal-derived gas for future domestic and industrial use. As a consequence, by the year 2000 it is expected that all domestic and industrial users will be using gaseous fuels.

Development of East China Sea Oil & Gas Field

Off-shore natural gas exploration activities are currently underway in the East China Sea with promising results. It is expected that after the year 2000, natural gas supply from the East China Sea will be substantially increased from 1.2 million m^3/day to 2.4 million m^3/day. As a result, existing coal gas works will reduce production. Supplies are expected to be high enough to also allow for natural gas to be supplied to power stations. The cleaner energy from natural gas will be of great advantage to the improvement of the urban air quality.

Improvement of the Collection and Disposal System for Municipal Solid Waste and Nightsoil

It has been planned that new facilities will be constructed to deal with municipal solid waste and to eliminate all garbage storage within the city's central area of 15 km^2. Plans also include 100% coverage of the urban area for municipal solid waste collection and disposal service by the year 2000. To reduce the volume of municipal solid waste, the ultimate objective is to construct five incineration plants with a capacity of 1000 tons/day during the period of 2000–2020.

Regarding the nightsoil collection system, the planning objectives are to renovate the existing inadequate nightsoil collection and disposal system by providing sewer connections and treatment for nightsoil. The targeted sewer service area will be increased from 13.8% in 1993 to 70% by 2020, and the nightsoil will be treated by sewage treatment plants and comply with the discharge standards.

Pollution Control and Prevention

As the largest industrial city in China, industrial pollution control and prevention have been and always will be a major task. This task can be divided into several distinct components:

Cleaner Production

Cleaner production is the right approach to a sustainable development pattern for industry. It is therefore planned in the Shanghai industrial pollution control scheme that by the year 2000, cleaner processes are to be initiated and promoted, and by 2010, cleaner processes will be widely adopted. To realize this plan, four main measures are required:

1. to plan the targets for reduction of waste discharge;
2. to develop technical policies with Shanghai local characteristics for reducing industrial waste discharge;
3. to develop policies and mechanisms for offering incentives to encourage the application of cleaner technologies;
4. to establish a more effective management system for industrial pollution control and environmental protection.

The initial directions for actions are: to assimilate and promote the concept of integrated and sustainable development of cleaner products consistent with economic and environmental development; to establish cleaner processes, related technical centres, training centres and the information network system; to carry out demonstration projects of cleaner processes; to improve the management system for industrial pollution control; and to strengthen international exchange and cooperation.

Control of Major Pollution Sources

For effectively controlling the industrial pollution, the 100 biggest polluters in Shanghai — who are listed on the national pollution control programme of the 3000 most important polluters in China — have been identified and evaluated. Electricity generation, iron and steel, chemical, petrochemical, textile, etc, are the key industries contributing the majority of pollutants in Shanghai. A programme for controlling these 100 major polluters has been developed. This programme includes projects for cleaner processes as well as end-of-pipe treatment. Some special control measures are to be taken, for instance, a licensing system for limiting the discharge of pollutants, requirements for the installation of self-monitoring devices, production of periodic reports, etc. Meantime, frequent inspection and heavy punishment is to be stressed for those violating the standards.

Pollution Control Projects

Apart from the measures mentioned above, a number of specific pollution control projects have also been planned. These include:

Construction of Power Transmission Facilities

The major power development projects in other provinces give great possibilities of supplying power to Shanghai after the year 2000. They are regarded as one of the major measures to reduce the number of local power stations and therefore protect the urban air quality in Shanghai. To receive power supply from other provinces, power transmission facilities must be constructed.

Demonstration Project for FGD in Power Station

As the biggest coal producer and consumer in the world, China must take action to control the environmental problems associated with its use. Clearly, this will be very expensive. Since Shanghai is supposed to be one of the leading cities to adopt FGD processes, the selection of a pilot project for FGD for demonstration purposes has been taken into serious consideration for the near future.

Establishment of a Hazardous Waste Management System

It has been planned that a system for the collection, transfer, and comprehensive reuse, treatment and disposal of hazardous wastes, be established in the near future. This will include:

1. construction of a final disposal site;
2. construction of a modified cement rotary kiln for accepting hazardous and toxic wastes;
3. establishment of a comprehensive reuse plant for hazardous and toxic wastes.

Other Aspects of Accomplishing the Target

Legislation

It is of great importance to formulate a complete and effective system of by-laws and regulations to guarantee the process of realizing the ambitious target of environmental protection in Shanghai. It is recommended to promulgate more by-laws and regulations between now and the year 2010.

Institutional Arrangement and Enforcement

For effectively enforcing the regulations and implementing the pollution control programme, it is essential to establish an efficient institutional structure and enforcement system. Regular meetings, chaired by the Vice Mayor and attended by decision makers from relevant departments, are held to discuss environmental management needs and to coordinate and organize activities of environmental protection in Shanghai.

Two principles related to the responsibility have been highly emphasized. The first is to clarify corresponding responsibilities and objectives of different departments involved in environmental management and to implement checks in regards to implementation. The second principle is to decentralize authority to the district and county level, and to set the responsibilities for enforcement. It is believed that these two principles can effectively push forward the city's environmental protection. However, it has also been recognized that enforcement must be strengthened through frequent inspection and heavy punishment to law breakers.

Public Participation

Current pubic participation in Shanghai has already gained fruitful results. However, it undoubtedly needs to be further promoted compared with overseas practices. The attitude of the public towards environmental protection not only depends on the level of economic development, but also on the government's role in promoting public awareness. A detailed arrangement for future public participation has been proposed in the city's Environmental Master Plan.

Investment Arrangement for the Action Plan

The financial analysis in the Shanghai Environmental Master Plan clearly shows that even the most efficient (least cost) approach to sustainable development will require major investment before the year 2000, due to the insufficient investment in the past. If such investments are adequate, by the year 2010, environmental investment may decrease, though operational costs may rise. However, the benefits will gradually build and continue to build, until by about the year 2005, benefits may surpass expenses.

Table 1 shows investment and operation expenditures for environmental improvement in three stages. In general, the environmental investment is quite evenly distributed in the three stages, with an average of RMB 20 billion/year required before 2000, and RMB 15 billion/year after 2000. In this way, a healthy recycling of the investment capital can be achieved.

Table 1
Cost for the three stages of the investment arrangment (in billion RMB)

	Before 2000	*2000–2010*	*2010–2020*
Investment	81.1	32.5	8.9
Operation	43.9	120.0	138.8
TOTAL	125.0	152.5	147.7

US$1 = 8 RMB

FINAL NOTE

To meet the target of changing Shanghai into a cleaner, environmentally sound metropolis with sustainable urban development, is obviously going to be a very difficult and long-term task. Hopefully, Shanghai will be able to learn from the mistakes of those cities in the older industrial world and to put environmental management systems in place during the development process. If this is done, Shanghai may reach this ambitious goal by locally based efforts and assistance from abroad.

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Industrial Wastewater Management Strategies in Pakistan

Uwe Stoll and Abdur Rahman

ABSTRACT

The industrial sector is a major contributor of water pollution in Pakistan with high levels of BOD, heavy metals and toxic compounds. Only 30 industries have some level of water pollution control and most of these work at very low operational levels. Priority industrial sectors for pollution control are textiles within the medium- to large-scale industries and tanneries, and electroplating within small-scale industries. Textile industries generate large quantities of wastewater with high BOD, while electroplating discharges highly toxic wastewater.

In-plant modifications can result in reduction of wastewater discharges in large- and medium-scale industries, particularly if economic incentives, such as tax rebates, subsidies and soft loans are used. Central treatment plants are probably the best option for the treatment of wastewater generated by small scale industries. Unfortunately, the current legal structure in Pakistan is insufficient for the control of industrial pollution. Needed improvements in the legal system go beyond the new laws and regulations to include steps to improve the performance of enforcement agencies. This study aims to identify priorities for water pollution control in Pakistan through assessment of all types of industries, data on their wastewater production, information on the strength of wastewater pollution and the existing treatment system. The recommendations are both technological and policy- related.

Keywords: *Pakistan, environmental management, industrial pollution*

INTRODUCTION

Industries generally use large quantities of water in their production process, resulting in correspondingly large waste streams. Traditionally, industry in Pakistan looked for minimum cost of production, overlooking social and environmental responsibilities. Hence, investment in effluent treatment was considered a non-productive activity. With increasing industrialization, the unattended pollution problem from indiscriminate discharge of industrial wastes might reach a 'no return' point beyond control and the damages caused to the environment become irreversible. Expanding on a brief paper entitled 'Priorities in Wastewater Management in Pakistan' (Stoll and Rahman, 1996), this paper first reviews the nature of industrial wastewater pollution problems in Pakistan. It then identifies priorities and outlines a series of specfic policy and technological recommendations to deal with the priority problems in a practical manner, considering the limited resources available in Pakistan at present.

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In Pakistan 80% of illness and 40% of urban deaths are estimated to be caused by polluted water (GOP, 1991). Chemicals and heavy metals in wastewater released into the water bodies have destroyed fish populations, leading to a decline in fish exports, an important source of foreign exchange. Agricultural lands around certain factories where wastewater is discharged, have been rendered unfit for any kind of production (GOP, 1983).

Water Pollution Control Legislation and Standards

A number of laws related to water pollution control existed even before the creation of Pakistan. Yet, in most cases, these did not meet the present requirements for environmental management. More recent additions to the legislation are Punjabi Local Government Ordinance (1979), Sind Fisheries Ordinance (1980) and the Baluchistan Ground Water Rights Administration Ordinance (1978). A list of water pollution control legislation is given in Table 1. Unfortunately, the legislative provisions and penalties are either inadequate or not clearly defined for the control and minimization of water pollution in the country. The existing environmental legislation structure needs to be up-dated with the addition of more laws in order to effectively implement measures for pollution control in the country.

National environmental quality standards have been implemented in Pakistan since August 1993 (Table 2). These standards allow existing industrial units to manage waste or install appropriate treatment methods until July 1996. The standards appear to be relaxed compared to those in other countries, but nonetheless do provide a basis for environmental protection in Pakistan. Overly strict or inappropriate standards tend to be ignored and hence become counterproductive, discrediting the government's regulatory operations. These standards may be tightened with the passage of time to bring them to the level of standards of other countries.

Table 1
Water Pollution Control Legislation in Pakistan

Legislation	*Enforcing Agency*	*Offence*	*Penalty*
Pakistan Penal Code, 1860	Provincial Government	Fouling water of a public spring or reservoir	Maximum imprisonment of 3 months and/or fine up to Rs.500
The Canal & Drainage Act, 1873	Provincial Government canal rendering it less fit	Fouling the water of any for the purpose it is used	Fine of Rs 200 or imprisonment of 3 months or both
Factories Act, 1934	Ministry of Industries	Disposing untreated industrial waste in water bodies	Fine of Rs. 500
Karachi Joint Water Board Ordinance, 1949, and Karachi Joint Water Board Rules, 1956	Karachi Joint Water Board Authority	Contaminating the water supply of water works	Undefined
Punjabi Local Government Ordinance, 1979	Punjabi Government	Polluting a water supply source for human consumption	The local council may rectify the situation and cost recovered from the concerned party
Sind Fisheries Ordinance, 1980	Sind Government Fisheries Department	Discharging untreated sewage and industrial wastes in water	Government will prohibit violation by force
The Baluchistan Ground Water Rights Administration Ordinance 1978	Water Board under Government of Baluchistan	Discharging unlicensed industrial into sanitation system or water bodies	One year imprisonment or fine or both

Sources: GOP (1991) and E&UAD (1993)

Table 2
National Environmental Quality Control Standards for Municipal and Liquid Industrial Effluents (values in mg/l unless specified)

S.No	Parameter	Standard value
1	Temperature (°C)	40
2	pH Value	6.0–10.0
3	5-days BOD at 20°C	80
4	COD	150
5	Total Suspended Solids	150
6	Total Dissolved Solids	3500
7	Grease and Oil	10
8	Phenolic compounds	0.1
9	Chloride (as Cl)	1000
10	Fluoride (as F)	20.0
11	Cyanide (as CN)	2.0
12	Detergents (as MBAS)	20.0
13	Sulphate (SO_4)	600
14	Sulphide (S)	1.0
15	Ammonia (NH_3)	40.0
16	Pesticide, herbicide, fungicide, insecticide	0.15
17	Cadmium	0.1
18	Chromium (trivalent & hexavalent)	1.0
19	Copper	1.0
20	Lead	0.5
21	Mercury	0.01
22	Selenium	0.5
23	Nickel	1.0
24	Silver	1.0
25	Total toxic metals	2.0
26	Zinc	5.0
27	Arsenic	1.0
28	Barium	1.5
29	Iron	2.0
30	Manganese	1.5
31	Boron	6.0
32	Chlorine	1.0

Source: PEPA (1993)

Institutional Framework

Environmental institutions in the country include the Ministry of Environment and Urban Affairs at the federal level, the environmental protection agencies at the federal and provincial levels, and the Pakistan Environmental Protection Council (PEPC) headed by the President of Pakistan. A sketch of the environmental institutional framework in Pakistan is shown in Figure 1.

STRATEGIES AND METHODOLOGIES

Estimation of Wastewater Flow and Pollution Load

Comprehensive data on discharge of wastewater from various industries in Pakistan is not available since a detailed survey for this purpose is yet to be undertaken. The literature cites different values of

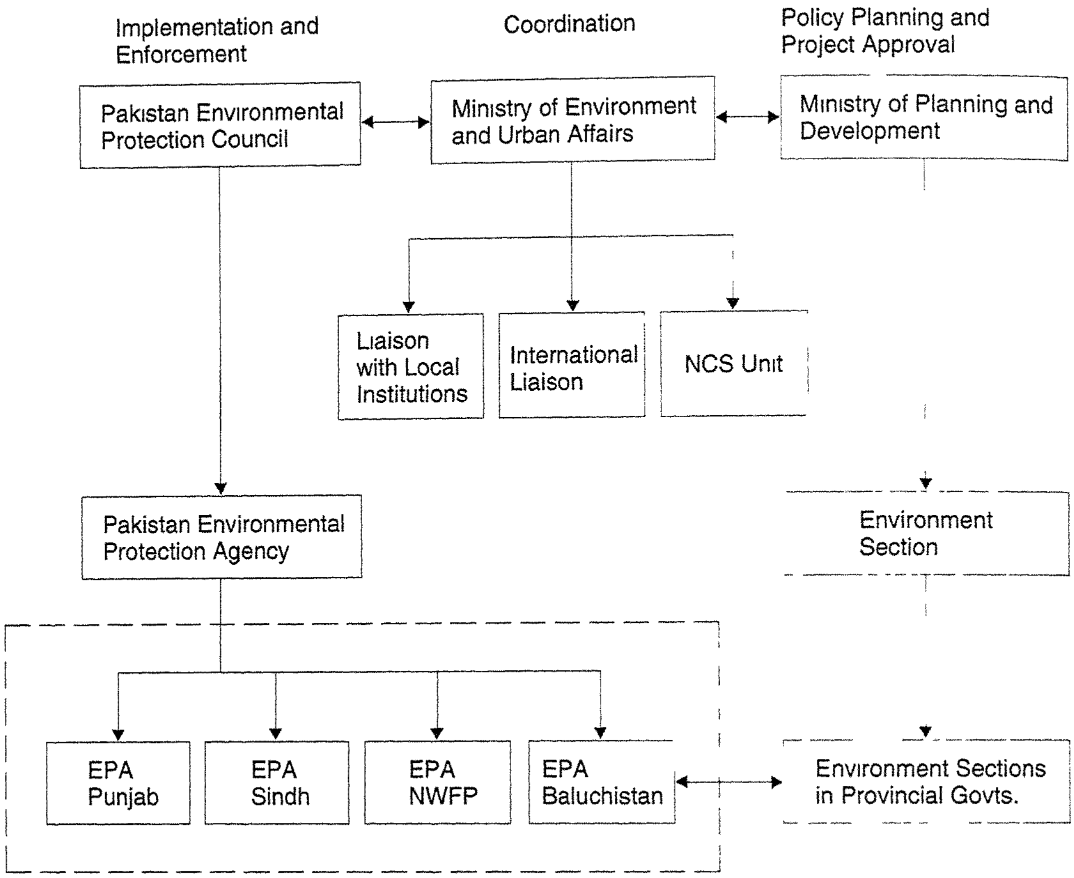

Fig. 1 Environmental institutional framework in Pakistan.

wastewater discharge for various industrial activities. For example, Imhoff (1971) cited 45 to 1000 cubic metres (m^3) as the range while Fresenius (1989) used the much narrower range of 50 to 100 m^3 of wastewater per ton of product from a textile dyeing and bleaching industry. EPA Punjabi has indicated that 1200 to 3650 m^3 of wastewater is generated per day from a medium-scale textile industry with a production level of 0.5 to 3.5 tons of finished product (Rahman, 1994). This indicates higher water consumption trends by industries in Pakistan. This appears to be mainly due to the use of groundwater and the fact that there was no restriction on the wastewater discharge into the sewers or drains. On average, a medium-sized industry in Pakistan uses 2500 m^3 of raw water per day. Tables 3 and 4 show the values of production and total wastewater discharged by each industrial group. Total biological oxygen demand (BOD) load and the toxicity of wastewater from small-scale and medium- to large-scale industries are also shown.

Prioritizing Industries for Water Pollution Control

The major objective of priority setting is to identify a strategy for dealing with industrial water pollution problems in a manner which minimizes the use of scarce resources. A systematic and easily understood method of prioritizing industries for water pollution control based on a 'Multicriteria Choice Analysis' approach (Heredia, 1993) is used here. To establish the ranking or priority of industries, each criterion, weighed in terms of percentages according to importance, is valued from 1 to 10 (Rahman, 1994). The criteria with their weights and priority setting exercise is shown in Tables 5 and 6. The ranking of industries is given in Table 7.

The Textile Industry

Textiles is one of the major industrial sectors in Pakistan, using large quantities of water in its pro-

Table 3
Estimated Wastewater Discharge, BOD Load and Toxicity of Wastewater From Small-Scale Industries

Industry/ Workshop (SSI)	Approx. No. of Industries	Av. Discharge Per factory	Estd. Total Effluent Discharge 10^3 m^3/d	Av. BOD mg/l	BOD Load t/d	Toxicity
Dairy Products	582	55 m^3/d	32	2000	64	-
Tanneries	823	65 m^3/d	53	1226	65	+++
Electroplating	1150	20 m^3/d	23	570*	13	++++
Wheat and Grain Mills	214 (36000 t/d)**	@0.36 m^3/t	13.1	300	4	–
Bakeries & Confectioneries	918	5 m^3/d	4.6	1500	6.9	+
Soap & Detergent	586	5 m^3/d	2.9	200	0.6	++

*COD, ** Production
Source: Rahman (1994)

Table 4
Production, Wastewater Flow, BOD Load and Toxicity of Wastewater From Medium to Large-Scale Industries

INDUSTRY SECTOR/ Industry	Total Production	Effluent per unit of Production	Total Flow 10^3 m^3/d	Av. BOD mg/l	Total BOD t/d	Toxicity
FOOD, BEVERAGE & TOBACCO						
1. Food Processing	1797 t/d	25m^3/t	45	800	36	+
2. Beverage	676493 l/d	10 lit/lit product	6.8	1500	10.2	-
3. Sugar	6362t/d	2.3 m^3/t	14.6	700	10.2	-
4. Vegetable Oil/Ghee	1797 t/d	13.7 m^3/d	24.6	900	22.1	+
TEXTILE, APPAREL & LEATHER						
1. Textile Manufacturing	170 t/d	500 m^3/t	85	450	38.2	++
PAPER, PRINTING & PUBLICATION						
1. Pulp, Paper & Paper Board	130t/d	228 m^3/t	30	2500	75	++
CHEMICALS, RUBBER & PLASTICS						
1. Fertilizers	7658 t/d	60 m^3/t	4.6	500	2.3	+++
2. Chemicals	1797 t/d	25 m^3/d	45	800	36	+++
3. Paint & Varnishes	52 t/d	10 m^3/t	0.5	350	0.2	++++
BASIC METAL INDUSTRIES						
1. Iron & Steel	5732 t/d	7 m^3/t	40.1	300	12	++
NON-METALLIC MINERAL PRODUCTS						
1. Cement	22800 t/d	**	***	-	-	-

** Cooling water *** Contains inorganic suspended solids, ++++ Most hazardous, +++ Moderately hazardous, ++ Potentially hazardous, + Nominal, - No effect
Source: Rahman (1994)

Table 5
Computations for Ranking of Small-Scale Industries

Industry	*No. of Industry 15%*	*Wast Water Flow 20%*	*BOD Load 25%*	*Degree of Hazardouness 40%*	*Weighted Average 100%*	*Rank*
Dairy Products	6	4	7	1	3.85	3
Tanneries	9	6	7	5	6.30	1
Electroplating	10	3	1	9	5.95	2
Wheat & Grain Mills	3	2	1	1	1.50	6
Bakeries & Confectioneries	10	1	1	3	3.15	5
Soap & Detergent	6	1	1	5	3.35	4

Source: Rahman (1994)

Table 6
Computations for Ranking of Medium & Large-scale Industries

INDUSTRY SECTOR/ Industry	*No. of Industries 15%*	*Waste-water Flow 20%*	*Pollution Load (BOD)*	*Degree of Hazardousness 40%*	*Total Weighted Average 100%*	*Rank*
FOOD, BEVERAGE & TOBACCO						
1. Food Processing	2	5	4	2	3.10	7
2. Beverage	1	1	2	1	1.25	10
3. Sugar	1	2	2	2	1.85	9
4. Vegetable Oil	2	3	3	3	2.85	8
TEXTILE, APPAREL & LEATHER						
1. Textile Manufacturing	10	9	4	5	6.30	1
PAPER, PRINTING & PUBLICATION						
1. Pulp, Paper & Paper Board	1	3	8	4	4.35	3
CHEMICALS, RUBBER & PLASTICS						
1. Fertilizers	1	1	1	7	3.40	6
2. Chemicals	1	5	4	7	4.95	2
3. Paints & Varnishes	1	1	1	8	3.80	5
BASIC METAL INDUSTRIES						
1. Iron & Steel	3	5	2	5	3.95	4
NON-METALLIC MINERAL PRODUCTS						
1. Cement	1	-	-	-	-	11

Source: Rahman (1994)

Table 7
Ranking of Industries for Pollution Control (in order of priority)

Medium to Large-Scale Industries	*Rank*	*Small-Scale Industries*	*Rank*
Textile Manufacturing	1	Tanneries	1
Chemicals	2	Electroplating	2
Pulp and Paper	3	Dairy Products	3
Iron and Steel	4	Soap and Detergent	4
Paints and Varnishes	5	Bakeries & Confectionaries	5
Fertilizers	6	Wheat and Grain Mills	6
Food Processing	7		
Vegetable Oil	8		
Sugar	9		
Beverage	10		
Cement	11		

Source: Rahman (1994)

duction process. The existing state of affairs is alarming because highly polluted wastewater is being discharged into sewers and drains without any level of treatment. Wastewater from textile dyeing and finishing products are highly coloured, usually alkaline, contain substantial suspended solids, have high biological or chemical oxygen demand (BOD/COD) and have high temperatures. The largest share of BOD comes from desizing operations. The wastewater flow and its characteristics from a typical textile industry are given in Table 8.

Table 8
Wastewater Characteristics from a Typical Textile Industry

Characteristics	*Values*
Average discharge	3000 m^3/d
Average production	3.5 tons/d
Wastewater produced	857 m^3/ton of fabric
Temperature	40°C
pH	10.5
BOD_5 at 20°C	250 mg/l
COD	640 mg/l
TDS	5740 mg/l
S.S.	620 mg/l
Chlorides	1150 mg/l
Sulfates	83 mg/l
Sulfide	17 mg/l

Source: EPA Punjabi (1991)

The best practicable approach for the treatment of textile wastewater is a combination of chemical and biological processes. In-plant control measures can reduce wastewater discharges resulting in a lower cost of treatment. The factors that prevent small-scale factories from adopting pollution control measures include low capital investment, tight factory space, and lack of expertise.

In order to maintain competitiveness for the small- and medium-size industries, treatment methods to be used must be effective, compact, easy to operate and affordable. Various waste minimization techniques can be adopted such as in-plant control measures and production process modifications. The treatment cost of textile wastewater has been estimated at US$0.32 per m^3 of wastewater using the formula of Dharmappa (1992).

Electroplating Industry

The electroplating industry is spread over the country as small-scale workshops, numbering roughly about one thousand. Although the quantity of wastewater produced by the electroplating industry is comparatively small, the wastewater itself is highly toxic due to the presence of copper, zinc, nickel, cadmium, chromium, acids, alkalies, and the highly dangerous cyanides. Based on criteria explained earlier, this industry has been accorded the second highest priority among the small-scale industries. The principal sources of wastewater discharge from plating operations are 'drag-out' from rinse vats used to remove electroplating solution films, 'dumps' during clean up of tanks or vats, 'vat blowdown' and the contamination of cooling water.

In practical terms, small-scale electroplaters cannot treat their waste flows due to high initial investment costs and operating expenses. A treatment system may cost up to 50% of the total investment in electroplating equipment (SEATEC, 1990). A careful strategy will help small-scale industries manage their waste streams. The strategy may include: (1) waste minimization and segregation of wastewater through process modification and drag-out reduction, and (2) central treatment plants where plating wastes can be treated by removing cyanide, chromium and other metals, oil and grease. The cost of treatment for electroplating wastewater has been estimated at US$1.27 per m^3 of wastewater (Rahman, 1994)

RECOMMENDATIONS AND GUIDELINES

Policy Planning Recommendations

The authors' major policy planning recommendations for industrial wastewater treatment in Pakistan are as follows:

1. the government should set out short and long term plans for industrial water pollution in line with the priorities set in this study and an appropriate allocation of resources made accordingly;
2. political consensus must be obtained for the introduction and enforcement of effective legislation;
3. an awareness campaign should be launched to make the people realize the seriousness of pollution problems;
4. for a meaningful strategy to be formulated and implemented, a thorough survey of all industries and wastewater discharge should be conducted as soon as possible;
5. a *comprehensive* set of laws for water pollution control must be framed and implemented;
6. adequate, formal enforcement procedures must be defined clearly and the monitoring system strengthened;
7. the existing penalties and fines for violating the laws are inadequate, having lost their significance hence, punitive measures must be revised to the appropriate level in light of current prices;
8. the environmental institutions must be strengthened and given adequate resources including more trained manpower, monitoring equipment and legislative support for enforcement;
9. for effective enforcement, laws relating to the existing industries should be grouped into one aimed primarily at large-, medium- or small-scale industries;
10. where necessary, discharge permits should be introduced and standards should be made more flexible for small-scale industries to allow them to carry out step-wise implementation of pollution control efforts;
11. central treatment plants should be set up to provide treatment facilities for small-scale industries; and
12. large-scale industries may be offered economic incentives such as tax rebates, subsidies, soft loans, etc. in lieu of adopting pollution control measures.

Technological Recommendations

The authors' technological recommendations for industrial wastewater treatment in Pakistan are as follows:

1. industries should adopt simple, low cost or no cost wastewater minimization techniques and control measures through in-plant changes and process modifications;
2. large-scale textile industries should build their own treatment plants for color and BOD removal;
3. treatment technology for small-size textile factories should include chemical coagulation and neutralization of wastewater at the factory site and then discharging this treated water into the sewer until central treatment facilities for biological treatment are available;
4. discharges from electroplating industries should undergo a certain degree of detoxification before discharging into municipal sewers and at a later stage — when central treatment plants become operational — segregated wastewater should be collected and treated for recovery and neutralization of metals;
5. to the extent possible, the small-scale electroplating industries should be relocated near the treatment facilities and the monitoring system improved; and
6. highly polluting and inefficient old industrial

equipment must be replaced with new and more sophisticated equipment.

CONCLUSION

The existing industries in Pakistan, through their indiscriminate toxic discharges into water bodies, are posing great threat to human beings, livestock and plants. The legislative framework in the country requires improvement for controlling the situation. Textiles, chemicals and pulp and paper mills have been revealed as the priority industries for water pollution control among the large-scale industries, while tanneries and electroplating have been identified among the small-scale industries. The treatment cost for textile and electroplating wastewater is estimated to be US$0.32 and 1.27 per m^3 respectively. The total investment requirements has been assessed as US$ 98.4 and 76.1 million for textile and electroplating industries respectively at the national level.

Appropriate pollution control policies should be designed, taking into account the position and capacity of both the small- and large-scale industries. A National Conversation Strategy has been formulated for Pakistan, and its successful implementation would lead to national capacity building in environmental resource conservation and management. Preventing and abating pollution is one of the 14 core programmes identified in the National Conservation Strategy. Yet, Pakistan is a developing country where lack of resources is the main problem hindering the successful implementation of such a strategy. This study refers to the phase-wise implementation of a pollution control strategy for industries in Pakistan and the priority for use of available funds. Total investment required for wastewater management in the textile and electroplating industries in various phases is estimated at Rs 1309 million (1995–97), Rs 1832 million (1998–2000) and Rs 2094 million (2001–2003). A brief implementation schedule is given in Table 9.

Table 9
Implementation/Investment Plan in Priority Industries

INDUSTRY/ INVESTMENT	*Pollution Control Technologies*		
	Year 1995–1997	*Year 1998–2000*	*Year 2001–2003*
Textile (Small-scale)	Chemical Coagulation, Flocculation/ Sedimentation, pH adjustment (Batch-process)	Activated sludge process at CTP* (WW** from SSI*** may be pretreated)	Tertiary treatment at CTP for colour removal by - Ozonation - H_2O_2 if necessary
Textile (Large-scale)	Equalization, Chemical Precipitation, Sedimentation, WW Segregation, Neutralization	Activated sludge process (at plant site)	Tertiary treatment by - Ozonation - H_2O_2 treatment
Investments	Rs. 738 million	Rs. 1033 million	Rs.1181 million
Electroplating (Small-scale)	Process Modification, Drag-out Reduction, WW Segregation, Neutralization	Chemical precipitation of metals and remova of cyanide & Chromium (+6) at CTP	Advanced treatment for metal recovery - Ion exchange - Electrolysis
Investments	Rs. 571 million	Rs. 799 million	Rs. 913 million

* CTP: Central Treatment Plant; ** WW: Wastewater; *** SSI: Small-Scale Industries
Source: Rahman (1994)

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Route Evaluation and Selection for a 500 Kilovolt Electric Transmission Line in Malaysia: An Environmental Assessment

Khairulmaini Bin Osman Salleh

ABSTRACT

This paper describes a methodology for selecting a 500 kilovolt (kV) transmission corridor using various environmental and other criteria and applies the approach to a transmission line siting problem in Peninsular Malaysia. Two main corridor alignments and various sub-alignments are investigated; each investigation covers diverse physical and human environments. Corridor selection is based on a factor scoring technique of environmental characteristics measured along the alignments. The major factors considered are the cost of construction, operation and maintenance of the transmission cables and towers (pylons), land costs, and the impact on the human and the physical environment. Routes were ranked on their overall total weighted factor scores (OTWFS), with the lowest scores being the most attractive.

One alignment located towards the coast would involve very high development and environmental costs (highest OTWFS value), because it cuts across extensive areas of swamp and peatland, rich in flora and fauna. An alternative route, located towards the inland of the Peninsula, was best in terms of low development and environmental costs (lowest OTWFS value). However, it had high human costs (incurred in relocating settlements, industries, schools, etc.). This assessment is designed to help decision makers evaluate the nature of the tradeoffs for this type of important infrastrucutrre project.

Keywords: *environmental assessment, transmission corridor, transmission alignment, factor scoring techniques, Malaysia*

INTRODUCTION

The rapid increase in Malaysia's gross domestic product (GDP) since the 1970s and expectations for its continued increase into the next decade have resulted in very large increases in demand for electric power and projections for further major growth. As shown in Table 1, this energy could be derived from a number of sources, but the most important is from fossil fuels for steam-driven power generation (Khairulmaini, 1994). Because of economies of scale in power generation and for local environmental quality considerations, power generation facilities are often located relatively long distances from the various demand centres they serve. Hence, one aspect of Malaysia's continuing economic growth is the need to plan for new major transmission corridors in order to extend the capacity of the national electric grid shown in Figure 1.

The country's highest voltage transmission at

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Table 1
Sources of Energy, 1985 - 1995

	1985		1990		1995		Average annual growth rate (%)	
	PJ	%	PJ	%	PJ	%	5MP	6MP
Crude Oil and Petroleum Products	406.3	70.9	482.7	59.3	603.7	52.2	3.5	4.6
Hydro	42.6	7.4	46.5	5.7	50.9	4.4	1.8	1.8
Gas	109.0	19.0	221.4	27.1	452.5	39.1	14.2	15.4
Coal and Coke	15.1	2.7	63.3	7.8	49.1	4.3	33.2	-5.0
Total	573.0	100.0	813.9	100.0	1,156.2	100.0	7.3	7.3

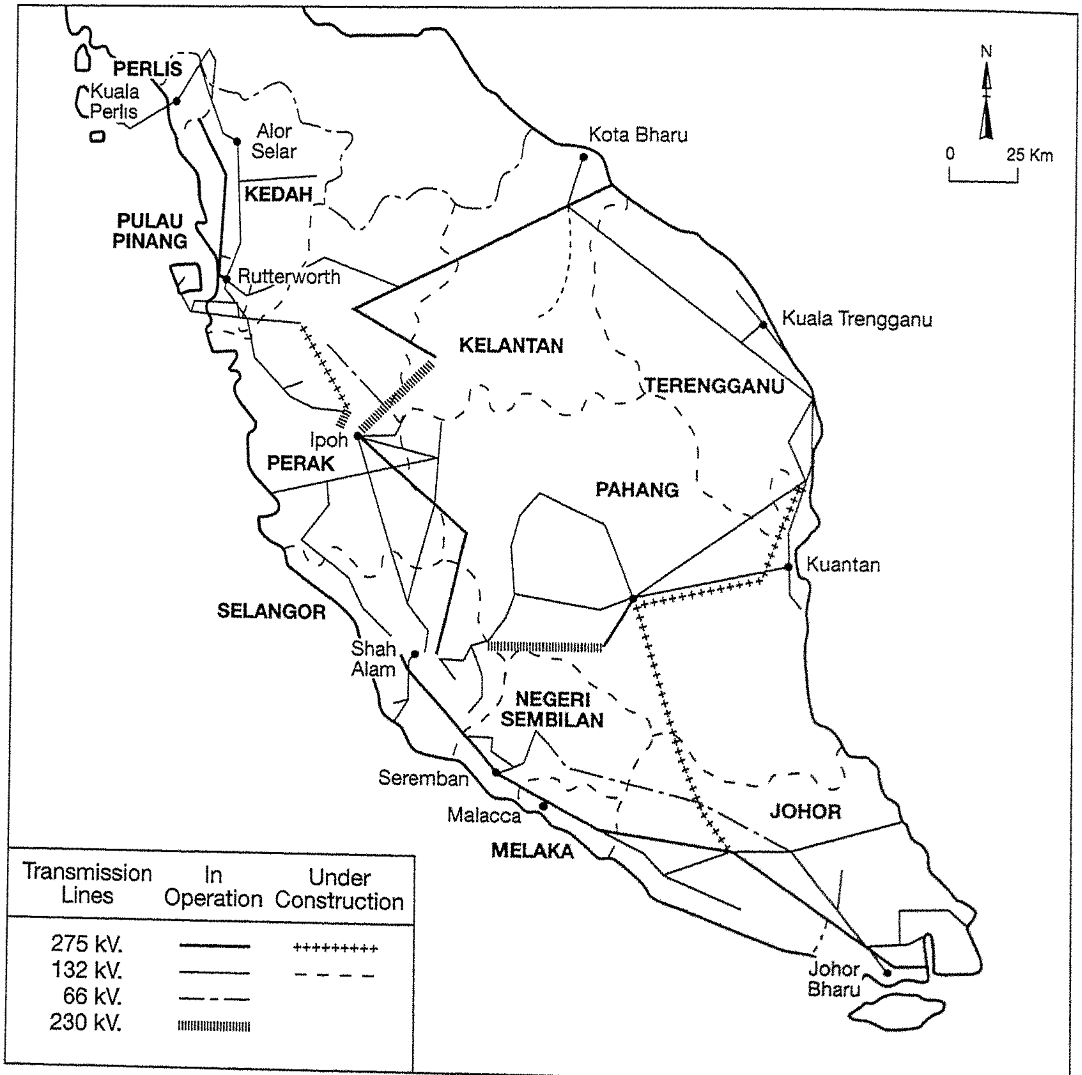

Fig. 1 The national grid for existing transmission lines in Peninsular Malaysia.

present is 275 kV and plans are underway to convert most of the 66 kV lines to 132 kV. There are also future plans to install 500 kV transmission lines to meet the expected demand of 13 gigawatts (GW) by the year 2000 (National Electricity Board, 1992). Energy experts also foresee a huge demand for energy in the region of the Association of South East Asian Nations (ASEAN). Eventually, an ASEAN grid could be a positive solution to increase supply to meet the rapid industrialization needs of the region. The proposed Bakun Hydro-Plant in Sarawak East Malaysia, for example, has a generating capacity of 2.4 GW and needs a high voltage line of greater than 132 kV to transmit electrical energy to the surrounding regions, either overland or through submarine cables.

It is clear that new high voltage transmission lines are needed to link the major load centres and the proposed future power stations in the country as shown in Figure 2 (Khairulmaini, 1994). In Peninsular Malaysia, these new transmission lines would be mainly in the form of 500 kV lines that are urgently needed to link the power plants to the various load centres in the country. The major industrial estates located mainly in the Klang River Basin, Seberang Prai – Penang Island, Senawang – Negeri Sembilan, Air Keroh – Malacca and Pasir Gudang in Johore, would greatly benefit from the proposed link up (Government of Malaysia, 1991). These 500 kV lines would typically require a 200 metre (m) corridor with a buffer zone of 100 m on either side (National Electricity Board, 1992).

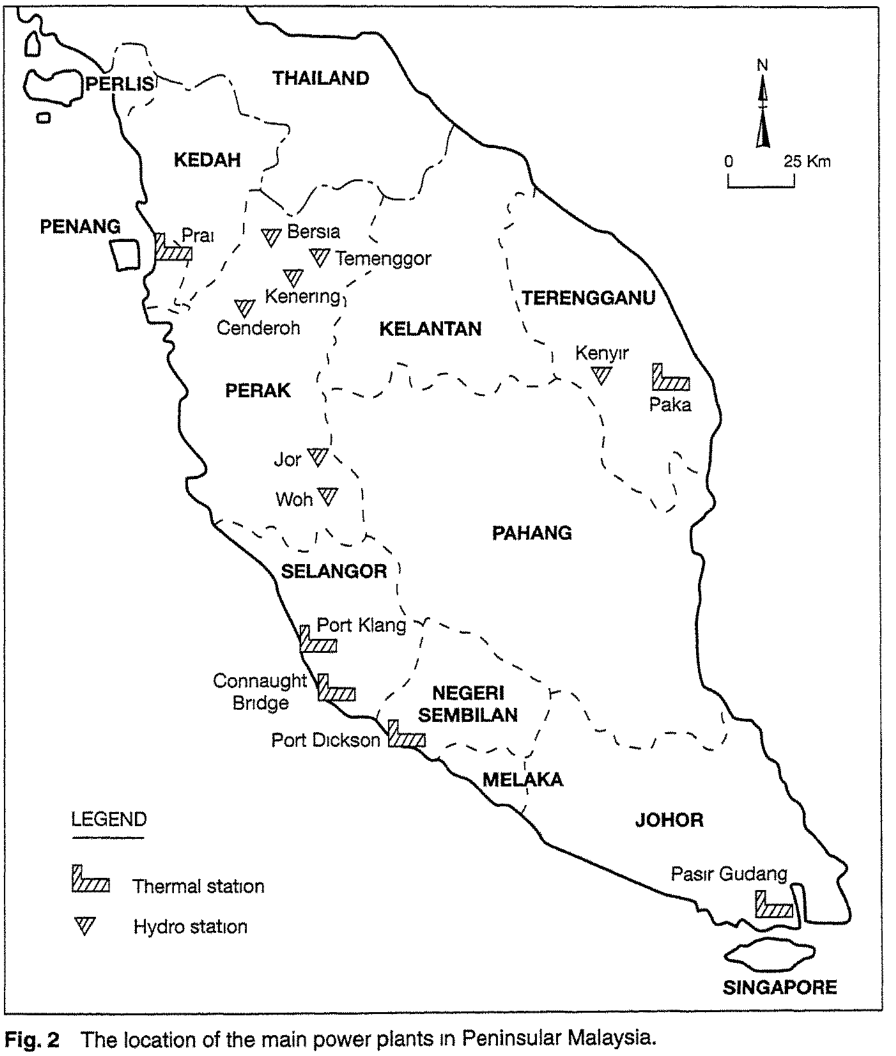

Fig. 2 The location of the main power plants in Peninsular Malaysia.

One of the proposed 500 kV transmission corridors would be located in the central region of Peninsular Malaysia, east of the Main Range. This corridor would link a new power plant in Lumut, Perak via the villages of Kampung Koh and Kampung Bukit Munchong, towards the town of Rawang in the State of Selangor. Rawang — located towards the south of the Peninsula — would be the receiving station where the electric energy would be downloaded to industrial estates and settlement areas within the Klang Basin. There would also be a line linking the power plant to the north of the Peninsula, accessing areas such as the Seberang Prai on Penang Island industrial estates and the emerging industrial estates in the states of Kedah and Perlis, further north of the Peninsula.

The present study evaluates the Lumut-Rawang transmission corridor in terms of environmental factors that would influence *development costs*, i.e. the total costs incurred to develop a transmission corridor. These factors include the construction and maintenance costs, funds to acquire and relocate settlements and industries, and costs associated with the potential impact on the human and natural environment. Apart from these factors, consideration was also given to factors influencing transmission losses and the potential impacts on the physical and human environments (Fritz *et al.*, 1980).

The variables used in the evaluation process were: bedrock and lithological formations, surface materials, relief characteristics, drainage characteristics and land use. These variables were considered because of their known influence on the cost of construction of major engineering works (Smith, 1992) and their sensitivity to development (Wiebe *et al.*, 1984; Wathern, 1992). Bedrock type and their lithological characteristics are considered important variables as they determine the extent to which a particular site would provide stable support to an engineering structure. In general, the bedrock formations dated back to the Ordovician-Silurian up to the later Holocene period. The Holocene period is generally associated with the formation of sedimentary deposits of mainly sands, silts and clays, generally located towards the coasts. The inland areas, generally progressing towards the Main Range of the Peninsula, are associated with mainly igneus and metarmorphic formations which occurs as light-seated and often exposed.

The surface materials are mainly weathered, redeposited or reworked materials and are generally unconsolidated in nature. These would range from weathered bedrock mainly of granites, metasedimentary bedrocks and soils formed over alluvial materials, to estuarine clays. Relief and drainage are known to correlate with one another, where a highly dissected relief is generally evidence of the existence of very high and steep slopes and dense drainage networks. In general, relief and drainage network is more pronounced towards the Main Ranges.

The western part of Peninsular Malaysia is entensively developed for agriculture (mainly rubber and palm oil), industrialization zones, urbanization and settlement areas and the development of communication infrastructures, e.g., the North-South Expressway. In relation to these landuse types, there still exists extensive pockets of tin mining lands in the Peninsula, though their contribution to the country's GDP is declining rapidly.

ENVIRONMENTAL CONSTRAINTS ON THE LAYOUT OF THE TRANSMISSION CORRIDOR

The best route for laying out a transmission line corridor or any other linear-defined corridor would be a straight line linking two end points (Dooley *et al.*, 1976). However, this is not possible as variations in the characteristics of the physical and human environment typical of an area must be considered. The best route, therefore, under such constraints would be that which would incur minimal costs in the construction, operation and maintenance of the transmission cables and towers (pylons), which does not involve high land aquisition prices and which gives minimal impact to the physical and human environments (Gilmore *et al.*, 1980; Haemisegger *et al.*,1985).

The main corridor routes and subroutes were identified based on detailed interpretations of the bedrock geology and surface soils of the study region. This preliminary assessment evaluates the foundation costs for erecting the transmission towers on the different types of geological and surface materials and the stretch length of the transmission cable between two towers.

In general, deep-seated unconsolidated materials, such as clays, peats and fluvio-alluvial deposits tend to incur very high piling costs and should be avoided (Ruxton, 1968; Little, 1969; Fookes *et al.*, 1971). Table 2 shows the different construction costs involved in erecting a single pylon on different types of earth materials (National Electricity Board, 1992). Piling conditions would be most suitable on bedrocks or those covered by skeletal soils and hill slopes experiencing very low rates of weathering (Coates, 1980). However, weakly structured sedimentary rocks such as shales and sandstones, formed on steeply inclined hill slopes, could succumb to rapid mass movement processes and in many cases, lead to the collapse of the towers (Selby, 1982). Under tropical humid climates, the latter condition could influence slope stability and the occurrence of mass movement processes (Goudie, 1994).

Table 2
Estimated Costs for Erecting Transmission Pylons (Towers) for a 500 KV Transmission Line

Earth Material	*Foundation Type (Depth)*	*Estimated Cost Per Foundation (RM 1000)*
1. Marine and alluvial clays	50 m	1000
2. Peat	40 m	720
3. Clays, Silts and Sands matrix	30 m	600
4. Sand and Gravel matrix	20 m	200
5. Bedrock (Metasedimentary)	10 m	100

Source: National Electricity Board 1992

In carboniferous terrain, the problem associated with chemical weathering and decomposition of rocks must also be taken into consideration as it could also influence the stability of the basal foundation that provides support to the towers. Under such cases, igneus and metarmorphic rocks like granite and gneiss provide stable support for piling structures because of their very high shear strength (Carson and Kirkby, 1982).

Two other important factors that need to be considered in aligning the transmission corridors are the existence of poorly drained areas such as swamps and the presence of very dense settlement and urbanized areas along the identified routes. Poorly drained areas should be avoided as they would be quite inaccessible for maintenance purposes and would also incur high construction costs, especially those involving the piling of towers, as compared to dry areas and those characterized by good drainage (Cooke and Doornkamp, 1990). These latter areas also would not be readily affected by basal corrosion which is quite typical in waterlogged areas. Densely developed settlement and urbanized areas usually create a negative perception from the inhabitants as transmission lines are generally perceived as a health hazard (O'Riordan, 1982; Robinson *et al.*, 1983; Gilad, 1984). Land values in these areas are also generally very high, giving rise to land compensation problems (Dooley and Newkirk, 1976). Other landuse activities that would incur high development costs are those associated with the agricultural and mining industries.

DEFINING THE LUMUT–RAWANG CORRIDOR

The diverse geology and surface materials of the area between Lumut and Rawang do not favour a straight line link between these two end points of the transmission corridor. Two main alignments were identified including the alignment that identifies the shortest link between the two end points. However, the alignments had to be redefined as spatial variations in settlement and landuse densities (including natural forest reserves) could influence land values and compensation costs, and displacement and destruction of the natural ecological balance.

In addition to these factors, relief and drainage characteristics were also studied as they are also known to influence the layout of engineering structures, including that associated with transmission cables and the construction of the towers (McHarg, 1968). The chosen transmission route must therefore incur minimal development and land aquisition costs and the impact to the physical environment must be kept very low. These prerequisites are often very difficult to meet as the factors influencing development and land aquisition costs varies greatly with space. Hence, any designated route is bound to transgress the factors described.

THE TRANSMISSION CORRIDORS

The Main Alignments

A brief account of the main alignments and subalignments are discussed below. The alignments are shown in Figure 3.

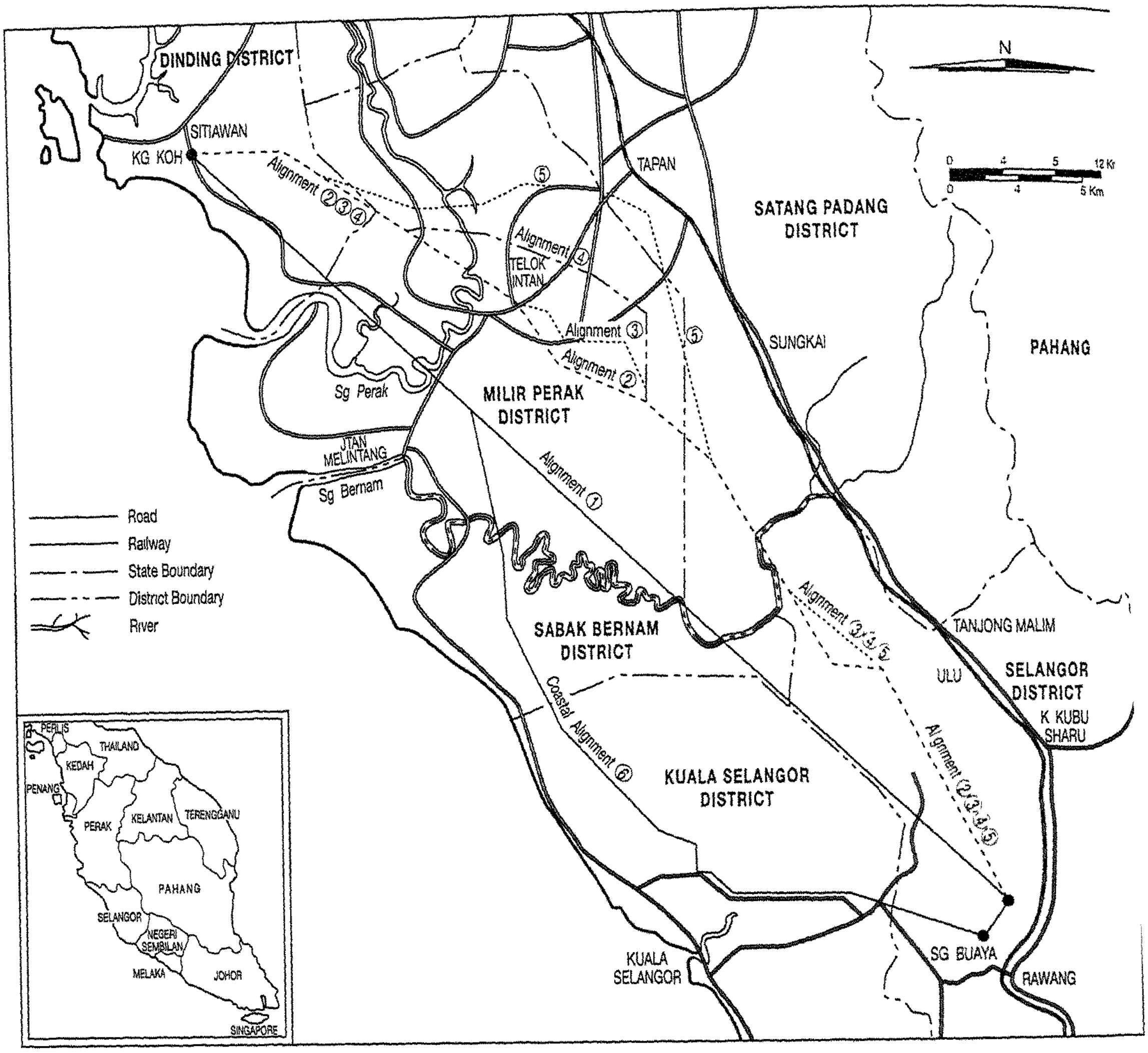

Fig. 3 The main alignments and subalignments of the proposed Transmission Corridor.

Alignment 1

This provides the shortest route between the two end-points of the transmission corridor. The alignment cuts through swampy, poorly drained, low-lying terrain, underlain mainly by peat and quaternary alluvium. At some stretches it also crosses through marine clays. Under these conditions, it is envisaged that the construction of the basal foundation of the pylons would be costly. However, the very sparse settlements along the route would involve very low land acquisition costs. The agricultural landuse along this route is mainly for oil palm.

Alignment 2

This is the second shortest link for the proposed transmission line. It is located further inland and thus avoids the problems encountered by Alignment 1. The alignment does, however, still cross small areas of marine clay and large stretches of agricultural land and may involve high land acquisition costs. The relief is slightly rugged, though with better drainage along the route.

The Subalignments

Alignment 3

This alignment is the third shortest route. It follows part of the route of Alignment 2 but is further inland to overcome the extensive areas of marine clays encountered in Alignments 1 and 2. The alignment crosses large amounts of agricultural land and a few areas of dense settlements.

Alignment 4

Alignment 4 is a variant of Alignment 2 and provides the fourth shortest route. It is very similar to Alignment 3 but has been shifted further inland to overcome localized areas of marine clays found along the path of Alignment 3. Alignment 4 cuts across vast stretches of agricultural land and dense settlement areas.

Alignment 5

This is also a variation of Alignment 2 and represents the fifth shortest route. It is shifted further inland from Alignment 4 to reduce the costs of land acquisition, as it crosses vast areas of economically productive mining and agricultural land. The relief is generally rugged with moderate to good drainage provided by upper tributaries of the main rivers of the region.

Alignment 6

Alignment 6 represents the longest route for the proposed transmission line. It provides an option for a coastal route and crosses vast areas of swamps, marine clays and agricultural land. Sparse settlement and pockets of urbanized areas exist along this route.

FACTOR SCORE ANALYSIS

Alignments 1 through 6 provide various alternatives for laying out the transmission corridors for central Peninsular Malaysia. In general, Alignment 5 would be the least costly. However, further refinement in defining the best alignment route has to be made, as the presence or absence of the studied environmental factors alone would not be sufficient to evaluate route selection (Lavine, 1978; Kirkwood, 1982). The magnitude of the environmental constraints could differ between the routes (Sondheim, 1978). One method to overcome this problem is to weigh the effects of an environmental factor on the development costs of the transmission line (Canter, 1983; Wathern, 1984). In the case of the present study, the selection of the best route was made based on the weighted scores of individual environmental factors along the alignments.

The weighted scores were derived based on the magnitude of the constraint (Hobs, 1985). The intercepted distance of each environmental factor was used as a surrogate for magnitude (Bisset, 1980). This value could be measured easily along the transmission route for each of the variables. For each environmental factor, 5 classes were distinguished as shown in Table 3. Each class is associated with a factor score or weight. A value of '1' would involve the least development costs, while a value of '5' would be associated with the highest development costs.

The effect of each environmental factor on the development costs depends on their intercepted distance. The overall effect of the environmental factors along the transmission corridors would be a summation of all the factor scores multiplied by the distances intercepted. One criticism of this method is that there was no attempt to consider the influence of the areal extent of each factor. A larger intercepted distance could in fact be associated with smaller areal extent (Lee 1982). This is especially significant in the case of linear features such as geological structures and certain types of settlement distribution (Ran and Woolen, 1980).

MAGNITUDE OF ENVIRONMENTAL EFFECTS

Table 3 shows the intercepted length for each class of each environmental factor, their weighted factor scores (WFS), and the total weighted factor scores (TWFS, i.e., summation of all the WFS of the classes for each environmental factor). The overall total weighted factor scores (OTWFS) of each alignment was derived by summing the TWFS of each of the environmental factors of the alignments (Table 4).

The TWFS was ranked for each environmental factor. This shows the alignment that incurs the least development costs in relation to that factor. The OTWFS was ranked to show the overall effect of the environmental factors and the alignment that involved the least development costs. Figure 4 shows the relationships between OTWFS and the environmental factors for the alignments defined in the study. At this stage, Alignment 6 could be discarded from further analysis. The other alignments, however, do not show any discernible pattern.

The overall ranking exercise based on the OTWFS shows that Alignments 1 and 6 rank poorly in terms of development costs. Figure 4 further il-

Table 3
Detailed Factor Scores for Each Alignment

Environmental Factors	*Factor Scores Class Type*											
	5		*4*		*3*		*2*		*1*		*TWFS*	*Rai*
Bedrock Lithology	Holocene		Pleistocene		Tertiary		Triassic-Jurassic		Carboniferous			
	dist.	WFS	dist.	WFS	dist.	WFS	dist.	WFS	dist.	WFS		
A1	77.0	385	0.0	0	0.0	0	0.0	0	8.0	8	393	5
A2	53.0	265	0.0	0	0.0	0	0.0	0	40.0	40	305	4
A3	45.0	225	0.0	0	0.0	0	0.0	0	50.0	50	275	2
A4	41.0	205	0.0	0	0.0	0	0.0	0	55.0	55	260	1
A5	48.0	240	0.0	0	0.0	0	0.0	0	68.0	68	308	3
A6	93.0	46.5	0.0	0	0.0	0	0.0	0	5.0	5	470	6
Surficial Materials	Peats		Marine/ Esturine Clays		Recent alluvium/ littoral sands		Subrecent alluvium/ littoral sands		Exposed bedrock			
A1	30.0	150	20.0	80	9.0	27	6.0	12	20.0	20	289	5
A2	6.0	30	5.0	20	27.0	81	7.0	14	48.0	48	193	2
A3	6.0	30	5.0	20	22.0	66	13.0	26	49.0	49	217	3
A4	6.0	30	5.0	20	22.0	66	13.0	26	50.0	50	218	4
A5	6.0	30	5.0	20	22.0	66	20.0	40	55.0	55	211	1
A6	54.0	162	28.0	56	4.0	12	4.0	8	8.0	8	410	6
Relief	Low plains		High plains		Moderate relief		High relief		Very high relief			
A1	25.0	125	38.0	152	10.0	30	20.0	40	0.0	0	347	5
A2	4.0	20	20.0	80	20.0	60	44.0	88	5.0	5	253	1
A3	4.0	20	22.0	88	25.0	75	29.0	58	15.0	15	256	2
A4	4.0	20	24.0	96	30.0	90	30.0	60	25.0	25	291	3
A5	4.0	20	25.0	100	35.0	105	13.0	26	60.0	60	311	4
A6	65.0	325	15.0	60	13.0	39	5.0	10	0.0	0	434	6
Drainage	Very poor		Poor		Moderate		Good		Very good			
A1	60.0	300	15.0	60	0.0	0	5.0	10	5.0	5	375	3
A2	58.0	290	25.0	100	0.0	0	5.0	10	5.0	5	405	4
A3	58.0	290	25.0	100	5.0	15	4.0	8	3.0	3	416	5
A4	22.0	110	3.0	12	4.0	12	43.0	86	25.0	25	245	1
A5	28.0	140	2.0	8	3.0	9	50.0	100	25.0	25	282	2
A6	60.0	300	15.0	60	13.0	39	5.0	10	5.0	5	414	6
Landuse Type	Developed areas		Peat swamps		Secondary forests/bare exposed areas		Undeveloped lowland forests		Undeveloped highland areas			
A1	25.0	125	15.0	60	4.0	12	46.0	92	5.0	5	294	4
A2	29.0	145	1.0	4	1.0	3	60.0	124	2.0	2	274	1
A3	31.0	155	0.0	0	0.0	0	62.0	124	2.0	2	281	2
A4	34.0	170	0.0	0	0.0	0	60.0	120	2.0	2	292	3
A5	35.0	175	0.0	0	0.0	0	68.0	136	5.0	5	316	5
A6	5.0	25	2.0	6	2.0	6	15.0	30	7.0	7	344	6

Table 4
Summary of TWFS

Environmental factors, their class types and associated factor scores (WFS is the weighted factor score. WFS was calculated by multiplying the factor score of each class type of an environmental factor with its intercepted distance and summing them up to give a TWFS for that environmental factor). The TWFS of a particular environmental factor was ranked to show the alignment with the highest development costs in terms of that environmental factor. The summation of each alignment environmental TWFSs would thus give the overall TWFS (OTWFS). This was ranked accordingly to determine the relationships of the alignments with their postulated development costs.

TWFS							
Environmental Factors	*Bedrock Lithology*	*Surficial Materials*	*Relief*	*Drainage*	*Landuse Type*	*OTWFS*	*Rank*
Alignments							
A1	393	289	347	375	294	1698	5
A2	305	193	253	405	274	1431	3
A3	275	217	256	416	281	1445	4
A4	260	218	291	245	292	1306	1
A5	308	211	311	282	316	1428	2
A6	470	410	434	414	344	2072	6

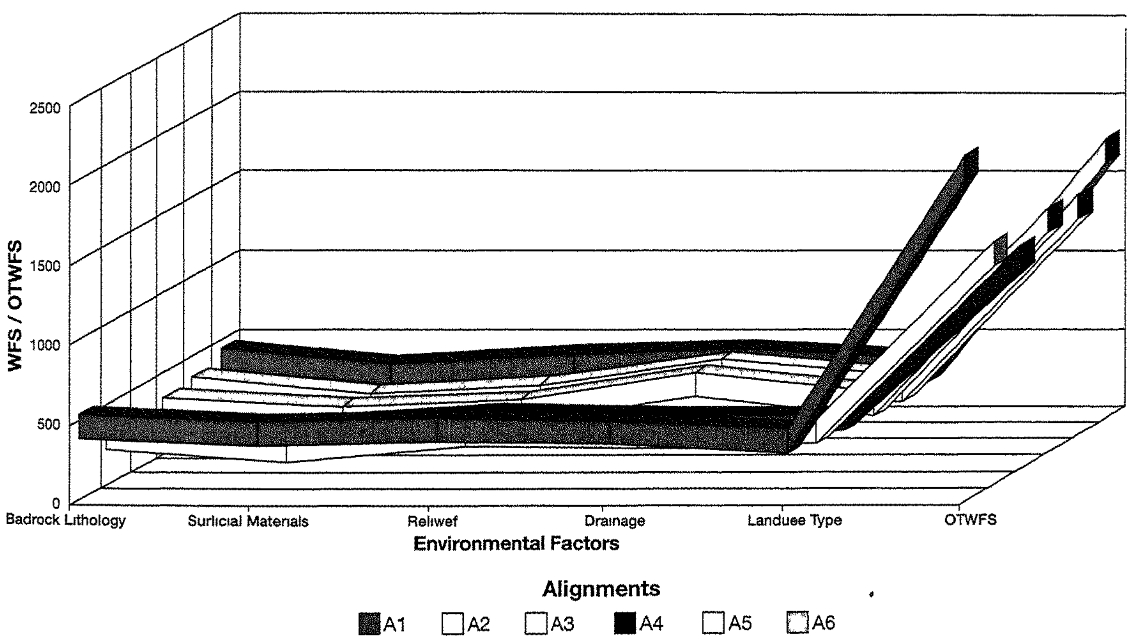

Fig. 4 The relationships between OTWFS and environmental factors.

lustrates this graphically, where both of the alignments cut across the classes of each environmental factor that would incur higher development costs. These alignments are the ones located towards the coast where the extensive swampy, peatland and marine clay terrain do not favour the construction and maintenance of the towers. Alignment 4 ranks as the best alignment in terms of low development costs followed by Alignments 5 and 2. The effect of each environmental factor also supports the ranking of the alignments. The latter alignments are located further inland. Another feature worth noting from Table 3 and Figure 4 is the small variation between Alignments 2, 3, 4 and 5. Alignment 6, with a OTWFS of more than 2000, deviates significantly from the values of the other alignments.

FACTOR SCORING AS A TECHNIQUE FOR SCOPING AND BASELINE STUDIES PRIOR TO ENVIRONMENTAL IMPACT ANALYSIS

Scoping and baseline studies are activities carried out prior to environmental impact assessment (EIA). Scoping refers to the process of identifying, from a broad range of potential problems, a number of priority issues to be addressed by an EIA. Baseline studies, in turn, are designed to provide information on issues and questions raised during the scoping exercise (Beanlands, 1992). The importance attached to both scoping and baseline studies arise from the fact that most EIAs are conducted under serious limitations of time and resources.

Many techniques have been developed in scoping and baseline studies, to evaluate the impact of a proposed development activity (Viohl and Mason 1974). These techniques, in general, give an overview of the potential impacts of a particular development and are considered an important component prior to the implementation of any formal environmental assessment. These techniques have been classified in different ways (see for example, Whitlatch, 1976; Coleman, 1977) but usually fall into the categories of checklists, overlays, matrices, networks and factor scoring (Kitchen, 1976; Mitchell, 1979). In evaluating the merits of alternative techniques, it is desirable to understand that no single technique is perfect. Each has their own strengths and weaknesses. As a result, it is futile to search for the 'ideal' technique.

A more realistic approach is to identify the relative merits of alternatives. In this way, a combination of techniques can be chosen to meet the needs of a particular problem. Ideally, an assessment technique should identify all of the impacts and indicate their timing and duration. Following identification, the technique should measure the magnitude of the impacts (high, medium and low). With the magnitude known, the technique should then suggest the significance of the impacts. An impact with high magnitude may not automatically have strong significance. Conversely, a low magnitude impact could have serious social significance.

The factor scoring technique used in this study provides a comprehensive, fairly accurate and easily understandable method to assess the impact of aligning transmission corridors on development costs. At the same time, the technique is not demanding of manpower, money, time, expertise and technological facilities that are beyond the capacity of the researcher. The technique initially identifies critical environmental variables thought to influence development costs, followed by a classification of the environmental variables, where each class is associated with a number scale (weights) to signify impact on development costs (in this study it ranges between 1 for the lowest to 5 for the highest impacts on development costs). The magnitude of impact of a particular class of an environmental variable is the distance intercepted along the corridor multiplied by the number scale of that class. The overall impact of each environmental variable is a summation of all the values of each class, while the overall impact of all environmental variables would be the summation of all the total values for each environmental variable.

Alignment 4 was chosen as the best alignment in terms of its lowest development costs based on the factor scoring technique. A detailed EIA would then be carried out on this alignment. This means that the omission of the other alignments through factor scoring has reduced problems associated with time, manpower and costs.

Malaysia realizes the potential and importance of carrying out detailed EIAs in light of her rapid development strategies toward achieving *Vision 2020* as propagated by the Prime Minister. Vision 2020 is the target for Malaysia to achieve a fully industrialized and developed status by the year 2020. The central issue here is that, whilst stressing the importance for economic development, the country must also stress the importance of a sustainable development strategy in view of the increasing environmental problems and decreasing environmental qualities.

The present study describes a preliminary or semi-detailed appraisal methodology prior to carrying out a full EIA. The point stressed here is to consider the best route from a number of *envisaged* routes or alignments with emphasis on their *postulated development costs*. The best route (or alignment) was chosen based on the lowest costs incurred to develop, operate and maintain the engineering structures, i.e., pylons and transmission cables, and also to purchase land whose *values* are determined by their aesthetic, ecological, socio-cultural and economic features. Without some idea of these development costs, the significance of the chosen corridor would be difficult to determine. Thus, establishing a set of screening criteria may be useful prior to conducting a detailed EIA. In certain countries, screening is a phased process in which checklists, matrices and networks are recommended for determining whether stringent investigations are required. Depending upon the outcome of such studies, a full EIA may be required. However, in the case at hand, the factor-scoring technique proves to be sufficient for a preliminary appraisal of environmental constraints on the selection of transmission corridors.

Although Alignment 4 was selected as the corridor incurring the lowest development costs, further refinements have to be made. The need for better spatial resolution (as captured by large scale base maps, for example at 1:5000) of the environmental constraints could improve the alignments of the corridors. Apart from mapping, the quantification of the physical and socio-economic factors also becomes an important constituent of a detailed EIA study.

CONCLUSION

Malaysia's development objectives are clear: to be fully industrialized by the year 2020. The supply of energy is seen as a crucial step towards achieving this goal. In order to fulfil Malaysia's energy requirements many power plants have been built or have been proposed to be built. These are mainly based on oil, gas, or hydro sources. Because of the increasing demand for electricity, larger transmission lines have to be built to add to the existing national grid. These lines would be in the form of 500 kV transmission cables linking the power plants to the major load centres in the country.

This study discusses a preliminary assessment method to study the effects of various environmental variables (constraints), considered important in influencing the alignment of the proposed transmission corridors. The method classifies each constraint into five classes, where for each class, a value is given as an indication of its effect on development costs.

This method is, however, not without limitations. Firstly, it only provides a linear account of the influence of a particular variable (i.e., along the alignment). This would not be representative of linear variables that cut across normal or perpendicular to the corridor, or for variables that are spatially variable. Secondly, the method provides only a general account of the effects of the environment on development costs. Further detailed measurement and quantification of the environmental variables and cost evaluations must be carried out for precise aligning of the final corridor. However, as a preliminary assessment tool, it does provide an objective way of looking at the multivariate effects of the environment on the selection of a transmission corridor.

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ꞵiomass-Fired Electricity as a Modern Option ꞏor Sustainable Rural Development in Yunnan ᵓrovince, China

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ꞁBSTRACT

Vith the implementation of China's open policy in the 1980s, Yunnan Province, along with much of the rest f China, began to develop rapidly. In doing so, its expanding economy created a steadily increasing demand ɔr commercial energy, especially electricity. Although Yunnan Province has a large potential for hydro, the ignificant seasonal variation in supply leads to a dilemma: the greater the dependence on hydropower, the ıore serious the dry season power shortage becomes. This problem is particularly acute in rural areas which ıften rely on highly seasonal, relatively small water courses where *flow* more than *head* determines capacity. 'et, in many parts of rural Yunnan, biomass-fired electric power systems, relying on sustainable plantation-tyle feedstock production, can economically balance out hydropower. This would give these local areas a eliable power supply in a manner that improves, rather than degrades, the environment.

This paper describes feasibility assessments carried out for a number of possible biomass-to-electricity BTE) sites in Yunnan. Although each of the projects assessed here involves an established commercial ılantation (for either sugar or rubber), the analysis and many of the findings are applicable to biomass eedstock systems of other types (e.g., those related to sustainable harvesting as part of afforestation pro-;rammes).

ƙeywords: *China, Yunnan, biomass, electricity production, environment, sustainable development*

NTRODUCTION

ɅS shown in Figure 1, Yunnan lies in the southwest ɔf China. Its population is about 39 million in an ırea of approximately 394 000 square kilometres km²). The terrain is quite varied, with elevations ·anging from a low of about 76 metres (m) above ;ea level to over 6700 m. Generally, the landscape ;lopes downward from the northwest toward the ;outheast with many basins and fault lakes located ımong the mountains. The southeastern and western monsoons, the great local relative relief, and the large overall elevation differences combine to form highly varied local climatic regions ranging within relatively short distances. These range from tropic-like to subtropical, or temperate to frigid. Precipitation is relatively high in much of the province, being over 1000 millimeters (mm) in most areas. These features lead to considerable biodiversity, particularly among plants, for which Yunnan has long been known for.

About 87% of the total population (nearly 34

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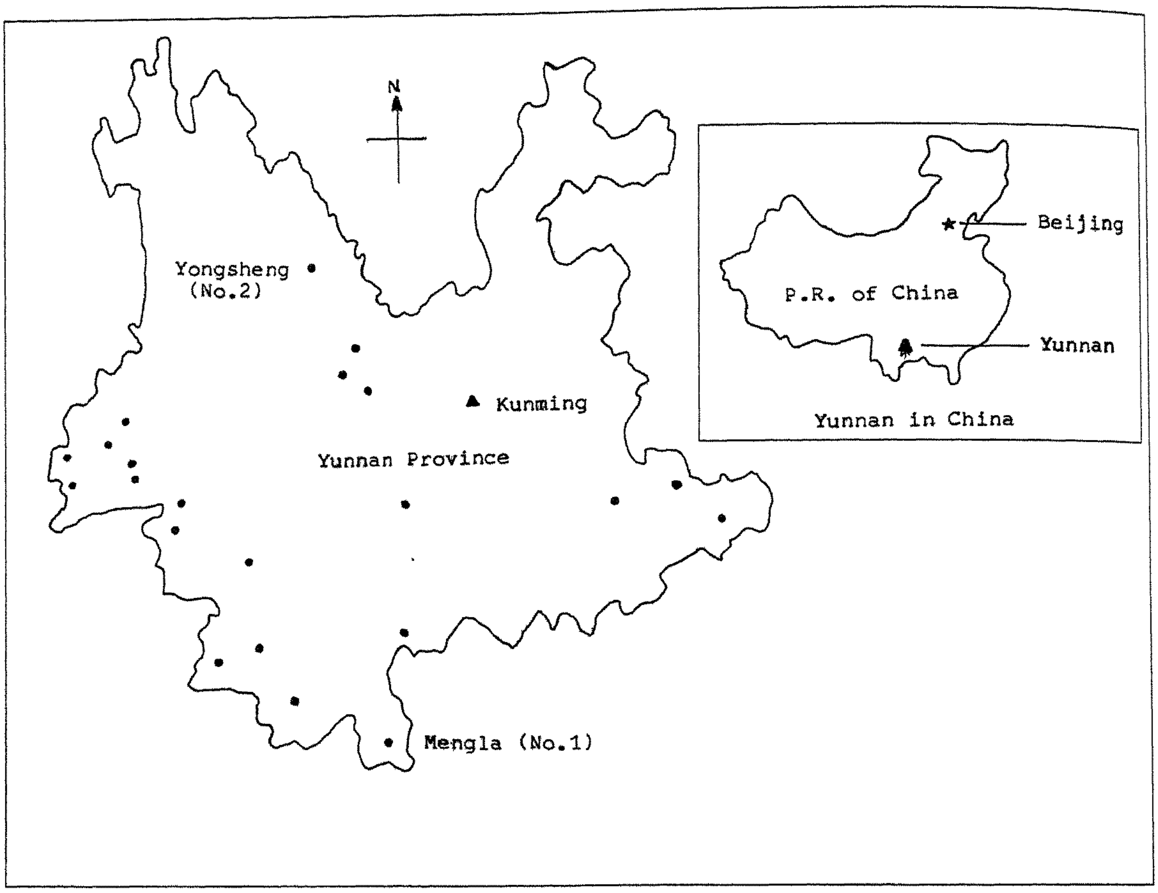

Fig. 1 BTE Projects in Yunnan Province.

million people) live in the rural areas and two-thirds of these are minority nationalities. While Yunnan has not yet reached the level of development of China's coastal provinces, in recent years the economy has grown at a rate above the national average (Yunnan Provincial Government [YPG], 1995).

The Energy Issues and Development Trends in Rural Yunnan

Energy consumption in rural Yunnan is 16.5 million tons of standard coal (TSC) energy equivalent[1] per year, accounting for nearly half of the total consumption of energy within the whole of Yunnan. The average per capita consumption of 0.5 TSC is lower than the national average of 0.7. More strikingly, the commercial energy consumed by each person is only 0.1 TSC/y, much lower than the national average of 0.3. The structure of energy consumption in rural Yunnan is revealing: fuelwood accounts for nearly 70%, coal for 12%, and grain stalks and animal wastes for 12%. Commercial forms of energy play a much smaller role: electricity 4% and fuel oil and methane 2% (Yunnan Provincial Planning Commission [YPPC], 1995). Hence, the vast majority of energy consumption is non-commercial and typically used with very low efficiency.

With rising living standards in the province's rural areas, not only is more energy needed, but there is a demand for higher quality energy, especially electricity. At present, the annual growth rate of electricity demand ranges from 20% to 30%, much higher than the overall energy growth rate of 5.4%. By the year 2000, rural Yunnan per capita energy consumption is projected to be about 0.6 TSC/y and the total energy consumption to be about 25 million TSC, with a commercial energy share of 40% (YPPC, 1995). Such growth would represent a 50% increase over the 1993 level. This trend is expected to continue for at least another decade. By the year 2010, the projection is a per capita level of 0.8 TSC/y, a total of 30.0 million TSC, with 70% of this being commercial energy. At the same time, the establishment of the market economy and the change of the operational mechanisms of town and village enterprises is expected to promote diversification of energy sources. Hence, the supply and consumption of energy will rely more on market forces, probably producing an even wider market for commercial energy, especially electricity.

Urban areas of Yunnan have seasonal power shortages, while most of rural Yunnan have extreme seasonal shortages and some level of shortfall year round. While Yunnan is rich in potential hydropower resources, this resource has only limited capacity for further development. Throughout most of the rural areas, especially those in the south and southwest of the province, there are no extensive (provincial) power grids and all the electricity comes from the local small or mini hydropower stations (i.e., several megawatts [MW] or less). Furthermore, the hydropower stations in Yunnan, including even the larger ones, tend to be run by river stations, hence leading to considerable seasonal variation. During the dry season — October to May — electricity production is typically only one-third of the installed capacity. Often, small and mini stations completely stop running. While the potential for considerable additional hydropower station development exists, such exploitation is becoming increasingly expensive and would provide power which is even more seasonal than existing ones.

Clearly, what is needed is further development of thermal power sources to supplement hydropower development. Yet coal or oil-fired thermal power generation in much of Yunnan is expensive because the fuel must be transported long distances through difficult terrain. In light of these problems, consideration came to be given to the possibility of biomass-fired power plants for appropriate sites in Yunnan. The BTE concept for Yunnan sets out a new blueprint for the effective development of clean, renewable energy resources.

This paper describes the types, locations and specific local conditions of selected potential biomass-to-electricity (BTE) projects in Yunnan. It also notes the implementation requirements and the necessary steps to make such projects a reality.

AN OVERVIEW OF BIOMASS TO ELECTRICITY RESOURCE POSSIBILITIES

Yunnan is a province with the most number of plant species in China and has one of the most diverse sets of plant species in the world. The greatly diversified climate, soil, topography, and the resulting rich mix of plant species lay a solid basis to the sustainable supply of feedstock for electricity production from such sources as bagasse, forest cutting residues, retired rubber trees and short rotation energy forests.

Bagasse

Sugarcane production and processing is one of the dominant industries of Yunnan. The total area devoted to sugarcane production is 151,000 hectares (ha), mostly in the south and southwestern part of the province. This provides an annual production of nearly 2 million tons of bagasse (Guo *et al.*, 1995). A small fraction of the bagasse is used to make paper and the rest to produce steam for electricity in sugar mills.

Forest Cutting Residues

Wood production in rural Yunnan is about 2 million cubic metres (m^3) per year (Statistical Bureau of Yunnan Province, 1994). Residues amount to roughly 40% of total tree production — about 1.3 million m^3 annually (i.e., about 1 million tons) (Guo *et al.*, 1995). Most of these residues are in large forest areas, distant from local residents and reached only by poor transport systems. Hence at present, they remain largely unused.

Rubber Trees

Yunnan is one of the three biggest rubber provinces in China. Rubber tree plantings began in Yunnan's south tropical areas in the 1950s and achieved a total plantation area of about 141 000 ha by the end of 1993. The economic life-span of rubber trees is 30 years and starting recently, the first trees planted have begun to be cut down to make way for new plantings. It is estimated that soon there will be about 4700 ha of rubber trees to be retired each year, with a total wood yield of about 564 000 tons (Guo *et al.*, 1995). While much of this retired rubber wood has use as lumber, a relatively large portion is in the form of branches, stems and cutting residues too small for uses other than burning. This wood is available for BTE.

Energy Forests

Stimulated by the national projects for the construction of *shelter forests* in the middle and upper reaches of the Yangtze River and provincial projects for afforestation, considerable money and effort have been put into the establishment of *shelter, fuelwood* and *lumber* tree plantings in Yunnan. By the year 2000, the province plans to add about another 3 million ha on suitable existing deforested lands (Guo *et al.*, 1995)[2]. In some cases such efforts might be undertaken in the form of short rotation energy forests.

METHODOLOGY FOR IDENTIFICATION OF PROSPECTIVE BIOMASS-TO-ELECTRICITY PROJECTS IN YUNNAN

A two-stage assessment process was used to identify and evaluate potential BTE projects in rural Yunnan. The first stage is a review of all potential sites and the use of a set of screening criteria to eliminate projects that are not technically viable. The second stage then involves ranking the remaining projects on the basis of various criteria.

Stage 1 is undertaken through a systematic review of available documents and other information, and the judgements of experts. The screening criteria are:

1. the availability of adequate land and appropriate climatic conditions,
2. the level of demand for additional power in the area,
3. whether the area is accessible (e.g., road quality),
4. whether there are lower cost power source alternatives available (e.g., hydro or coal) to meet local demands,
5. whether there is sufficient local management capability,
6. the level of interest in BTE projects on the part of local institutions, and
7. other factors.

The approach in Stage 1 is to screen out possibilities which are likely to be highly problematic. This is not to say that such projects are necessarily infeasible. Rather, the purpose is to allow the Stage 2 efforts to concentrate available analytic resources on those project possibilities which are most likely to be immediately attractive.

For projects which pass the Stage 1 screening, a multicriteria decision model is applied in Stage 2 to *rank order* candidate projects by means of a multi-attribute value theory (MAVT) decision model, which can be represented as follows:

$$V(X_j) = \sum_{i=1}^{n} w_i v_i (x_{ij})$$

where $V(X_j)$ is the overall additive value (OAV) function for the prospective BTE project j,
w_i is the weight assigned to criteria i,
v_i the single attribute value function for x_i,
x_{ij} is the measurement on attribute i for project j, and
n is the number of the criteria.

In performing the ranking, four criteria are used

1. the internal rate of return of the project;
2. biomass productivity;
3. the level of local unmet demand index; and
4. a qualitative assessment of local capability to organize and implement the project.

Appropriate scaling functions are developed, weights to the criteria are assigned, the OAV for each project is calculated, and then the order of the candidate projects is determined according to the OAVs. The higher the OAV, the higher the project is ranked. For the most part, the processes in Stage 2 are carried out using data collected during field visits to the potential sites and other in-depth data collection.

In the work carried out in 1995, 25 potential BTE projects were identified in 24 counties or cities in Yunnan as part of the Stage 1 work. These projects were then ranked in Stage 2 with the results for the highest ten projects shown in Table 1. The locations of the these ten sites are shown in Figure 1.

In Table 1, the ranking was attained by assigning a weight of '4' to the internal rate of return, a weight of '3' to the need for power, '2' to the local capability to organize and implement the project, and '1' to the biomass resource size. These weightings are preliminary and could be changed in future analyses to determine how robust the ranking is under different weightings.

Table 1
Some Data of the First 10 Highest Ranked Projects in Yunnan

No.	Project	Type	Capacity MW	Investment Million Yuan	IRR %	NPV Million Yuan	SPP Year	DPP Year	Cost Yuan/kwh
1	Mengla	Stand-alone	6.0	18.15	20.87	16.12	4.5	7.8	0.21
2	Y.S. Qina	Cogeneration	6.0	4.29	25.27	7.27	2.9	6.3	0.21
3	Luxi	Cogeneration	6.0	15.65	20.23	13.46	4.6	8.2	0.10
4	Baoshan	Cogeneration	6.0	10.50	19.03	8.89	4.3	8.8	0.14
5	Guangnan	Stand-alone	6.0	18.15	16.18	9.16	5.7	10.8	0.12
6	Yongde	Cogeneration	6.0	4.29	20.91	4.66	3.8	7.8	0.14
7	Tengchong	Cogeneration	6.0	15.65	17.55	10.01	5.2	9.8	0.11
8	Y.S. Maguohe	Stand-alone	3.0	8.02	10.95	0.70	6.9	21.6	0.24
9	Menghai	Cogeneration	3.0	5.79	17.67	3.68	5.3	9.7	0.16
10	Shuangjiang	Cogeneration	6.0	15.65	14.65	6.20	5.9	12.5	0.13

IRR: internal rate of return; NPV: net present value; SPP: simple payback period; DPP: dynamic payback period
Source: Guo et al., 1995

GENERAL COMMENTS ON THE POTENTIAL PROJECTS

While the 25 potential projects which have been identified so far in rural Yunnan would provide a total generation capacity of over 150 MW, most individual projects are in the range 6 MW. The projects evaluated may be divided into two types: stand-alone and co-generation (with a sugar mill). The 19 co-generation BTE projects identified, rely as much as possible on the existing facilities of the existing sugar mills. New equipment is then added to allow for increased power production, transmission and sale to outside users. In this way the capital investment is reduced and the overall economic benefit of the sugar mills may be increased due to year round operation. Most of the 6 stand-alone projects would need to buy new facilities and have new sites for the construction of the power stations, staff quarters, etc. Hence, the capital investment for the stand-alone projects will be higher than those for co-generation projects. The major advantage of the stand-alone projects is the potential for use of more advanced technologies, resulting in higher efficiency and return on the investment after operation has begun.

The greatest potential for sustainable supply of BTE feedstock lies in several types of sources: bagasse (e.g., in Qina, Baoshan), forest cutting residues and lumber mill wastes (e.g., at the Luxi and Tengchong projects), retired rubber trees (in Mengla and Menghai), artificial energy forests (in Yongsheng and Guangnan) and other agricultural residues. In addition, the tropical and subtropical counties including Mengla, Menghai, Luxi, etc. have a species — *Mesua ferrea* — which appears to have considerable potential for BTE because it grows very fast, has a strong ability to resist insect diseases, and may be harvested after only three or four years (Guo *et al.*, 1995).

A LOOK AT SELECTED POTENTIAL PROJECTS

Context

Each of the 24 counties in which the 25 potential BTE projects are located lacks large interconnected power grids. Small and mini hydropower stations are the major energy sources for the local power grids which serve the major population centres in these counties. Power shortage problems are very serious, especially during the dry season, which lasts for more than half the year. In some cases, the most appropriate solution lies in interconnecting these local grids with larger grids (e.g., Baoshan City will be connected with the provincial grids around 2010). In other cases there are particular local resources which might be more attractive than BTE (e.g., Tengchong county is rich in hot springs, which may be developed as an inexpensive energy source in the future). Such plans and prospects need, of course, to be taken into account when considering whether a particular BTE project is worth undertaking.

On the other hand, in some cases there may be potential for external sales which should not be overlooked in evaluating a project's attractiveness. For example, most of the identified potential BTE projects are located in the south and southwest rural counties of Yunnan which neighbor Vietnam, Laos or Burma. The border areas in these neighboring countries also tend to face significant power shortages. Surplus electricity from BTE might possibly be sold to the people in these neighboring countries if commercially viable sales possibilities exist (e.g., sales to a power-short industry across the border).

Mengla Project (No. 1)

This project, involving the use of retired rubber tree residues from a new sawmill, ranked highest. The sawmill is already planned and will use large numbers of retired rubber trees. The BTE project involves building a thermal power plant next to the saw mill to feed power to the adjacent local electricity grid.

Mengla county lies in the south of Yunnan, 886 km from Kunming and 192 km from its prefecture capital of Jinghong. Although distances are long, the roads are generally good. Mengla county has a total area of 6857 km^2 and a population of 177 000. Elevation varies from 480 to 2023 m, and more than 90% of the land is relatively mountainous. Mengla has three kinds of climates — north tropical, south subtropical and middle subtropical — depending on the elevation. The annual mean temperature is 21.5°C, rainfall 1290 to 2240 mm, and 1856 hours of sunshine. Forest cover is about 49%. Fuelwood costs about 60 yuan/dry ton (dt) (Guo *et al.*, 1995).

The main energy sources in Mengla are fuelwood and small hydro with a total installed capacity of 5.7 MW. Annual electricity production is 11.73 million kilowatt-hours (KWH) and there is an estimated power shortage of 40 MW (Electric Power Bureau of Yunnan Province[EPBP], 1993a,b).

Mengla county has four large rubber plantations with a total area of 36 700 ha and as of 1996, the annual average area of retired rubber trees will be about 1200 ha. The rubber plantations themselves and local residents are the major customers of the electric power. At present, to make up for the hydro's seasonal shortfalls, electricity consumers must rely on diesel generators as a supplementary power source — at a cost of about 1.5 yuan/KWH ($0.18 US). Diesel power is very expensive because the fuel must be transported by road over very long distances.

The Mengla BTE project has been planned to be developed in the Mengpeng rubber plantation as a stand-alone 6 MW project. Estimated production cost is only 0.21 yuan/KWH in contrast to the diesel cost of 1.5 yuan/KWH (Guo *et al.*, 1995).

Mengpeng plantation has a total staff of more than 8900 and a planned rubber tree area of 12 000 ha by the year 2000. Each year there will be 400 ha of aged rubber trees retired and 48 000 dt of wood produced, of which approximately 12 000 dt is to be used by the new lumber mill to make wood products, leaving the remaining 36 000 dt potentially available to produce electricity. The local power transmission system, including power lines and distribution network, already exists. If electricity production capacity exceeds local demand, the surplus might be sold to the power-short industries across the nearby border with Laos.

Yongsheng Projects (No. 2 and No. 8)

Yongsheng county is located in the northwest of Yunnan, 516 km from Kunming and 100 km from its prefecture capital of Lijiang. It has a total population of 363 000 and area of 4998 km^2 of which about 77% is relatively mountainous. The elevation ranges from 1056 to 3964 m. The climate is characterized as low latitude mountainous monsoon with an annual average temperature of 13.5°C, rainfall of 924 mm, and sunshine of 2404 hours per year. The forest coverage is about 27%. Forest cutting residues amount to about 28 000 dt/y. The afforestation cost is 2700 yuan/ha with an average productivity of about 8 dt/ha/y. The firewood price is 120 yuan/dt (Guo *et al.*, 1995).

The locally consumed energy comes mainly from fuelwood and electricity. This electric power comes from small hydro stations with a total capacity of 15 MW and an annual production of 35.7 million KWH. The annual power shortage of Yongsheng is estimated to be about 8.5 million KWH. Power demand has been increasing at more than 14% annually, leading to serious shortages (EPBYP, 1993 a,b). To help ration the shortage and to reflect the high cost of thermal generation, the power price can be as high as 1.20 yuan/KWH during the dry season. Major electricity customers include a copper electrolysis factory, a zinc oxide factory, a silk factory, a cement plant and those engaging in agricultural activities, as well as local residents.

Yongsheng county has two identified BTE projects: one is a 6 MW co-generation project with the Qina sugar mill, while the other is a 3 MW stand-alone project for the idle Maguohe power plant. The Qina sugar mill was set up in 1988 with a capacity of 500 tons of sugarcane/day and milling season of 110 days/year. The Qina BTE project would use and modify the sugar mill's existing staff and facilities (including houses, power transmission lines, generators, boiler, water supply equipment, etc.) to produce sugar and electricity during both the milling and non-milling seasons. The feedstock will be bagasse and the planned energy forests.

The Maguohe power station was built in 1964 and is idled because of the shortage of coal and the low efficiency of its dated facilities. The Maguohe BTE project would improve the existing facilities and use the forest cutting residues nearby and the planned artificial energy forests, in place of coal, to produce electricity.

Yongsheng county has been involved in projects to establish a shelter forest in the middle and upper reaches of the Yangtze River. It has also been an important area for rural electrification efforts. Yongsheng has been planting about 1500 ha of energy forests (mostly eucalyptus and acacia) each year since 1991. The final total area of the energy forests is planned to be 13 220 ha (Forest Survey and Planning Institute of Yunnan Province, 1992). Mature forests will be cut on a regular rotation basis and much of this wood would be available for BTE projects.

Luxi Project (No.3)

Luxi county is in the west of Yunnan, 788 km from Kunming. Its county town, Mangshi city, is also the capital of its prefecture. It has a total population of 304 000 and an area of 2892 km^2, 85% of which is mountainous. The elevation ranges from 528 to 2889 m. The climate is a south subtropical monsoon one with an annual mean temperature of 19.5°C, rainfall of 1653 mm and annual sunshine of 2452 hours. Forest cover is about 47%. The area of land suitable for reforestation is estimated to be about 47 km^2, from which annual cutting residues would be about 37 700 dt. The afforestation cost is 2250 yuan/ha with wood productivity of 35 dt/ha/y. The local fuelwood price is 50 yuan/dt (Guo *et al.*, 1995).

Fuelwood and small hydro facilities are the major energy sources of the county. The total installed capacity of the hydros in 1994 was 35.7 MW, with an annual power production of nearly 200 million KWH. The annual power deficit is estimated to be about 40 million KWH. Peak power demand is projected to be 66 MW by the year 2000, necessitating another 31 MW in new generation capacity (EPBYO 1993, a,b).

The 6 MW Luxi BTE project is planned to be united by co-generation with the Mangshi sugar mill, like the Qina sugar mill of Yongsheng (No.2). Besides the bagasse from sugar processing, the feedstock will mainly be the forest cutting area residues nearby. Since fuelwood is of a low price in the area, it might also be bought under contract as required.

Luxi is very rich in forest resources, hence the BTE concept here has considerable potential for the future, due to the county's large sustainable supply of feedstock and the large electric power demand caused by the fast development of the local economy in recent years.

NEXT STEPS

Research on the development of BTE projects in Yunnan began in 1989. With the identification and order ranking of 25 potential projects (completed under a joint program of the Yunnan Institute of Environmental Science (YIES) of China, with the techncial and financial support provided through the Joint Institute for Energy and Environment (JIEE) of the USA), the feasibility study is now finished. The next stage will focus on the implementation of the identified projects, in a step-by-step approach.

First, a management organization — such as a Renewable Energy Development Corporation organized at the provincial level — should be created to provide an effective implementation vehicle for the projects. This organization would be in charge of carrying out more detailed analyses of the potential BTE projects. It would also prepare master implementation plans and coordinate relations among the domestic departments at different levels, foreign organizations and both private sector investors and agencies for international cooperation. Such activities would include efforts to solve technical difficulties and financial issues, training of local technicians for the future administration and operation of the projects, as well as directing and managing the systematic implementation of the these projects at the provincial level. It is probably fair to say that at least for the near and mid term, the future of the BTE projects in Yunnan will depend in a major way on the capability and efficiency of this organization.

Another important step to be undertaken to promote BTE in Yunnan is that domestic and international information channels be more widely opened to better explain the feasibility and economic and environmental benefits of the BTE projects. In this way, the preparation processes, including fund raising and acquiring project approvals at different levels of implementation, may be accelerated.

It is also important for the overall start-up of the BTE in Yunnan that one or a few projects be undertaken soon to 'demonstrate' the concept in a practical, commercially viable manner. These commercial demonstration projects will play an important role in verifying — through actual operational experience — the feasibility of BTE in terms of the technology, the economic and financial benefit/cost streams, and the environmental impacts. It is likely that successful commercial demonstration projects will give more confidence to the decision makers and managers for quicker implementation of other projects.

According to the results of the order ranking, the BTE projects at the Mengpeng rubber plantation and the Qina sugar mill have been selected to demonstrate the concept. Efforts are now underway to find funds from domestic and international sources for the implementation of these two projects.

CONCLUSION

The sustainable development of the economy, society and culture relies on the effective exploitation of reliable energy resources. In Yunnan, the hydropower distribution is very uneven in space and over time. Local coal resources are very limited in quantity and mostly confined to the east and northeast of Yunnan. Coal brought over longer distances is often prohibitively expensive even when it is available. In addition, more use of coal would bring to Yunnan some of the serious air pollution problems from which the province has so far suffered far less than much of the rest of China.

These characteristics determine that there should be other types of electric power resources developed. Ideally, these should be widely distributed geographically and not limited by season. Yunnan has a rich range of climates, plant species, favourable lands and existing feedstocks which provide a solid base for the sustainable production of biomass. The BTE projects in Yunnan attempt to exploit this potential by producing electricity relying on advanced technologies and facilities, and promoting a sustainable development of the economy and environment.

To summarize, the roles of the BTE projects in Yunnan are to:

1. provide a sustainable, clean and renewable energy resource to overcome the power shortages;
2. promote the development of local industries, agriculture and village enterprises;
3. create and enlarge employment opportunities for local people;
4. up-grade the low technological utilization methods for biomass (e.g., for the burning of fuelwood) and improve the utilization of biomass energy on the whole in rural Yunnan;
5. increase the tax income of the local communities for further advancement;
6. plant energy crops, and reduce and prevent soil erosion through planned afforestation in suitable barren areas;
7. fix the carbon dioxide in a form of standing biomass and reduce the net emission of greenhouse gases to the atmosphere; and
8. promote the introduction and dissemination of more advanced technologies, administration systems and economic information into rural areas of Yunnan, and speed up the process of allowing Yunnan to move more quickly towards world recognition.

In addition, as the pioneer in the development of clean and renewable energy from biomass raising to electric power production, the successful implementation and operation of the BTE projects in Yunnan will hopefully become a model for the development of renewable energy in other provinces of China and other countries of the world, which are facing similar problems.

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NOTES

1 1 TSC = 29.3 gigajoules.

2 Yunnan is an area in which the terrain is mountainous and forest cover relatively low (about 24%) and these forests are very unevenly distributed. As part of its effort to fight serious soil erosion, siltation of rivers and reservoirs, and other associated environmental problems due to inadequate soil cover, government at various levels in Yunnan, is working to further the planting of trees and afforestation over relatively large areas.

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The Strategic Multicriteria Decision-Making Model for Managing the Quality of the Environment in Metropolitan Taipei

Gwo-Hshiung Tzeng, June-Jye Chen and Yung-Kun Yen

ABSTRACT

Taipei's rapid economic growth in recent years has increased the standard of living through income growth, but the process of development has caused a series of social and environmental problems. This paper uses the multiattribute evaluation and the analytic hierarchy process to evaluate urban environmental quality. The evaluation objectives focus on the performance of public infrastructure. The survey dealt with the preferences of metropolitan Taipei inhabitants about environmental quality and the factors influencing their evaluation. The survey showed that there are two primary issues related to governmental infrastructure planning: allocation and equality.

In this research, the authors first structured the utility functions, and then used multiobjective programming to solve the trade-off objectives so as to maximize the utilities and the equality objectives. Such an approach may be used to help attain a reasonable allocation of resources in different districts.

Keywords: *environmental quality, infrastructure planning, multiattribute evaluation, multiattribute utility theory, analytic hierarchy process (AHP), resource allocation, multiobjective programming*

INTRODUCTION

Rapid economic growth, such as that which has occurred in Taipei in recent years, has increased the monetary standard of living while lowering environmental quality. This process of development has caused a series of social and environmental problems. Therefore, it is important to consider how to make a more reasonable provision of environmental quality, particularly that which may be provided through environmental infrastructure.

Much literature on environmental quality has been produced, including some definitions of environmental quality (Dalkey and Rourke, 1973; Mitchell *et al.*, 1973; George, 1975; Lester and Seskin, 1981; George and Bearon, 1980; OECD, 1970) and some research on items of environmental quality (Lee *et al.*, 1992; Maeda and Murakami, 1985). However, less research has been done on how reasonable resource-allocation can improve environmental quality (Tzeng *et al.*, 1991). In this study, the basic approach is to use a survey model con-

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ducted through home interviews. Next, utility theory is applied to find out attitudes towards the improvement of environmental quality and level of needs. This includes physical indices of current and future environmental quality, and civic and goal indices. Following this, multiattribute utility theory and analytic hierarchy process (AHP) is applied to establish the district-level utility function. Finally, the dynamic notion of metropolitan space development, using multiple objective programming and limited financial resources, is employed to assess the optimal allocation of resources for maximum improvement in the quality of the environment.

This paper will begin with an introduction which will elaborate on the motive, scope, and content of the study. Next, the multiattribute utility theory, multiple objective programming theory, and methods of weight solving are explained to show the type of information needed for the study. In the third section, a multicriteria decision-making model for metropolitan environmental quality is proposed. In the fourth section, there will be the case study of the results for the Taipei metropolitan area.

METHODLOGY

Multiobjective Programming Theory and Application

Multiobjective programming, like other operations research methods, is a tool developed particularly for decision making. When the decision maker faces more than one objective while also needing to satisfy various constraints, multiobjective programming may be quite useful. Multiobjective programming does not seek the optimal solution. Rather it seeks to obtain the best compromise solution from the non-inferior solutions, (i.e., where no one objective function can be improved without a simultaneous detriment to at least one of the other objectives). These non-inferior solution sets can be cited as references for decision making. However, it is necessary to take into account the preference of a decision maker so as to locate the best compromise solution considering the tradeoffs among the objectives (Hwang and Masud, 1979).

The application scope of multiobjective programming is rather broad and the common characteristic of these problems is in the allocation of limited resources (Benjamin, 1985; Baker, 1976; Daniels, 1990; Holthausen and Assmus, 1982; Pang and Yu, 1989; Zilla, 1984). Since multiple objectives are suitable in handling resource allocation problems, the present study utilizes the concept of objective formulation to consider the administration of several objectives of the planning study. The authors use the ε-constraint method to solve the multiobjective programming (see Annex 1).

Method of Weight Determination

During the administration of multicriteria decision-making problems, it is necessary to have the relative importance of every related attribute. Eckenrode (1965) suggested using six methods: the eigenvector method, the weighted least square method, the entropy method, the linear programming techniques for multidimensional analysis of preference (LINMAP method), the extreme weight approach, and the random weight approach to collect the relative importance of judgmental attributes. The basic calculation theory of analytic hierarchy process (AHP) used in this study is an extension of the eigenvector method (see Annex 2).

IMPROVEMENT STRATEGY OF A MULTICRITERIA DECISION-MAKING MODEL FOR ENVIRONMENTAL QUALITY IN METROPOLITAN AREAS

This study assessed the optimal resource allocation to a metropolitan area to improve environmental quality. The constructed improvement strategy of a multicriteria decision making model for environmental quality in a metropolitan area is described as follows:

Step 1: To construct an evaluation hierarchy system for an acceptable environmental quality

For the establishment of an evaluation hierarchy, it is necessary first to identify the characteristics of problems and the problems to be solved. These problems are then transformed into indices, and finally the suitable hierarchical system is expanded in the hope that such a system can attain the goal of comprehensive evaluation. During this evaluation, the hierarchy can be constructed with the use of systematic analysis, empirical analysis and other methods.

During the formulation of criterion, several principles related to clarity, consistency, completeness, timeliness, operational, and non-redundancy have to be fulfilled.

Step 2: Investigation of an acceptable environmental quality

For the evaluation of an acceptable environmental quality, it has been decided that upon establishment of utility functions, the degree of the inhabitant satisfaction will have to agree with each of the evaluation attributes. Then this study will design a questionnaire and a face-to-face interview based on the devised structure of the evaluation hierarchy system on an acceptable environmental quality, so as to obtain the evaluation of inhabitants towards environmental quality. The primary contents of the questionnaires are about the cognition of the relative importance of inhabitants towards the attribute of environmental quality, the evaluation of the current environmental quality, and basic information on inhabitants. Aside from the relative importance that is conducted by pairwise comparison, the attributes of the evaluation hierarchy and the comparison of goal hierarchy will have to be correlated individually.

Step 3: The location of attribute weights and consistency tests

The cognition information of relative importance shared by inhabitants towards the attributes of environmental quality obtained by the questionnaire, can be computed to establish the weights of each attribute with the help of computer software and AHP. A consistency test is then conducted to identify the consistency of inhabitant cognition. At the end, the geometric average is utilized to integrate regional group opinions.

Step 4: Establishing a utility function, an aspiration-level and civic-minimal indices

The index devised in accordance with the evaluation of inhabitant consciousness is of a subjective nature, and is a direct judgement on the willingness of inhabitants living in that district, which corresponds to the service-level index standard of each attribute. Therefore, the subjective information can be used to fabricate utility functions for each attribute, to analyse the aspiration-level and civic-minimal indices of each attribute for the references of programming. As a matter of fact, the service-level index is a judgement on government policy implementation; if investment is improved, the environmental quality can be elevated.

Step 5: To establish an integral utility function

Based on the utility function of each attribute as well as its weight, the additive mode of integral utility function can be formed as shown in equation (1) and can be used to measure the total utility of each attribute brought to the inhabitants.

$$U(X_j) = \sum_{i \in I} W_i U_i (X_i),$$

$$\sum_{i \in I} W_i = 1, 0 \le W_i \le 1, 0 \le U_i (X_i) \le 1 \qquad (1)$$

where U(X): the integral utility function;
W_i: the weight of attribute i;
U_i (X): the utility function of attribute i;
X_i: the index value of attribute i.

Step 6: Unit cost analysis of the facility improvement and resource prediction

To conduct the investment analysis, it is necessary that the unit cost of the improvement facility be analysed and resources be predicted. The invested cost of a regular plan needs to take the initial and future cost into account. The former includes planning costs of the starting operation, technological costs of the primary construction, design costs of construction, material facilities, equipment costs, and human resource costs; the latter embraces factors such as operation costs, maintenance costs and residual value, interest rates or depreciation rates during the consideration of estimation, and inflation. Future resources can be left to future economics and budget growths of past administrations for any predictions. Generally in government, long-term plans include the investment plan and financial forecast from which data concerning unit cost and resource forecast can be obtained from this analysis.

Step 7: To establish a multiobjective programming model

When the government is working on infrastructure planning, it should try to allocate construction resources to each district; however, due to different district characteristics and needs, the results are not always equal. Thus, although the government would like these to be more evenly handled, it is often very difficult. The government's budget is always limited and investment cannot exceed the budget. The investment must also be based upon public opinion. The decision on trade-offs is not easy. In planning for improving the environmental quality in a metropolitan area, the multiobjective programming model of this study will be applied to problems of this nature. The model to be constructed will employ the approach of inhabitant-oriented needs. Such a model considers not only the total utility of metropolitan inhabitants, but also takes the principle of fairness into consideration so that the needs of inhabitants can be used as criteria for formulating a plan.

The multiobjective programming model for improving environmental quality in a metropolitan area, constructed in this study, is as follows:

Objective 1: maximal satisfaction for living environmental quality

$$\max Z_1 = \sum_{i \in I} W_i \left(\sum_{j \in J} P_j^* U_{ij}(X_{ij})\right) \qquad (2)$$

Objective 2: equality (fairness)

$$\min Z_2 = \sum_{i \in I} W_i \left(\sum_{j,k \in J} ((X_{ij} - X_{ik})/X_i^*)^2 \right. \qquad (3)$$

$$\text{s.t.} \quad \sum_{i \in I} \sum_{i \in j} C_{ij} (X_{ij} - X'_{ij}) \le B \qquad (4)$$

$$\begin{cases} X_{ij} \ge XC_i, & \text{if } X'_{ij} \le XC_i \\ X_{ij} \ge X'_{ij}, & \text{otherwise} \end{cases} \qquad (5)$$

$$\begin{cases} X_{ij} \le XI_i, & \text{if } X'_{ij} \le XI_i \\ X_{ij} \le X'_{ij}, & \text{otherwise} \end{cases} \qquad (6)$$

where i: indices of attribute; j, k: indices of district; I: set of attributes; J: set of districts; X_{ij}: decision variable (plan indices) under the matrix $[X_{ij}]$ of attribute i for district j; $U_{ij}(X_{ij})$: the utility value of attribute i in a planned year for district j; X_{ij}: the index value of attribute i in a planned year for district j; X'_{ij}: the physical index value of attribute i in the basic year for district j; P_j:; the population in the planned year for district j; C_{ij}: the product of the unit cost (facility improvement of attribute i for district j) and the total demand volume q_j in district j; B: the budget of the planned year; XC_i: the civic-minimal index for attribute i; XI_i: the aspiration level for attribute i; X_i*: max X_{ij}; W_i: weight of attribute i.

In the model described above, Objective 1 is to find the maximal total utility of all inhabitants in the metropolitan area under the maximal efficiency of resource utilization. Objective 2 is to find the minimal deviation between plan index and aspiration level after improvements in various metropolitan districts. This distributes the resource that can be used fairly in various districts. Furthermore, it develops the various districts that can be developed with balance. For avoiding the offset of positive and negative effects, the objective function of this Objective 2 is the quadratic equation. Equation (4) denotes the constraints when the investment improvement is less than the budget. Equation (5) denotes the constraints in the plan index value after improvement is more than the civic-minimal value or the physical index value. It forms the plan index that can satisfy minimal requirements of inhabitants without the deterioration. Equation (6) denotes the constraints to the plan index value after improvement is less than aspriation index value or physical index value. From equation (5) and equation (6), we know when the physical index is more than the aspiration index, the plan index value after improvement, can maintain the existing physical index value.

A CASE STUDY IN THE TAIPEI METROPOLITAN AREA

After having considered the case study with reference to expert opinions, integrated analysis, and relevant past literature, we have obtained the objective hierarchy of the environmental quality of the Taipei metropolitan area, as shown in Figure 1. In Table 1, those items of corresponding physical indices to each of the selected attributes are also shown. Here, the enhancement of the environmental quality is designated as the highest goal, and under it are five objectives: physical environment of each district, public environment of the community, transportation environment, cultural and education environment, and social environment; with 14 indi-

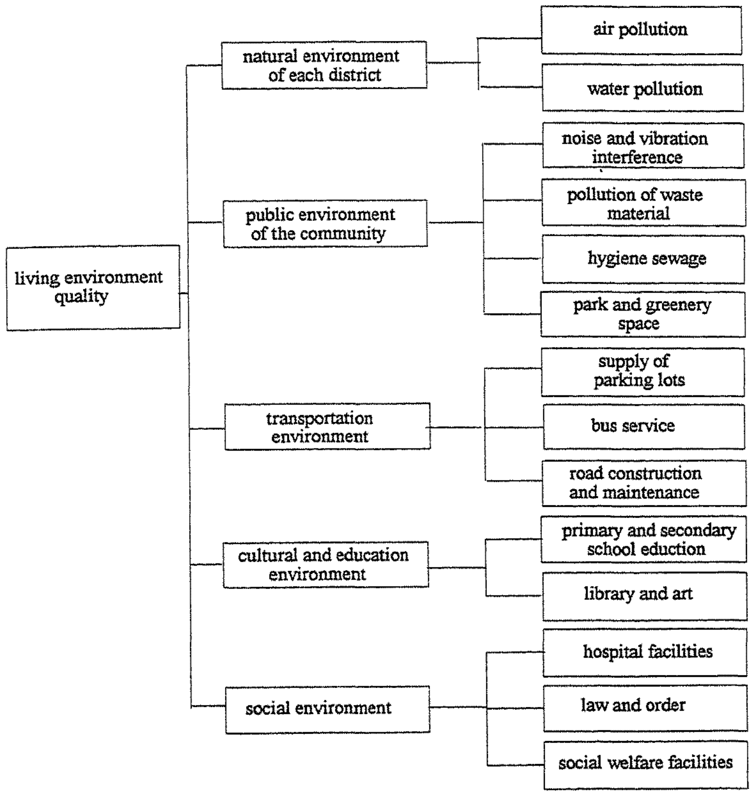

Fig. 1 Evaluation hierarchy system for living environmental quality.

Table 1

Weights of Environmental Attributes and Evaluation Results

Items	*Weights of aspects and attributes*	*Current Satisfaction attributes*
Hierarchy 2 (aspects)		
C1: natural environment of the area	0.196	-
C2: public environment of community	0.200	-
C3: transportation environment	0.192	-
C4: cultural and education environment	0.183	-
C5: social environment	0.229	-
Hierarchy 3 (attributes)		
D1: air pollution	0.113	0.35
D2: water pollution	0.083	0.39
D3: noise and vibration interference	0.058	0.35
D4: pollution of waste material	0.054	0.37
D5: hygiene-sewage	0.044	0.38
D6: park and greenery space	0.044	0.45
D7: supply of parking lots	0.070	0.38
D8: bus service	0.052	0.43
D9: road construction and maintenance	0.070	0.40
D10: primary and secondary school education	0.101	0.52
D11: library and art	0.082	0.41
D12: hospital facilities	0.063	0.44
D13: law and order	0.089	0.47
D14: social welfare facilities	0.077	0.38

ces including air pollution, water quality, interference of noise vibration, and so forth.

In this study, a questionnaire was constructed in accordance with the above-mentioned structure, with the content of investigation including the cognition of relative importance shared by metropolitan inhabitants towards the attributes of an acceptable environmental quality, the evaluation towards current environmental quality, and basic information of the interviewee. The relative importance towards the attributes of environmental quality is conducted by pairwise comparisons using AHP. To facilitate responses from the interviewee, the gauges of nominal scale were simplified to five-points instead of nine-points, and conducted in the Chinese language, for the evaluation of the current environmental quality. An evaluation by inhabitants with the 14 items of indices derived from the attribute hierarchy, was conducted. Here, the degree of satisfaction employs the 11-tiered level extending from extremely dissatisfactory to extremely satisfactory (from 0 to 1 points) for their selection of inhabitants . The selection by inhabitants will reflect the cognition difference of districts.

The interviewees here are inhabitants who have lived in the Taipei metropolitan area for at least five years, excluding inhabitants living in other areas or the mobile working population in Taipei. Selection is done by properly stratified sampling. A total of 1300 samples went taken in the beginning, while each administrative district is restricted to have no less than 20 samples. However, when districts with an insufficient number of samples were complemented, the number of actual samples reached 1520 at the end. The data of the surveyed samples were processed with a χ^2 test on sexuality and show no significant difference to the embryonic data (under a 5% significant level), indicating the reliability of the investigation. For the relative importances of environmental quality, the retrieved samples must be first conducted with the test of a consistency index and consistency ratio before they are deemed valid, after which weights to each of the attributes are calculated.

The analysed results of relative importance to the attributes of living environmental quality are shown in the second column of Table 1. It can be seen that social environment is most highly regarded in the goal hierarchy, while a cultural and educational environment is considered least important by the public. The weights of the physical environment of a district, the public environment of the community, and the transportation environment, are rather close, showing that they have received tantamount importance. In attribute hierarchy, attributes such as hygiene-sewage and park and green space receive the least attention, while air pollution, primary and secondary school education receive the most.

The results derived from the satisfaction analysis towards each individual attribute are indicated in the third column of Table 1 and the information listed is the average value of the metropolitan area It is found that people have a higher degree of satisfaction towards primary and secondary education, law and order, and park and greenery space, while having lower satisfaction for air pollution, interference of vibration and noise, and pollution of waste materials. Overall, the satisfaction levels for all of the attributes do not exceed 0.6 points (the lower bound of satisfaction), which denotes that the public is not satisfied with the current environmental conditions. Furthermore, different levels of importance are endowed to different attributes by the public in various administration districts (such information is too complex and is therefore not printed here). As a rule, areas with a higher degree of urbanization and higher population density give more attention to the physical and social environment, while areas with a lower degree of urbanization and lower population density place more importance on the environment of the community, transportation, and cultural and education conditions. Such phenomena indicate that the public is more concerned for those aspects of environmental attributes that suit their basic needs. Primary and secondary school education is an exception.

With the multiattribute utility theory, the additive type of utility function can be employed to integrate the evaluation of the living environment in each district with the variations of living environmental quality in each district, as shown in Table 2. Of the five levels indicated in Table 2, Pinlin village enjoys the highest integrated evaluation, while Nankan, Shulin, Shichu, Tuchan, Luchou show the poorest quality. The reason Pinlin village can obtain the highest integrated evaluation is that its four environmental attributes of its proximal natural environment have all achieved the highest level of satisfaction, while the five districts with the lowest integrated evaluation have been given the lowest satisfaction by inhabitants towards environmental attributes, with the degree of satisfaction being mostly below 0.3 points. It is due to the rapid devel-

Table 2
Integrated Evaluation Results of Living Environmental Quality of Each District

Integrated evaluation	*Districts*
0.201–0.300	Nankan, Shulin, Shichu, Tuchan, Luchou
0.301–0.400	Hsinyi, Ta-an, Wanhwa, Chungshan, Nahu, Panchia, Sanchung, Hsinchuen, Hsintien, Yinko, Wuku, Taishan, Shenkan, Shimen, Pali
0.401–0.500	Chungchang, Tatung, Wenshan, Shihlin, Peitou, Chungho, Yunho, Sanchia, Tamsui, Linkou, Shedin, Wulai
0.501–0.600	Tsungshan, Sanchi
0.601–0.700	Pinlin

opment of these five districts that the levels of environmental quality have deteriorated.

The utility functions constructed from the physical service-level indices and the probed information of satisfaction are shown in Table 3. Since information on hygiene sewage, bus service, and social welfare facilities of each district was hard to obtain, such imformation was not included in this utility function. Based on the average satisfaction values collected from the investigation, one can see that the value of the environmental attributes was designated between 0.35–0.52 points. This study has defined the civic-minimal index as the corresponding physical index level at the utility value 0.4 points in the utility function (the lower bound of common satisfaction) so that the improvement of the living environmental quality can be maintained at a certain level, and that the inhabitants of each district will not be dissatisfied in the future. For the possible realization of a goal index, the index is defined as the corresponding physical index level at the utility value 0.6 points in the utility function, so that the inhabitants of each district will be satisfied towards their future living environmental quality. And the civic-minimal and aspiration indices of each attribute are as shown in Table 4. The utility value of this Table 4 is obtained by reverse solving X_{ij} and setting 0.4 and 0.6 as the utility value of the civic-minimum and satisfactory level respectively from Table 3.

Based on the multiobjective model as constructed here, this study has conducted programmed allocation of resources with respect to the given constraints of total resources. Such a method is devised under the utility for inhabitants and deviates from the traditional allocation method of resources. Furthermore, the need for an inhabitant-oriented approach has been adopted as well as the principle of fairness, so that the results can be applied to the formulation of short-span plans.

This model has employed the ε-constraint method, to transform two objectives into one single objective, then uses GAMS package software for obtaining the solution. The unit costs for facility improvement in the model are based on the costs of similar past improvement facilities after their completion. Then the cost is estimated after the experiential judgement of experts and scholars. Resource prediction is estimated by means of a simple regression based on past years.

The preference solution resolved from the equal marginal substitution ratio of the two objectives shows that districts of worse environmental attributes should receive more resource contribution, while areas of better environmental attributes receive less resource allocation. Consequently, the difference of attributes in each of the districts can be clearly narrowed. Take individual index for instance, those values of air pollution, noise vibration, road construction and maintenance, primary and secondary school education, library, and hospital facilities are observed at the civic-minimal level. Comparing Taipei City and County, it is found that Taipei City should have more resources allocated in regard to air pollution, noise vibration, and the supply of parking lots, while Taipei County should receive more resource allocation in the other eight environmental attributes. In addition, Taipei County should receive 55% of the resources — the current manner of resource allocation should be drastically changed as the budget of Taipei City is now several folds that of Taipei County.

Table 3
The Utility Function of Inhabitants of Taipei Metropolitan Area Towards Each Attribute

Attributes	*Coefficient (t value)*	R_2
air pollution	a=1.00001(12.95), b=-0.00676-(-8.29)	0.76
water pollution	a=-0.37483(-6.67), b=0.12963(14.05)	0.90
noise and vibration interference	a=2.60608(7.42), b=-0.03074-(-6.39)	0.65
pollution of waste materials	a=0.1482(1.78), b=236.62063(2.87)	0.27
park and greenery space	a=0.13228(1.33), b=0.04915(4.41)	0.82
supply of parking lots	a=0.19987(3.43), b=3.67213(4.68)	0.50
road construction and maintenance	a=0.37032(12.40), b=0.006(1.94)	0.26
primary and secondary school education	a=0.03694(0.37), b=0.001553(4.68)	0.88
library and art	a=0.33044(13.78), b=9.22763(2.81)	0.26
hospital facilities	a=0.31766(4.58), b=199.0109(1.45)	0.20
law and order	a=1.01073(20.37), b=-0.00833(-10.71)	0.84

*utility function type: U(x)a+bx, ( ): t-value

Table 4
General Table of Minimal Civic Services Indices and Aspiration Indices of Each Attribute

Attributes	*Civic-minimal indices*	*Aspiration indices*
air pollution	88 (µg/m³)	59 (µg/m³)
water pollution	5.98 (mg/L)	7.52 (mg/L)
noise and vibration interference	72 (db)	65 (db)
pollution of waste materials	0.00106 (person/person)	0.00191 (person/person)
park and greenery space	5.45 (m²/person)	9.52 (m²/person)
supply of parking lots	0.05966 (lot/car)	0.1144 (lot/car)
road construction	4.95 (m²/person)	38.30 (m²/person)
primary and secondary school education	23.4 (m²/person)	36.3 (m²/person)
library and art	0.0075 (m²/person)	0.0292 (m²/person)
hospital facilities	0.00042 (no. of hospitals/person)	0.00145 (no. of hospitals/person)
law and order	73 (crimes per 10 000 pop.)	49 (crimes per 10 000 pop.)

CONCLUSION

Several major conclusions are reached as follows:

Evaluation Phase

1. In terms of the relative importance (weights) of environmental attributes, the general public has a greater concern about pollution and primary and secondary school education than it does for sewage, park and green space; the regional differences indicate that the public has more concern for what is lacking in their own environmental needs.
2. In terms of the questionnaire regarding satisfaction towards environmental quality, as a whole

it shows a poor level of satisfaction. Air pollution and interference of noise and vibration are manifested at the lowest level of utility in comparison with the rest. The items of primary and secondary education in most of the districts are fairly satisfactory, while the degrees of satisfaction are higher in districts with better environmental attributes.

3. From the integral evaluation, the living environmental attributes of Pinlin Town,Tsungshan district, and Sanchi village are the best, while that of Nankan area, Shulin Town, and Shichu Town are the worst. This indicates that the public places a lower value on environmental attributes in districts with faster development.

Planning phase

For resource allocation in the implementation of government policy, the most important conclusions are:

1. The final resource allocation is more beneficial to districts of lower environmental quality, since their living standards can be raised substantially. From the objective of fairness, the differences in environmental attributes among districts can be narrowed.
2. Indices such as air pollution, noise vibration, road construction and maintenance, primary and secondary education, library, and hospital facilities, have been observed to satisfy the minimal civic needs.
3. Among 11 of the environmental attributes, there are eight in which Taipei County has a higher investment priority over that of Taipei City. It is found that Taipei County should have received 55% of the total resources allocated. In view of the budget allocation deficiency, the manner of resource allocation should be largely changed so as to fulfil the demands of the public.
4. The objective of fairness is considered as the principle of impartial administration. When the living environmental quality can be uniformly elevated, it can avoid the difficulty of policy implementation for the government.

Environmental decision making always takes place in the context of multiple goals, a number of constraints and limited resources. This study focused on a particualr set of problems in a particular geographic area to illustrate how the systematic assessment of resource allocation options may be undertaken in a rigorous, but still highly practical manner. The results of analyses employing methods similar to those reported here can be quite valuable to decision makers who must allocate limited resources to address a range of problems.

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ANNEX 1

(1) First, the optimal solution of each objective is found. Then the optimal solution of each objective function is individually put into other objectives, and objective values of other objectives obtained. Finally, the pay-off table matrix is constructed. Taking an illustration with two objectives, the form of the pay-off table matrix is shown in Table A-1.

Table A-I

Pay-off Table Matrix

	f_1	f_2
f_1	$f_1 (x^1)$	$f_2 (x^1)$
f_2	$f_1 (x^2)$	$f_2 (x^2)$

x^i: the optimal solution of i^{th} objective
$f_j (x^i)$: the objective value of j^{th} objective when i^{th} objective is the optimal solution.

(2) For the specific objective function, other objective functions are limited to a certain range between $f_i (x^i)$ and min $f_i (x^i)$. Then we find this solution.
(3) By iterating the process (2), the non-inferior solutions can be generated.
If a decision-maker provides the preference information, the best compromise solution can be obtained.

ANNEX 2

The AHP method was developed by Saaty in 1971 (Saaty, 1980; Saaty and Vargas, 1982). The procedures can be summarized as follows:

(I) Building the hierarchical relevance

The AHP method is used to make the complicated decomposition. The concepts of system including a subsystem, are used to build a hierarchy for deciding the belonged-relation at various levels. In general, the AHP method divides the complicated problem into three levels: (a) the goal for resolving problems; (b) the objective for achieving the goal; (c) the evaluation criterion for deciding the objective.

(2) Building the pairwise comparison matrix

After building a hierarchy relevance, we will construct the pairwise comparison matrix of each level. During the pairwise comparison the nominal scale is used for quantification.

(3) Calculating the weights and testing the consistency for each level

For each pairwise comparison matrix, using the theory of eigenvector to calculate the eigen value and the eigenvector, weights can be estimated. Finally, the consistency of the comparison matrix was tested and the opinions of the regional decision-maker group were integrated. In the consistency test, consistency index (C. I.) is utilized as the evaluation to determine the degree of consistency, generally speaking, when C. I.< 0.1 it is considered to be acceptable. But when the size of the consistency index is exposed to the effect of the nominal scale and the rank numbers of reciprocal matrix, then the consistency index produced from such a reciprocal matrix is dubbed as a random index (R. I.). The test of consistency ratio has employed the comparison value of C. I. and R. I. as the acceptable level of consistency procedures (C. R. = C. I./ R. I. and C. R. ≤ 0.1) is acceptable.

When the group judgment is to be administered, Saaty suggested that the characteristics of reciprocal relation must be satisfied when integrating opinions of anyone. The geometric average is capable of satisfying such a condition. Therefore, this study has used the geometric average to integrate regional group opinions.

Monitoring the Effectiveness of Environmental Impact Assessment in Southeast Asia

Clive Briffett

ABSTRACT

Environmental impact assessment (EIA) is practised in many countries of Southeast Asia particularly for large infrastructure projects funded by overseas agencies. To be effective, EIA requires substantial political support, a comprehensive institutional capacity, enforceable legal controls and adequate training and educational systems. This paper looks at the EIA management processes by identifying and analyzing implementation problems experienced by professional practitioners, researchers and project managers in the region. It considers political and institutional issues, legal needs, technical aspects of the project management processes, and social and cultural considerations. In general, the results of this investigation suggest that the implementation, control and enforcement processes are not fully effective, and auditing and monitoring techniques are often ignored. This limits the knowledge gained from experience, minimizes the acceptance of EIA as a planning tool and reduces its full potential.

Keywords: *Asia, Southeast Asia, environmental impact assessment (EIA), environmental planning, environmental management, institution building*

INTRODUCTION

This research attempts to provide a general overview of the problems arising in the implementation of environmental impact assessments (EIAs) in Southeast Asia and recommends forms of action that could be taken to improve the effectiveness of EIA implementation in the region. The research is based on part on the opinions of practitioners based in the region, or who operate from outside and provide consultancy services in it. In addition relevant literature is reviewed based on EIA in developing countries with particular reference to Southeast Asia. The effects of using developed country techniques and methods are also examined in terms of prevailing technical, social, ethical and cultural aspects as well as political ideologies.

STATUS OF EIA IN DEVELOPING COUNTRIES

It has been suggested by some that the EIA in developing countries is more important to environmental quality and human health than elsewhere (McCormick, 1993). Despite this, the underlying need to develop and to encourage economic growth has tended to obscure the longer term requirements of protecting the environment. Other critical problem areas for developing countries have been the lack of available expertise and monetary resources for formulating the legislation, setting guidelines, establishing standards, implementing baseline studies, predicting impacts and reviewing quality of the work. As a consequence, developing countries have sometimes been deterred from adopt-

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ing EIAs by what they consider to be unduly burdensome complexities of a multi-disciplinary exercise (Tolba, 1985). EIA has also been viewed as a possible obstacle to achieving much needed developments. Despite this, its introduction in loaning banks and lending government agencies requirements, and in the work ethic established by some of the larger international consultants appointed to plan and design developments, have triggered it's adoption in many developing countries.

There is considerable variation amongst the EIA systems used in relation to the scope (public or private), scale (national or local), and content (physical, biological and social parameters). However, there is common agreement that the fundamental aim of EIA is not simply to determine the balance placed by the decision maker on environmental compared to economic, social, or other considerations. Rather, it is to ensure that the decision is made on the basis of informed knowledge of the environmental consequences of the decision (Roberts, 1984a).

To a large extent, the emphasis has been on essentially negative issues, with a stress on damage control. This has been perpetrated and institutionalized by policies such as the 'polluter pays' principle. In the 1990s, however, new approaches have emerged. Positive, holistic 'sustainable development' has also been identified as the universal target (Campbell, 1993). This has, however, given rise to severe criticisms of the EIA system. As one writer puts it, 'EIA, a 20-year-old tool for environmental management, is not living up to its full potential' (Mudge, 1993). Other even stronger objections to EIA derive from suspected hidden agendas perceived by developing countries. Some of these include environmental imperialism, studies used to fill the pockets of Western consultants and devices to increase democratization (Sivalingam, 1994).

STATUS OF EIA IN SOUTHEAST ASIA

Of the world's 100 largest cities (based on population), 36 are located in Asia. A projected 2.3 billion people will live in Asian cities and towns by 2020, almost equal to the total urban population of the world today (World Bank, 1994). The largest Asian cities already rank as the most environmentally polluted in the world in some respects.

Southeast Asia comprises a number of developing countries, many of which are achieving high economic growth, increased urbanization, large scale exploitation of the region's extensive, though finite, natural resource base and widespread despoliation of air, water and soil by industrial and domestic wastes (WRI, 1995).

The need for recognizing these environmental problems has been responded to in many different ways, through legislation, institutional structuring, practical application and improved technical expertise. EIA has figured prominently in a number of countries albeit at the local project level, but interest in introducing strategic EIA at the sector/regional and national levels is increasing. Most regional planning in developing countries has been undertaken by the national economic planning agency with regional and urban planning agencies generally limited to a back-up role. These have paid insufficient attention to environmental factors in the past. The task now is to modify the process to become an economic-cum-environmental development planning process (ADB, 1988).

An environmental profile of all the Southeast Asian countries is shown in Table 1, defining their development status and other characteristics including natural resources. Table 2 outlines the status of EIA in Southeast Asia using a model that assesses political, legal, institutional, technical and educational issues. Whilst every effort has been made to include accurate and up-to-date data in these tables, changes do occur fairly rapidly. It is recognized, for example, that in the case of Hong Kong mandatory EIA legislation is likely to be introduced fairly soon. The tables provide a useful set of comparative data, but this needs to be treated with caution. For example, two countries which have had mandatory EIA legislation for the longest period (Thailand and Philippines), have lost the most natural resources. In contrast, two countries which have not yet adopted EIA legislation (Singapore and Brunei) are perhaps the least polluted. These cases confirm that it is not necessarily the legislation that counts. Rather, it is its effective implementation.

MALAYSIA

A survey of environmental consultants in Malaysia was conducted in May/June 1993 to obtain feedback on the operation and effectiveness of the EIA legislation introduced in 1987. The postal survey circulated the detailed questionnaire to all consultants listed on a register compiled by the Department

Table 1
Environmental Country Profile of Southeast Asia

Country	General		Development Status*					Economies by Income@			Urbanization % of total pop+		Natural Resources			
	Size km²	Pop. million	1	2	3	4	5	Low	Medium	High	1965	1990	Forests#		Wetlands§	
													Orig. km²	Now % left	Area km²	Sites No.
Brunei	5,765	0.26			x					x	-	-	5,000	24	1,380	3
Hong Kong	1,075	6.00					x			x	89	94	1,074	9	119	3
Indonesia	1,900,000	184.00		x				x			16	31	1,700,000	69	87,800	137
Kampuchea	186,000	8.00	x					x			11	12	160,000	71	36,500	4
Laos	236,726	4.10	x					x			8	19	225,000	55	2,220	4
Malaysia	329,743	18.00			x				x		26	43	320,000	63	31,200	37
Myanmar	676,577	42.00	x					x			21	25	600,000	52	54,900	18
Philippines	300,000	62.50			x				x		32	43	295,000	22	14,100	63
Singapore	642	3.00					x			x	100	100	500	4	7	2
Thailand	513,110	56.00			x				x		13	23	250,000	43	251,000	42
Vietnam	330,000	70.00	x								16	22	280,000	20	58,100	25

Key
* Development Status: 5 = fully developed Æ 1 = undeveloped
\# World Conservation Monitoring Centre - 1992 Global Biodiversity
@ Table 30, Income distribution, World Development Report 1992
§ Directory of Asian Wetlands, Asian Wetland Bureau 1989
\+ Table 31, Urbanization, World Development Report 1992

Table 2
Environmental Impact Assessment Status in Southeast Asia

Country	EIA leg. date	Political*			Legal#			Institutional Agency	Technical+						Educational@			
		C	D	O	L	R	A		G	Sg	Sn	Sc	M	Ep	Gr	Pr	EIA	IEA
Brunei	-	x					x	Environmental Unit Min. of Dev.								x		
Hong Kong	1990	x				x		Env. Prot. Dept. (EPD)	x	x	x		x		x	x	x	
Indonesia	1987	x			x			BAPEDAL	x		x			x	x	x		
Kampuchea	-			x			x	Interim Mekong Committee										
Laos	-			x			x	"										
Malaysia	1987		x		x			Dept. of Env. Min. of STI	x	x	x			x	x	x	x	x
Myanmar	-			x			x	National Com. for Env. Affairs NCEF										
Philippines	1977		x		x			Environmental Management Bureau EMB	x	x	x			x		x		
Singapore	-	x					x	URA								x	x	
Thailand	1978		x		x			Nat. Env. Board NEB	x	x	x		x	x	x	x		
Vietnam	-			x			x	Env. Committee										

* Political Framework: C - Centralized; D - Decentralized; O - Other

\# Legal Status: L - Legislation; R - Regulation; A - Adhoc

\+ Technical Implementation: G - General Guidelines; Sg - Sectoral Guidelines; Sn - Screening Review; Sc - Scoping; M - Monitoring; Ep - Environmental Management Plan

@ Educational Provision: Gr - Graduate Education; Pr - Practitioner Training; EIA - EIA Centre Correspondent; IEA - Institute of Environment Assessment

of the Environment (DOE). An accreditation process is underway in Malaysia and all consultants who have completed and had approved at least three EIA's will be assessed for future listing by the DOE. It is not clear how new consultants will be able to qualify without the required experience (Turberfield, 1994).

The overall response rate on this survey was 24 consultants (22%), which is unlikely to be truly representative of the total environmental consultant population. Nonetheless, it does provide insights into consultant problems and highlights some areas worthy of future amendments to the EIA procedures. The following is a summary of the information obtained.

General Data

The majority (88%) were independent as opposed to in-house consultants and 83% found the DOE guidelines useful (DOE,1987). The guidelines were first published in a more abbreviated format in October 1990 and have since been revised three times with the latest version dated May 1993 (DOE, 1993). Other comments on the guidelines were that it was too detailed and lacked practicality; that a better distinction was needed between the scope of a preliminary and detailed EIA; that the format should be more flexible; in cases where the development falls outside of prescribed activities, the procedure for determining the need for EIA should be specified.

Of the respondents, 13 confirmed they have difficulties in obtaining specialist expertise. The most problematic are socio-economic assessments where expertise is difficult to obtain due to a lack of experts and the length of time needed to obtain the information. Eight respondents confirmed they experience difficulties with the application stages of EIA. For example, there was insufficient evaluation by the project proponents of some of the issues such as site selection and site layout. This also leads to an inadequate in-depth evaluation on some technical aspects such as radioactive materials, hazardous sludge disposal, waste treatment and underground water contamination. Another example is the delays caused by reviewers who ask for too much data on insignificant impacts, especially in their own specialist subject area. Finally, there are inadequate built design details provided by clients and designers.

Out of the 14 listed activities for which EIAs are normally prepared, industry and resort/recreation had a much higher use than the others. Quarries, petroleum and infrastructure projects were also cited as common project types. The time taken to complete an EIA is on average five months, but this can vary, depending on the activity, from two to fifteen months with the longest for petroleum projects.

Six consultants were involved in only preliminary EIAs. The majority covered preliminary and detailed assessment. Only one had completed a post completion monitoring project and none had been commissioned to deal with site implementation. Six areas were listed as possible specific EIA problem areas including administrative data collection for the proposed built and existing natural environments, waste treatment and disposal, construction implementation, and management processes. The most difficult related to construction details and existing natural habitat data. The following comments were supplied under each heading.

Specific Comments

Administration

- DOE requirements not consistent; varies with officer in charge.
- Disputes often arise on lack of integration of results between specialists. DOE require copies of everything submitted to other agencies. It would be better to have a one-stop agency like the DOE to send only one copy of all forms.

Data Collection

- Difficulties in getting design and construction information early enough from clients and other consultants. Sometimes this is withheld until the last moment since it is considered as a trade secret!
- Very difficult to obtain government maps, plans and air photos of sites, especially in rural areas as much of this data is considered confidential in Malaysia for security reasons.
- Information on flora and fauna not freely available or does not exist for many sites and detailed surveys are needed.
- Data on radioactive materials often not available and air quality monitoring is difficult as few private laboratories have the facility and where they do, charges are exorbitant.

Waste Treatment and Disposal

- Requirement to submit details may not be necessary in the preliminary assessment but is needed later. This often involves two consultants which gives rise to problems.
- Difficulty in controlling waste generation. No contingency provision for waste treatment.

Implementation

- Most EIAs are simply required by proponents to obtain the necessary approvals and planning permission. There are rarely any instructions received to audit progress on site during construction or to monitor impacts after completion.
- Additional ground works are often implemented on site but are not included or shown in the drawings and have therefore not been evaluated from an environmental perspective.
- There is very little awareness amongst contractors' staff and operatives of environmental issues on site and the effective control and precautions required are rarely implemented.

Management Processes

- Procedures, regulations and requirements, and recommendations of the EIA are not well-known or effectively communicated to the management staff including senior project managers and implementation therefore suffers.

Government inspectors are normally more concerned with construction in terms of compliance with building regulations, fire codes and general planning requirements relating to site layout, set backs, etc., and control for EIA proposals is therefore conducted.

Other Notes

The sample obtained for this survey has been fairly small and the inability to conduct interviews limited a more accurate clarification of opinions and facts. There are, however, some interesting findings which generally tend to confirm that the existing EIA system as practised in Malaysia still needs further modification and improvement.

On the positive side, there are strong indicators that the system has been accepted and that most proponents at least attempt to comply with the administrative procedures. The weakest area by far is the implementation on site and post-contract monitoring. The DOE is aware of this and proposals have already been made to reinforce the need for monitoring (Harun, 1994). Whilst this can be implemented through environmental consultants and their contractual appointments with project proponents, there still remains the question of site control and awareness. Education for managers and operatives, as well as increased resources and expertise for government control agencies, is clearly needed. Until such matters are effectively dealt with, the EIA system will continue to be perceived as an obstacle for the proponents to overcome in paper report form only, rather than as an integral planning tool which can be used to effectively protect the environment and minimize adverse impacts.

UNITED KINGDOM AND HONG KONG CONSULTANT SURVEY

The purpose of this survey was to obtain practitioner opinions and perceptions of the effectiveness of the EIA process in Southeast Asia. This was a two-part process, initially comprising a postal survey followed up by a personal interview for selected companies. A total of 43 environmental consultants were chosen from the ENDS Directory on the basis of having experience in EIA in Southeast Asia (ENDS,1993).

General Data

Postal Survey

A one-page questionnaire was sent to all firms to obtain basic information on status, experience and problem areas. This also served to establish contacts for future communication, assess general reaction and encourage participation for possible interviews. The following results were obtained from the returns.

Thirty-eight (88%) consultants responded and 26 (60%) of these returned forms. Eight firms referred the forms to overseas offices and four of these were returned from Hong Kong. Twenty (77%) of the respondents confirmed independent status and four (15%) were in-house whilst the remaining two (8%) operated as both. The in-house companies were all large international civil engineering concerns.

Interviews

A total of eight consultants were visited in London, Manchester and Oxford over a three-month period and these were selected partly to cover a wide range of expertise identified in the first questionnaire and according to responses obtained in the telephone follow up.

Seven of the consultants operate on an independent basis in relation to environmental impact statement work. A similar number also provide comprehensive, general and specialist services and four offer sub-specialist service, which may range from coastal/marine expertise to ecology. One of the companies solely specializes in ecology. Five operate from the UK only on an international basis whilst the remainder act through regional offices, most of which are based in Hong Kong. One has an office in Malaysia and Singapore. Generally, most companies cover a wide range of project categories. The categories for forestry, petroleum and power generation and transmission tend to be less frequently covered and it was noticeable that the companies specializing in these areas are generally not doing work in other areas. Other specialist areas such as noise and vibration, corporate environment strategy and contaminated land, are less frequently encountered. Most of the task categories are covered by six consultants but post-auditing is less frequently completed by only four.

Specific Comments

Implementation Problems

These were categorized for convenience as follows: administration, planning and design, baseline environmental surveys, impact prediction, project construction and management.

Administration
Experiences varied considerably between different countries but the general view was a need to have a local agent, office or academic representative. Such matters as obtaining government guidelines, completing forms and administration procedures and 'easing the wheels' according to established practice and tradition, were best done by local agents. Some companies did have their own overseas office in Hong Kong, Singapore or Malaysia, or used local consultancy partnerships, especially in Hong Kong.

Other matters included difficulties with interpreting environmental legislation particularly in a country where guidelines were not available. Inefficiency in government departments, especially a lack of coordination between departments where no integrative protection agency exists, was generally observed. In some countries, like the Philippines, there is a lack of political will to activate the legislation effectively, whilst in others too much interference is experienced. Hong Kong appears to stand out as being the easiest administration to deal with.

Planning and Design
This includes the processes of screening (deciding whether a development requires an EIA), scoping (choosing between alternative actions and impacts), and coordinating design activities.

In screening, the initiative is mainly with government departments who make the decisions about whether a proposed development requires an EIA or not. Where specified lists are available of the types, size and location of projects, and are clearly set out, the task becomes easier although sometimes a little inflexible, as in the case of Malaysia (DOE, 1993). Where legislation on EIA is less well defined, then screening is left to government departments.

For scoping, the opportunities to change or influence project selection, location or design layout are generally limited for the following reasons:

- developer proponent only owns one site and is only interested in one type of development,
- a consultant is only appointed after the preliminary design investigation process has been completed,
- some planning authorities are excessively aggressive on planning profit or gain-creating developments,
- selection is dictated by an overseas agency such as an aid group or government department,
- insufficient detailed design information is made available from designer or client at the EIA stage.

These problems may not be so apparent when projects are large scale, highly impacting or controversial, such as Hong Kong's new airport. If the proponent is a government agency with plenty of alternative land sites to choose from, such as sewage work sites or landfill sites, an effective screening process can be undertaken.

Opportunities to scope the impacts to be investigated are considerably greater as this comprises part of the EIA process for which a consultant is appointed. The procedure is to select the likely magnitude and significance of impacts considered important for future study. Guidelines for doing this are not usually available from governments, although in cases where there is a review committee, impacts to be fully investigated may be defined. Indonesia and Malaysia, for example, include this facility.

Baseline Environmental Surveys
The scoping process is important here as it helps to reduce the extent and depth of survey data required, according to its relevant importance for identifying significant impacts. Very few consultants are able to supply all the specialist expertise in-house and most rely on local groups, often based in universities, to cover such areas as ecology and cultural factors. Problems arising from this include higher costs, insufficient relevant data, lack of integration between specialists and associated discrepancies with parts of the total statement, and timing delays.

Impact Prediction
Considerable difficulties were experienced here, especially where there is a lack of previous monitoring feedback and local knowledge. Most consultants agreed this was the most problematic area. Conflicts of environmental requirements with political, economic and social considerations, were also common. Availability of adequate baseline data and development information was often lacking.

Project Construction and Management
This relates to the actual implementation processes of the EIA and covers site control and organization, environmental auditing and monitoring.

In the case of large contracts an environmental overseer, controller or adviser is usually appointed to check on compliance with statement recommendations, especially regarding construction problems such as noise, dust and damage to adjoining sites. Mitigating measures are also supervised. As a member of the project management team, the influence, power and effectiveness of such supervisors are often extremely limited and they may be overruled by other construction project managers. On smaller jobs, no one is appointed to look after the environmental considerations and government authorities rarely check compliance unless public complaints are received or major health hazards are apparent.

In relation to EIA, environmental auditing is a process designed to check and record the environmental events taking place on site during construction and in the commissioning stages. In many projects this is entirely ignored and is often not required under legislation. For some larger type projects, some consultants have been appointed to set up an auditing and monitoring programmes, e.g. for Hong Kong's Airport and West Kowloon Reclamation.

Environmental monitoring relates to the process of checking the nature, extent and significance of impacts once the project is in operation. Most consultants interviewed have not been requested to do this and there is hardly any mandatory legislation for it in Southeast Asian countries. All interviewees expressed concern on this as they felt that the most important learning exercise could be covered by monitoring, and that the accuracy of impact prediction could be evaluated. It is also an activity that could measure the effectiveness of the EIA system in terms of assessing the degree to which the environment was protected, conserved or in some cases, enhanced.

FUTURE NEEDS

Integration Into Strategic, Regional and Project Planning Processes

EIA in Southeast Asia is still a project-based activity that at best identifies and integrates significant environmental impacts and at worst is used simply as a means to obtain planning permission. The need to view EIA as a major contributor to strategic planning and to the compilation of national environmental protection policies is important. When it is properly built into the strategic planning system of a country or state, and in the master planning system of a development, its recognition, influence, and effect is likely to be more substantial (Malone, 1993, Young, 1993). The experience already gained through implementation in Southeast Asia, however, will certainly provide more opportunities and progress in this region.

The need to establish EIA as a positive pro-development technique in conjunction with economic planning and in project design feasibility studies to prove that its utilization can assist in reducing costs, saving time and improving quality in the long term, is vital to its survival. As previously noted, EIA needs to be viewed as a means of assisting in planning and the rational use of resources, not as a brake or obstacle to economic development (de Souza, 1980).

A major constraint in the implementation process of EIA in Southeast Asia is its current divorce from the planning and design processes. When applied at the project level after design and planning is completed, at best, it will only serve as a means to show how environmentally friendly a development can be, using mitigating measures which are invariably too late, too insignificant, too ineffective or too difficult to implement.

Enforcement of Legislation and Regulations

The countries reviewed provide many examples of ineffective legislative control and there seems to be a case for phasing in standards and controls on a gradual basis to suit the realistic resources available for achieving them. If such standards are clearly unattainable and unenforceable, then the credibility of EIA is lost. This leads to general avoidance and abuse of the legislation especially where fines and penalties are minimal. As noted above, unrealistic standards drawn from more developed countries may be unenforceable. Command and control regulations often do not work in developing countries for a variety of reasons (e.g., they are difficult to enforce and monitor, fines are too low or corruption is too rampant) (Panayotou, 1991).

Strengthening of Institutional Capacity

The complicated bureaucratic procedures of government have long been stumbling blocks to obtaining satisfactory compliance with legislation, and delays and a lack of integration between central and sectoral agencies create confusion and unnecessary complexity. There is a strong case for creating an environmental agency which has sufficient capacity and influence to act as a coordinating one-stop facility for applicants. Providing a coordinating and integrating role as a post office type arrangement for relevant state governments, specialist ministries and departments, is also necessary.

Establishment of Appropriate Technical Competency

The technical issues are many, but there are two main areas worthy of attention. One relates to the need to have an environmental management plan which clearly sets out the development requirements, identifies roles and responsibilities of project participants and establishes a management structure for achieving effective implementation. Several countries including Indonesia and more recently Malaysia, do request such plans but government resources available to check their adherence and implementation is weak. The second issue concerns monitoring, which should become a mandatory requirement of EIAs for all major developments in the future to heighten awareness, improve education, develop better quality data bases and to accurately measure impact prediction. The potential feedback facility of monitoring can rapidly upgrade and improve the quality of EIA in the future.

Sensitivity Towards Social and Cultural Awareness

The sensitivity of an EIA is probably one of the most important characteristics of its effectiveness. Social and cultural issues have long been identified as being a very weak area in EIA implementation in Southeast Asia. This mainly derives from the top-down induction process of EIA, where the needs and desires of the public are not given the attention they deserve. Public participation is becoming an increasing phenomena in the region through the action of non-government organizations (NGOs). Yet some countries may perceive pressure groups as a nuisance. NGOs tend to be most effective when they are well informed and responsibly represent a relatively large proportion of the public. The segments of the public most likely to be directly affected by proposed developments deserve to be identified and listened to and most of all, adequately compensated if their life styles have to be radically changed.

Organizing Comprehensive Education and Training

Education has been confirmed as a major component in improving the effectiveness of EIA and efforts to target participating groups of the development process would seem to be a useful tactic. The quickest pay back is for potential trainers and leaders to be identified at all levels including schools, colleges, universities, professional institutions, non- government organizations and the general public. Regular ongoing training programmes designed as workshops with participants from most countries in the region, are especially useful for creating networks and a cross pollination of views and ideas.

Coordinating and Identifying Sustainable Development Objectives

The final and perhaps the most interesting and challenging prospect for EIA is its potential contribution to sustainable development. This means to improve the quality of human life while living within the carrying capacity of supporting ecosystems (IUCN, 1991). If this is to be met, then the current negative, project based and mitigating image of EIA will have to be radically rethought. The ideal arrangement is for EIA to perform a central function in the environmental management plan that includes a broader based, planning and development tool designed to assist in protecting and enhancing developments. Participation from residents and regular users of development sites must be sought to reduce conflict and enhance cooperation towards these objectives.

CONCLUSION

EIA in Southeast Asia is well established and is likely to remain so, even though its benefits, as discussed in this paper, have not been fully realized. The objectives set in EIA management processes are first and foremost to protect the environment, which has clearly not been achieved even in those Southeast Asian countries which have already been implementing it for nearly 20 years. Whilst it could be forcibly argued that increased awareness and education has improved, the consequent influences on development participant behaviour to take a longer term view and to bring about meaningful improvements to the quality of life for both humans and wildlife, has been minimal.

The important questions that derive out of this study are 'Should an alternative to EIA be devised for use in developing or newly industrializing countries?' or 'Can EIA be modified to suit?' The information from practitioners would suggest the latter, as EIA is generally considered to be an acceptable and worthwhile concept without any fundamental deficiencies (Campbell, 1993; Brown, 1989b).

The reasons why EIA needs to be modified relate partly to meeting the specific needs of developing and newly industrializing countries, but also to achieve the heightened expectations of EIA as a key component of sustainable development planning in the future. This of course is a role for which EIA was not originally developed.

The modified EIA needs to establish new scope, criteria and implementation strategies that give it more positive, integrated, strategic and participative dimensions. At the same time, the need for EIA to be more simple, direct, appropriate, locally based and flexible, are also desirable components for future acceptance and effective implementation.

As suggested by one writer, the environmental assessment process generally needs extensive reform in almost all agencies, in the following ways:

- to examine sustainability from an economic, social and environmental perspective,
- modify to take account of traditional political and cultural values and to make the process public,
- to make it more effective by conducting it earlier in the process, especially as a prerequisite for major policy decisions (Runnells, 1991).

Hopefully the increased experience and awareness acquired by professionals and government administrators in all countries of Southeast Asia in recent years will lead to more appropriate and successful EIA processes being developed and implemented, for the future benefit of both their human populations and the rich and diverse natural environments.

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Faculty of Environment and Resource Studies, Mahidol University, Bangkok, Thailand

BACKGROUND

The Faculty of Environment and Resource Studies had its origins in 1973 in the establishment of the Environmental Education and Research Project at Mahidol University. This project was set up as a result of growing public concerns about the deteriorating quality of the environment. The aims of this project were to provide facilities for teaching and research, and to be a common meeting ground for environmentalists and responsible authorities to iron out differences of goals and approach to development and environment, in a cordial and rational manner which avoids confrontation. In 1978, the project was promoted to full institutional status as the Faculty of Environment and Resource Studies and is today housed within Mahidol University's Salaya campus, some 20 kilometres west of Bangkok. The Faculty has about 30 core members acting as an interdisciplinary team, with approximately 70 supporting staff.

ACTIVITIES

The Faculty currently offers a number of degree programmes: a Bachelor of Science in *Environmental Science and Technology*, three two-year full-time interdisciplinary Master of Science degree programmes (in *Technology of Environmental Management, Appropriate Technology For Resource Development* and *Information Management on Environment and Natural Resources*) and a doctoral programme in *Technology of Environmental Management*. Additional programmes being organized are a Master of Science in *Technology of Investigation and Planning for Rural Development* and a Master of Science in *Technology of Agro-biological Management*.

RESEARCH

The Faculty stresses applied research and its members have been involved in more than one thousand research activities/projects. The major areas include:

- energy and food studies
- rural technology and rural development
- natural resource survey techniques
- natural resource conservation and management
- environmental toxicology and pollution control technology
- environmental impact assessment
- environmental laws and regulations
- remote sensing and geographical information systems

Major new areas of current and planned work include:

- resource utilization and recycling
- the study and preservation of biodiversity
- development of biological information systems.

TECHNICAL ASSISTANCE SERVICES

Since 1985, the Faculty has been licensed to perform environmental impact assessments (EIAs). Technical assistance and dissemination of research for both governmental and non-governmental organizations is carried out through a variety of channels including the organization of seminars, workshops and short training courses (at both the national and international levels), giving lectures, technical discussions, audio-visual presentations, and promotion of public awareness of environmental issues through the media.

The Faculty of Environmental and Resource Studies maintains technical cooperation linkages with a number of tertiary institutions in various parts of the world including: Australia (The Department of Human Geography, Research School of the Pacific, and The Centre for Resource and Environmental Studies, Australian National University; and The Macintosh Centre for Quaternary Dating, of The University of Sydney); Hong Kong (The Centre of Urban Planning and Environmental Management, The University of Hong Kong); and Sweden (The University of Lund).

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Yunnan Institute of Environmental Sciences

BACKGROUND

The Yunnan Institute of Environmental Sciences (YIES), an environmental research unit of the Yunnan provincial government of the People's Republic of China, was founded in 1978 under the Yunnan Science and Technology Committee and the Yunnan Environmental Protection Bureau. Its facilities cover 1.7 hectares and YIES employs 140 people of whom 120 are professionals and technicians specializing in such fields as biology, ecology, geology, geography, hydrology, agriculture, soil science, chemistry, medicine, computer science, and planning and evaluation.

The Institute is divided into offices of 'Lakes', 'Water and Soil', 'Ecology', 'Engineering', 'Chemical Analysis', 'Environmental Assessment' and an 'Environmental Spatial Information Center' among others. A 'Division of Project Development' has been set up with staff from all offices for the development of technologies and industrial techniques for environmental protection. This division has extensive cooperation for the development of cleaner production technologies and operations with industries producing such products as phosphorous-free detergent, bricks and tiles, sulphur, and food.

RESEARCH ACTIVITIES

Since its establishment, YIES has carried out more than 350 scientific research programmes in a wide range of fields relating to environmental science and nature conservation covering all parts of Yunnan Province, and in a few cases going beyond Yunnan's and even China's boundaries. Of the projects carried out so far, 3 have won the China National Science and Technology Advancement Award, while many others have won provincial and local awards. YIES has been recognized on a number of occasions by the National Environmental Protection Agency of China and by the provincial government for its high quality work.

Work such as 'Technical Research on Dianchi Pollution and Its Eutrophication Prevention' and the 'Comprehensive Treatment Plan of Dianchi (Lake) Pollution' illustrate some of the major types of research activities of YIES. Both projects are part of YIES's interdisciplinary studies of Yunnan's major plateau lakes. These studies deal with such topics as (i) lake ecosystems, (ii) analysis of the relationships between socio-economic development and pollutant loads, and (iii) assessment of technical proposals for comprehensive treatment systems. Related work includes biological engineering for treatment of water and soil pollution, treatment and recovery of industrial and domestic wastewater, and promotion of clean agricultural areas (high productivity with less pollution).

Other major research programmes include the 'Environmental Impacts of Phosphorus Resources Development in China,' 'Revegetation in Exhausted Areas of Phosphorus Mines,' 'Municipal Wastewater Treatment by Agricultural Lands,' 'Environmental Planning of the Lanchang (Mekong) River,' 'Prevention and Management of Water Pollution in the Nanpan River in Yunnan,' and 'Development of Biomass-to-Electricity Projects in Yunnan, China'. YIES has conducted more than 100 environmental impact assessments (EIAs) and completed more than 30 pollution treatment engineering projects. The Spatial Information Center carries out its work using Geographic Information Systems (GIS) and Computer Aided Design (CAD).

Some examples of research published for national and international audiences include 'Determination of the Potential Market Size and Opportunities for Biomass-to-Electricity Projects in Yunnan, China', 'Water Pollution Control and Sustainable development in the Upper Nanpan River Basin of Yunnan Province, China,' 'Research on the Ecological Effects of Air Pollution On Plants', 'Pilot Research on Cover Plants of Exhausted Areas of Phosphorous in Kunyang', 'Research on Yunnan Migratory Birds and Their Migrations,' and 'Analysis of Economic Loss by Ecocide in Yunnan.' YIES has cooperative agreements with the World Bank and with various bilateral organizations in the USA, Japan, Britain, France, Sweden, Switzerland, Australia, and Thailand.

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From the Editor

This issue begins with an Invited Commentary from Jinnan Wang of the Environmental Management Institute of the Chinese Research Academy of Environmental Sciences. He outlines proposals for a system of price, tax, investment and credit reforms as well as market-based incentives and an improved environmental and economic accounting framework. His point of departure is that much of China's environmental laws and regulations and the basic management systems for the environment were established before the full effect of economic reforms took hold and so are becoming increasingly inappropriate for actual conditions. He proposes specific reforms in these areas and recommends how the proposed changes could be tested.

New approaches to environmental management are also the subject of the paper by Afsah, Laplante and Makarim. They review experience with the Indonesian Clean River or PROKASIH programme. This innovative programme for industrial water pollution control includes important voluntary elements. While the authors note that data on the programme was still incomplete, they show that for a subset of participating plants for which data is available, total biological oxygen demand (BOD) declined under the programme and they argue that were it not for PROKASIH, total BOD would likely have been far higher than it actually is.

As a reminder that not all innovation leads to success and that the success may be more apparent than real, Niaz Ahmed Khan takes a critical look at Community Forestry in Nepal. *Community Forestry* (CF) has received considerable attention in recent years with often quite impressive claims made for its achievements. While noting that the programme in Nepal produced some benefits, he argues that in the final analysis '. . . the Nepalese CF in reality functioned as a routine government-sponsored rural development programme, administered by a collaborative alliance between the bureaucrats and local political elites, which produced some marginal benefits to local people'. In particular he stresses that the '. . . intended beneficiaries are rarely consulted in any decision making'.

Continuing on the general topic of approaches to forestry managment, and this time on a positive note, Barry Nicholson examines the history of the Tai Po Kau Nature Reserve, which is widely regarded as one of Hong Kong's most important woodland areas today. His examination of how Tai Po Kau came to be the way it is today after nearly a century of effort is intended to identify practical lessons for reforestation or ecological restoration techniques.

Also from Hong Kong is a paper by Joseph Liu and Anthony Hedley which stresses the importance of locally derived epidemiological and economic data to assess environmental health policy interventions. They argue that given the seriousness of air pollution in Hong Kong, and the importance of local factors in determining the level of benefits and costs of possible interventions, that much greater attention should be given to developing a more comprehensive information base so that policy setting in this area may be made more systematic. They illustrate their argument through a case study of one intervention for which local data on certain important elements of the benefits and costs of the intervention were available.

The workshop report for this issue focuses on a March 1996 Asian regional workshop on how to make environmental law more effective. The workshop brought together environmental professionals from thirteen economies in the region, as well as several participants from North America. The invited participants were a diverse group representing a range of professional backgrounds (e.g., lawyers, engineers, economists) from private industry, government, academia and voluntary organizations. Once the common ground on the underlying nature of the failure of environmental law in much of the region was identified and elaborated through the working sessions, the findings were presented in what the group believes to be highly practical recommendations for more effective environmental law in the Asian setting today.

This issue of *AJEM* concludes with two institutional profiles. The first is from the Center of Environmental Sciences (CES) of Peking University. CES was formally established in 1982 and is jointly supervised by the National Environmental Protection Agency of China and by Peking University. CES's activities focus on education and scientific research. The second institutional profile is that of a much newer organization, the Vietnam Environment and Sustainable Development Center (VNESDC) established in 1995 under the direction of the Vietnam Association for the Protection of Nature and the Environment. VNESDC conducts research and training and also has as one of its major goals promotion of more effective community participation in Vietnam's environmental management.

ANNOUNCING A SPECIAL SPRING 1997 ISSUE:

Hong Kong's Environment on the Eve of the Creation of the Hong Kong Special Administrative Region of China

The spring issue of 1997 will be devoted to the environmental situation in Hong Kong as it prepares to become a Special Administrative Region of China. While the political aspects of the changeover clearly have the attention of the world, for the people of Hong Kong the political changeover comes as part of a larger context of economic changes, growing population pressures and continuing environmental declines, even as incomes continue to rise. This issue of *AJEM* will present reviews of the overall level of Hong Kong's environmental quality, pressures on it and steps being taken to address these problems. In addition, other articles will consider the broad policy debate (e.g., the appropriateness of proposed massive reclamation and infrastructure development) as well as particular aspects of the problems and the search for solutions (e.g., transport policy, air quality modelling, sewage treatment, solid waste disposal).

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AJEM welcomes replies to the articles and commentaries published in it. These may be in the form of a relatively short (several hundred words) *Letter to the Editor* or in the form of a full manuscript which specifically address a previously published article.

Call for Papers

The *Asian Journal of Environmental Management* (*AJEM*) invites articles on practical aspects of environmental management in Asia. Priority is given to papers involving (1) descriptions of efforts (or specific proposals) to *manage* problems associated with pollution or nature conservation, and (2) matters of concern to organizations involved in environmental management or public awareness (for example, environmental data, management tools, institutional developments).

The manuscript should be clear and concise. Where some of the material presented is highly specialized in nature, the text should include explanatory statements which convey its importance to a readership from different professional backgrounds. Submissions will be refereed by an international panel of experts in the field, and the referees will determine if the submitted papers are to be published as received, published following specific requests for revision, or not published. In keeping with *AJEM*'s goal of facilitating information exchanges, comments on published articles are invited and these will be published. Comments and rejoinders should be between 50 and 800 words.

Submission of a manuscript will be taken to imply that the material is original and no similar paper has been published or currently submitted for publication elsewhere.

The manuscript should be between 3000 and 8000 words and the cover page must include the title (less than 15 words), the author's correspondence address, fax and telephone numbers, an abstract of 100 to 200 words, and a list of up to 10 key words. The typescript must be submitted along with a photocopy of original illustrations (for example, photographs, drawings). Indications of appropriate style for references, and other points of style, may be taken from the articles in this issue. Manuscripts must be submitted double spaced with wide margins on all sides along with a copy on a computer disk. (If requested, *AJEM* will return computer disks or printed material to the author.)

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INVITED COMMENTARY

A Framework for Evolving Environmental and Economic Policies in the Transition Economy in China

Jinnan Wang

ABSTRACT

Current environmental and economic policies in China are facing new challenges in the transition to the market economy. Based on a review of implementation problems with respect to current environmental economic policies, this paper proposes a framework of environmental economic policies in line with the emerging market economy of China, including price changes, taxes, investment and credit promotion, market-based incentives, and environmental and economic accounting.

Keywords: *China, environmental policies, economic instruments, market economy*

INTRODUCTION

Many market economy countries, especially OECD member states, have actively encouraged the application of environmental economic instruments and have achieved some success (OECD, 1994). The UN's 'Declaration of Environment and Development' passed in June 1992 in Rio de Janeiro also required each government to promote the complementary function of price, market, national finance and economic policies in the formulation of environmental policies and to internalize environmental costs into policy making with regard to production and consumption. The Chinese government supports, in principle, the idea that full use should be made of economic instruments and market incentives to promote sustainable development and to protect the environment. As part of this, market prices should reflect the environmental cost of economic activity (State Council, 1992).

China is presently building and improving its economy and so the role of the market mechanism becomes more and more fundamental. In light of this, it has become urgent for China to speed up the establishment of an adequate environmental economic policy system and to make greater use of economic instruments in environmental protection.

Based on a review of implementation problems with current economic instruments for environmental management, this paper proposes a new framework of environmental economic policies suited for the transitional economy in China. The proposed measures include pricing changes, taxation, investment and credit promotion, greater use of

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market-based environmental protection incentives and integrated environment and economy accounting.

Existing Environmental Economic Policies in China

Environmental economic policies are those which use economic instruments such as price, tax, credit, investment and macro-economic adjustments to adjust or affect the pollution and abatement behaviour of the persons or parties concerned.

The conventional environmental management policies in China were established by the direct administrative action of the government. They were simply of a command and control nature with economic incentives playing only a supplementary role (e.g. with regard to concentration-based discharge standards). The presently applied environmental economic policies themselves have not become a coherent system, but rather remain piecemeal. The main components of the present set of policies are: the pollution levy system; a system of rewards; and channels for the investment of funds for environmental protection.

The *pollution levy system*, which has been applied in China for more than 16 years, has become the most important and fundamental part of China's environmental management system. The existing pollution levy, which is being implemented across the country, covers 113 items for the discharge of waste water, waste gases, solid wastes, noise and low-level radioactive wastes. In 1995, the number of enterprises which paid the charge was 368 200, with a total value of 3.713 billion yuan collected. This represented 0.6% of the national financial income (NEPA, 1996).

While the amount of fines collected may appear impressive, the main function of the current pollution charge is to raise revenue for on-site clean-up. The current charge rate is simply too low to provide enough incentive for significant pollution reduction. Since 1989, *ecological destruction compensation* has been introduced in some provinces and cities, mainly in the form of a product charge (Wang, 1994). A sulphur dioxide (SO_2) charge has been applied experimentally in two provinces and nine cities, where acid rain pollution is very serious. This involves a uniform charge rate of 0.20 yuan per kilogram of sulphur.

For economic incentive policies, the adjustment tax on investment for environmental protection projects is zero. In addition, certain incentives will be given for the integrated use of waste and for environmental protection products. Six investment channels have been issued by the state to encourage environmental protection, including the 'three simul taneousnesses' fund for newly built projects, a fund for replacement and innovation, a municipal maintenance fund, an ear-marked grant from the pollution levy, and a fund for waste utilization. The total state investment for environmental protection in China reached 30.7 billion yuan in 1994, which is about 0.7% of GNP (NEPA, 1995).

Problems With Existing Policies

The incentive policies of the currently implemented pollution levy system and the integrated use of wastes have played an active role in China's environmental protection. These systems and policies were formulated either under the old centralized planning economic system or during the early economic transition period. With the gradual establishment of a market economy in China, the specific contents of these policies need to be adjusted because the basis for them has changed. For example, the *pay-back principle* for the pollution levy and loan remission fund is not consistent with the 'Polluter Pays Principle (PPP)'. The channels for most of the funds for abating pollution have been weakened, because the investment context for enterprises has changed, from a soft budget limit to a hard one. Private and town-village enterprises are neither directed nor controlled by government departments and may obtain investment funds from the private capital market. In this case, the amount of funds used for reducing pollution will depend on the degree to which these enterprises decide to comply with environmental regulations rather than funding decisions from the State.

In addition, the existing environmental economic policies have not fully reflected the real value of environmental resources. For example, pollution levy is much lower than the treatment cost and damage cost caused by pollution, and the amount of the levy has remained the same for many years despite rapid economic growth and high inflation. Hence, most enterprises prefer to pay the pollution charge rather than to reduce pollution. More generally, prices for most environment-related resources are lower than their full value which causes a great waste and far more pollution than is appropriate.

The existing environmental economic policies are not systematic and an environmental economic policy system which is beneficial for the implementation of sustainable development, has not been established. Every department or agency concerned with water resource management likes to broaden its sources of income, especially by implementing a levy on water users. As a result, specific charges on wastewater by certain enterprise in some cities, are up to 11 items and the collected revenue goes to 6 government departments (CRAES, 1994). It is clear that some of these charges actually overlap or are inconsistent, resulting in efficiency. It will be more effective to integrate the existing independent charges into one integrated charge and to appoint a single department as the collector. When attention is paid to environmental protection, it is on the 'interior' part of environmental management systems (i.e. on pollution control within the larger system of production) rather than on macro-economic considerations and integration with other policies such as economic structural adjustment plans, energy development strategies, agriculture and transportation policies and fiscal and taxation policies.

A SYSTEMATIC FRAMEWORK FOR ENVIRONMENTAL-ECONOMIC POLICIES

The author believes that what is most needed is to speed up the establishment of environmental-economic policies for compliance, with greater use made of the market mechanism. In general, this system should include price signals, tax incentives, investment credit, and comprehensive environmental accounting among other features. The framework is illustrated in Figure 1.

Pricing Policies for Environmental Resources and Energy

Presently, the prices of the majority of China's products are determined by the demand and supply of the market. There are, however, some serious abnormalities in the price system, especially with regard to the low prices of raw materials and even no charges for environmental resources. Energy and some environmental resources should be gradually

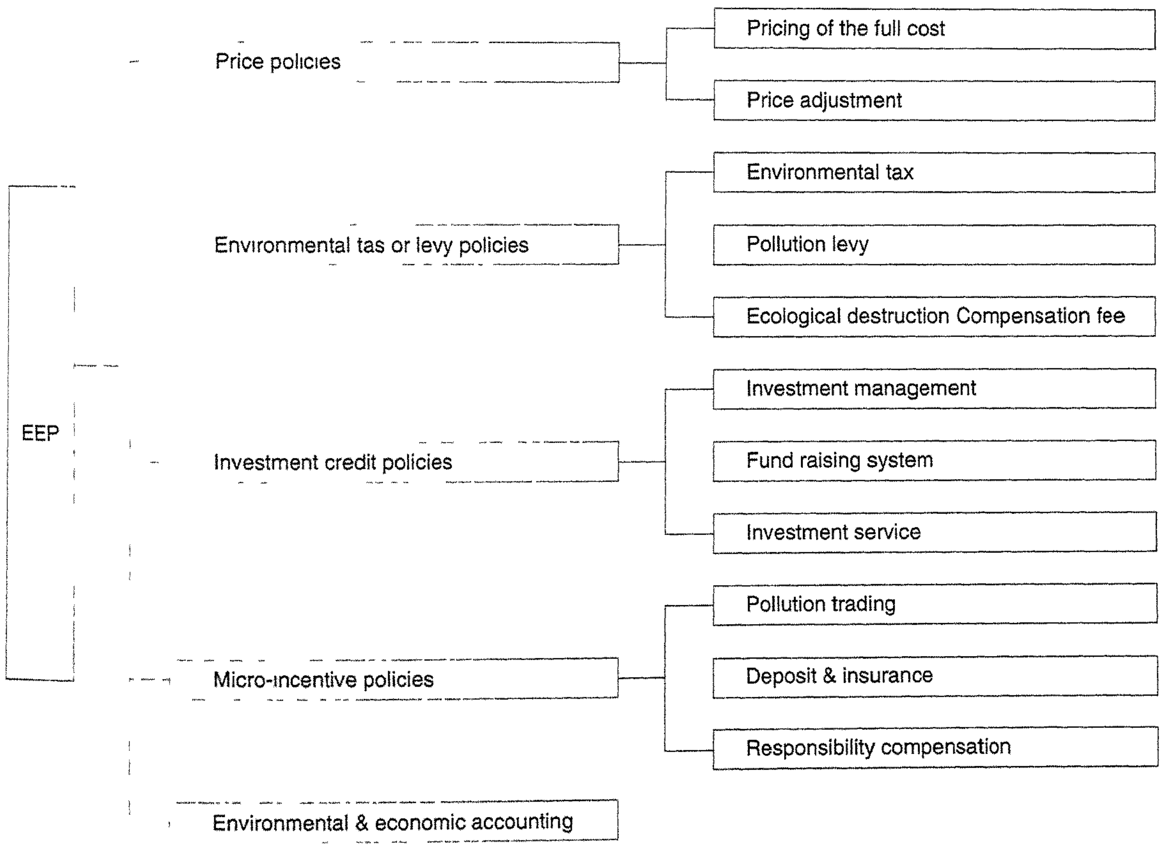

Fig. 1 Recommended framework of environmental economic policies (EEP)

put into the market directly and their value determined by supply and demand. The main areas where this should be applied include, but are not limited to, the following:

- determination of product prices based on full costs including environmental costs (which may mean adding an extra charge or tax to those products whose production, use or disposal is environmentally damaging);
- opening up the coal market and abolishing the present 'Double Channel System' of coal prices so as to gradually make it equal to the international market price as far as feasible;
- applying different price policies according to the location and local environmental quality;
- encouraging water saving and increasing energy efficiency and urban consumption of coal gas as well as crick and good coal;
- abolishing the ration system for fertilizers and pesticides as well as the subsidies for imported fertilizers and pesticides; encourage farmers to use the fertilizers and pesticides which have high efficiency, low residue and no toxicity, while gradually opening the market price for agricultural products;
- adopting economic prices (in investment planning by state enterprises for the exploitation of energy and other natural resources) to replace those directive prices which are lower than the long-term marginal cost.

Environmental Charge and Taxation Policies

An environmental charge/tax means the charges or taxes on the pollution or exploitation activity caused by all institutions and personnel exploiting and using the environmental resource. The purpose of this tax is to encourage exploiters or users to conserve environmental resources, reduce pollutant discharges and to protect the environment. Because there is no hard budget constraints for companies under the planned economy, an environmental tax or levy can only be effectively applied to internalize the external diseconomy of pollution under market economic conditions. This is the critical moment for the reform of the financial and tax system. The system suitable for the Chinese characteristics supported by financial and tax measures should include the following contents.

- Improving the existing pollution levy system e.g. by increasing the charge rate and applying it to multiple pollutants.
- To study and set up an environmental tax system (e.g. for fuel) and gradually integrate complementary resource charges collected by various resource management sectors into an 'environmental tax'. As a first step, this might be applied to some easily identified products such as CFCs, halons and lead in gasoline.
- Studying and fully implementing ecological destruction compensation charges. Here, the major factor in the charge base would be the ecological destruction degree caused in the exploitation process of natural resources. The charges might be applied to coal, oil, water, forests, grasslands, medical plants and electricity generation. This charge scheme should be integrated with current resource taxes.
- Establishing and imposing different taxes or preferential policies to support and promote the development of an environmental protection industry. In the long-term, it is suggested that the tax rate on such an environmental protection industry be reduced gradually. In the short run some established environment-friendly taxes, e.g. exemption of incorporate tax on waste-reuse or recycled products, should be implemented fully.
- Providing some tax incentives for waste products or cleaner products and waive all or part of the tax for a period of time. An incentive tax should also be granted to income from nature reserve management.

Environmental Investment and Credit Policies

Environmental protection is an activity with social benefits, so it needs government support in financial budgets, investment channels and credit markets. Government sectors should speed up the establishment of a stable investment credit system to enhance the input of more funds into environmental protection. The following practical measures should be taken.

- Establish a National Environmental Protection Fund or State Environmental Protection Investment Company under suitable conditions and set up a national environmental protection loan fund in state policy banks (e.g. development banks). The state also can issue middle or long term bonds to collect money for large-scale environmental protection and ecological engineering projects. The state should also provide incentive policies with regard to the loan rate, return conditions and depreciation.

- Fully implement the payment principle for environmental investment. For example as demonstrated by the Shenyang Municipal Environmental Protection Investment Company, it is possible to fully distribute payable uses of environmental protection investment including government financial allocation, pollution discharge levy and resource complementary levy, etc. Local environmental protection investment companies may collect funds through various channels such as middle-term bonds, stocks, foreign currency.
- Raise money through various channels to increase environmental protection investment. First, implement payable uses for environmental resources gradually, increase the pollution levy level and add an environmental tax. Second, companies should actually become investors and beneficiaries under government supervision, through the relaxation of conditions of investment credit, so that they can obtain more funds to invest, for pollution control in new construction or technology innovation projects. Third, government should increase investment in basic engineering facilities for projects with major social benefit (including socialized environmental projects).
- Increase investment benefits through the market mechanism, e.g. put the environmental protection industry onto the market as soon as possible and introduce a bidding system for environmental protection projects. As feasible, enhance and promote enterprise operation and management of some types of environmental infrastructure, e.g. public sewage plants and waste landfills.

Market-based Environmentally Incentive Policies

After the establishment of macro and middle level environmental economic policies, relevant micro-environmental economic incentive instruments must be set up to fully reflect the PPP. Besides the pollution levy and environmental tax polices mentioned above, the following environmental economic incentive instruments can also be addressed in China.

- *A pollution discharge permit trading system.* The state should summarize the demonstration experience of some areas (such as in Shanghai and Shenyang) and publish policies and regulations concerning the trading of pollution discharge permits. This system should be distributed nationwide as far as possible and coordinated with the existing pollution levy, and other measures.
- *A Deposit-refund system.* A deposit should be charged for the implementation of 'Three Simultaneity' Projects. A deposit should also be charged for the collection and treatment of hazardous products or packing products. The level of the deposit should be high enough to encourage producers and consumers to be environmentally-friendly.
- *An environmental insurance system.* An environmental insurance system should be established as feasible, to provide for compensation and economic responsibility for pollution treatment caused by non-error pollution accidents.

Integrated Accounting System for Environment and Economy

Accounting for environment and natural resources has an important meaning in determining actual national wealth, and when objectively evaluating the level of the social economic development and future development potential. It is also crucial for the appropriate coordination of the relationship between long-term development and short-term income increases, and for evaluating tradeoffs between economic development and resource and environmental protection. This system is still in the process of study worldwide. China should adopt the following measures to set up this system.

- Establish a system of environment and natural resource accounting principles and methodology, so as to strengthen information exchange on environment and economy accounting between Chinese experts and the international institutions concerned.
- Improve and reform the existing national economic accounting system, by considering the environment and natural resources debt in the accounting system.

- Select suitable sectors and areas to conduct a demonstration of an integrated environmental and economic accounting system.
- Include environmental resource accounting and environmental pollution damage, as well as ecological destruction, in the national economic accounting system.
- Establish an independent industrial sector accounting system based on environmental and natural resource regeneration in the future.

CONCLUSIONS AND OVERALL RECOMMENDATIONS

The existing environmental economic policies cannot effectively meet the needs of the emerging market economy of China. The Chinese government should use this opportunity provided by the transition economy to formulate and implement relevant environmental economic policies in compliance with market economics. The majority of China's environmental laws, regulations as well as environmental management systems have been established under planned economy or in the early phases of the transition period. Due to the large differences among different regions of China, the state should permit local governments to formulate and implement new environmental policies, and to disseminate experience according to the local characteristics.

Price policies, environmental tax policies and incentive policies for investment and credit should be formulated as soon as possible. Local funds raised through environmental taxes or the pollution levy, should be included in local taxes and resources taxes to be shared by the central and local governments.

The sectors concerned with environmental economic policies are complicated. The pre-assessment and assessment of the policies under formulation or implementation should be carried out so that adjustment and improvement can be made promptly.

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Programme-Based Pollution Control Management: The Indonesian PROKASIH Programme

Shakeb Afsah, Benoît Laplante and Nabiel Makarim

ABSTRACT

While regulation does frequently exist in developing countries, the monitoring of the regulated community and the enforcement of environmental standards are often extremely weak. As a result, incentives to comply with environmental standards and to control pollution emissions remain generally very small. It does not follow, however, that environmental regulators of developing countries have no options and should remain powerless in face of deteriorating environmental quality as a result of excessive emissions of pollution.

In Indonesia, the Ministry for Population and the Environment had limited resources to monitor or regulate industrial pollution, and the governors of provinces had no incentives to do so. As a result, the ministry decided in 1989 to focus its limited resources on implementing a programme-based approach for controlling the discharge of industrial pollution in waterways. On 19 June 1989, the ministry introduced its 'Clean River' Programme, better known as PROKASIH. The purpose of the programme is to improve water quality by seeking pollution reduction from the most important sources of water pollution in Indonesia. Though participation in the programme is *not* voluntary per se, a particular characteristic of the agreement signed by the plant is that it is not legally binding. Hence, once the agreement has been signed, *compliance* with the terms of the agreement is to a very large extent voluntary. We show that both total BOD discharges and pollution intensity from PROKASIH plants fell significantly over the period of analysis.

Keywords: *monitoring, PROKASIH, water quality, pollution reduction, voluntary, BOD discharges, Indonesia*

INTRODUCTION

Two issues in environmental economics have attracted most of the attention and research effort: the control of pollution emissions and the valuation of the costs and benefits of reducing those emissions.[1] With respect to the control of pollution emissions, most of the environmental policy debate has centred around the comparison of command-and-control (CAC) and economic instruments (emission charges, tradable permits, subsidies).[2] Recent experiments with economic instruments have revealed that a combination of both CAC and economic instruments is most likely to be efficient.[3] It remains the case, however, that the design and implementation of these approaches (or of a mix of them) are highly resource-intensive and impose stringent requirements on the regulator.

The implementation of environmental objectives is particularly demanding for environmental regula-

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tors of developing countries. Policy makers may indeed express concerns about diverting resources to pollution control when poverty, illiteracy and infant mortality are still major problems. Hence, most developing countries typically do not allocate the resources necessary to establish comprehensive and extensive systems of pollution control. This may explain that while regulation does frequently exist in developing countries, the monitoring of the regulated community and the enforcement of environmental standards are often extremely weak.[4] As a result, incentives to comply with environmental standards and to control pollution emissions remain generally very small.[5]

It does not follow, however, that environmental regulators of developing countries have no options and should remain powerless in face of deteriorating environmental quality as a result of excessive emissions of pollution. On the basis of the dataset used to analyse the impact of the Indonesian experience, we argue in this paper that a programme-based approach targeted at a specific subset of polluters can increase the incentives for pollution control, and pave the way to setting in place a reliable compliance management system.

Indonesia has achieved remarkable economic success over the last 25 years: per capita income increased annually at a rate of 4.5% after 1970.[6] This success was achieved through rapid industrialization: while manufacturing represented 13% of GDP in the 1970s, it represented 23% of GDP in the 1980s.[7] This rapid development had serious adverse impacts on the environment, especially in Java where 75% of the total Indonesian industrial activity is located. In particular, the quality of surface water has become a major source of concern.[8] Given the fast rate of industrialization and urbanization, the environmental and health costs imposed by the increasing release of pollution was expected to grow rapidly despite the presence of environmental regulations both at the national and provincial levels. The fact is that the behaviour of the regulated industries was not closely monitored, and enforcement of the environmental standards was, for most purposes, non-existent. The Ministry for Population and the Environment had limited resources to monitor or regulate industrial pollution, and the governors of provinces had no incentives to do so. Though reliable data is not available, it is widely believed that industrial plants simply ignored (or were unaware of) the environmental regulation. As a result, the ministry decided in 1989 to focus its limited resources on implementing a programme-based approach for controlling the discharge of industrial pollution in waterways. On 19 June 1989, the ministry introduced its 'Clean River' Programme, better known as PROKASIH. Upon its establishment in 1990, the Environmental Impact Management Agency (BAPEDAL) chose to use the PROKASIH programme to introduce control of industrial pollution of Indonesia's rivers and to begin implementation of the Water Pollution Control Regulations (PP20/1990), and related Ministerial Decree on Effluent Discharge (KEPMEN 03/1991).[9]

The purpose of the programme is to prevent a further decline in water quality by seeking pollution reduction from the most important sources of water pollution in Indonesia. Though participation in the programme is *not* voluntary per se, a particular characteristic of the agreement signed by the plant is that it is not legally binding. Hence, once the agreement has been signed, *compliance* with the terms of the agreement is to a very large extent voluntary.

Recent literature has pointed out the potential role of other policy tools to induce greater pollution control effort from industrial units. In particular, programmes based on 'voluntary' participation and programmes based on the provision of information to various stakeholders increasingly attract attention.[10] There is some evidence from the US experience that emissions can be reduced through voluntary programmes. Such an experience is the 33/50 Programme, initiated by the US Environmental Protection Agency (EPA) to reduce releases of 17 toxic chemicals by 33% and 50% by the end of 1992 and 1995 respectively (hence the name 33/50). Participation in the programme is voluntary, and commitments to achieve reductions are not enforceable by law. As of February 1992, more than 700 plants had committed their participation.[11] Early evidence suggests that for the period 1988–1992, toxic emissions fell by 40% (7 points above the target). After more than 20 years of CAC, the EPA claims that its 33/50 Programme is an effective alternative to traditional regulation.

The purpose of this paper is to identify the impact of PROKASIH on both total discharges of biological oxygen demand (BOD) as well as on the pollution intensity (pollution per unit of output) of participating plants. Looking at changes in BOD load is justified by the regulator's concern over ambient quality. Indeed, ambient quality is primarily affected by the total load of emissions discharged in receiving waters. Changes in total discharges is therefore of relevance to the regulator. We show that total BOD discharges from PROKASIH plants[12] fell significantly over the period of analysis. However, we also show that this aggregate result hides considerable differences in the performance of plants. In particular, the reduction in total BOD discharges has been achieved through an improvement in the environmental performance of a small number of plants.

A plant's performance can be explained by both a change in its scale of activity and by a change in its level of emissions per unit of output. We thus also look at changes in pollution intensity by PROKASIH plants. We show that the pollution intensity of PROKASIH plants fell significantly over the period of analysis. These results suggest that environmental regulators of developing countries, despite a lack of resources, can proceed forward to control pollution emissions and achieve significant results through a programme-based approach targeted at a specific subset of polluters. On the basis of that experience, there appears to be alternative policy pathways that can complement or precede the implementation of traditional command-and-control regulations in the context of limited resources.

In the next section, we discuss PROKASIH in more detail, and describe the dataset that has been used to perform the analysis. Then we analyse changes in BOD discharges by PROKASIH plants and we examine changes in pollution intensity. Finally, we discuss in more detail the role of a pollution control programme of the PROKASIH nature.

THE PROKASIH PROGRAMME AND THE DATASET

The PROKASIH Programme

The primary objective of PROKASIH is to prevent further decline in river quality. The programme is based on pollution reduction agreements co-signed by provincial vice-governors, BAPEDAL, and participating plants. In 1989, eight provinces were participating in the PROKASIH programme. This number increased to 13 provinces in 1994, 5 of which are on Java.[13] Vice-governors serve as local coordinators. In each province, an implementation team (called PROKASIH team) has been constituted with representatives from various institutions: public works, regional development planning board (BAPPEDA), health department, laboratories, environmental study centers, etc. Both BAPEDAL and the provincial governments provide financial resources to the PROKASIH team. The responsibilities of the PROKASIH team include the following:

- identification and selection of industrial units that are significant polluters;
- measurement of the quality of polluters' effluents and water ambient quality;
- data collection and reporting to BAPEDAL.

Priority is given to specific rivers, or portion of rivers where concerns over water quality are most serious, and by seeking pollution control agreements with the largest polluters along the chosen rivers. It is the responsibility of the provincial PROKASIH team to choose both the rivers and the polluters. In 1994, 1405 establishments were participating in PROKASIH. Given the importance of industrial plants in the programme (industrial plants account for 90% of participating establishments), we focus solely on these plants in this paper.

The number of PROKASIH plants varies considerably across provinces. As shown in Table 1, Jawa Barat and DKI Jakarta represent by far the largest number of participating plants, with approximately 75% of the total number in 1994. Jawa Barat itself covers 56% of the total number of plants, and exhibits a substantial increase in participation since 1990. Though both Jawa Barat and DKI Jakarta appear to be very active in terms of enrolling plants in the PROKASIH programme, it is interesting to note that they are also the two provinces where the budget of the PROKASIH team *per plant* is the smallest. As will be shown in the next section, this may explain that *none* of the PROKASIH plants in Jawa Barat and DKI Jakarta survive our selection criteria for inclusion in our final sample of analysis. In particular, plants in DKI Jakarta and Jawa Barat report their emissions at a frequency that is insufficient to estimate reliably their pollution profile.[14]

The dataset

Our objective is to construct a database that is as reliable as possible. Plants joining the programme in 1990 should have provided BAPEDAL with at least one observation for each of the year of the period of analysis (for a total of five observations). A number of plants have failed to do so and we have not in-

Table 1
Number of PROKASIH Plants Per Province

Province	1990	1991	1992	1993	1994
Jawa Barat	100	326	529	723	723
DKI Jakarta	96	193	220	228	228
Jawa Tengah	44	44	44	64	64
Jawa Timur	39	45	45	45	45
Lampung	9	30	30	34	34
Sumatera Selatan	33	33	33	33	33
Kalimantan Timur	30	30	30	30	31
Sumatera Utara	30	30	30	30	30
Kalimantan Selatan	0	0	0	0	20
Riau	0	18	18	19	19
D.I. Aceh	0	14	14	14	17
D.I. Yogyakarta	0	0	0	0	16
Kalimantan Barat	0	15	15	15	15
TOTAL	381	778	1008	1235	1275

cluded those plants in our dataset. As pointed out earlier, this is especially the case for Jawa Barat and DKI Jakarta where the budget per plant of the PROKASIH team is the smallest. Though we have not included these plants in our dataset, this strongly suggests a positive correlation between the budget of a PROKASIH team and the number of plants the team can properly monitor. We also developed a strict set of guidelines that allowed us to identify and reject observations that could not be technically explained because of extremely wide variation in pollution concentration from one observation to another in the time series.[15]

As described in Table 2, the final dataset for the period 1990–94 covers 100 plants located in 6 provinces along 24 rivers, and for which a total of 2819 observations are available (this represents an average of 5.6 observations per plant per year over the time period); the 1991–94 dataset covers 55 plants located in 5 provinces along 10 rivers, and for which 937 observations are available (for an average of 4.5 observations per plant per year).[16]

The number of plants in our dataset (100 and 55) may appear small relative to the total number of PROKASIH plants participating in the programme in 1990 and 1991 (381 and 778 respectively) . However, as shown in Table 2, none of the plants in DKI Jakarta and Jawa Barat are included in our dataset since the data from those provinces is too sparse and unreliable. If one excludes PROKASIH plants from those two provinces, the total number of PROKASIH plants in the remaining 11 provinces in 1990 is 185 (Table 1). Our 1990–94 dataset therefore covers more than 50% of the participating plants. Similarly, excluding DKI Jakarta and Jawa Barat, 74 plants became PROKASIH plants in 1991. Our 1991–94 dataset therefore covers approximately 75% of those plants. The coverage of our dataset per province is described in Table 3. Both datasets will be used to assess the overall trend in pollution load and pollution intensity of industrial sources participating in the PROKASIH programme.

In the next section, we examine the *aggregate* changes in BOD load by PROKASIH plants for each of the rivers along which PROKASIH plants are located. Then we disaggregate this result to examine the response of individual plants following their participation in PROKASIH.

CHANGES IN AGGREGATE BOD LOAD

In this section, our interest is to analyse the trend in *aggregate* BOD load by PROKASIH plants. For this purpose, let C_{it} be a measure of BOD concentration of plant i's effluent in year t, and be the average

Table 2
Description of Datasets

Provinces	*Rivers*	*Period of analysis*			
		1990–94		*1991–94*	
		Number of new plants	*Number of observations*	*Number of new plants*	*Number of observations*
Jawa Tengah	Anyar	2	46	–	–
Jawa Tengah	Bengawan Solo	2	46	–	–
Jawa Tengah	Kaligarang	2	44	–	–
Jawa Tengah	Ngringo	6	134	–	–
Jawa Tengah	Palur	1	21	–	–
Jawa Tengah	Pengo	4	92	–	–
Jawa Tengah	Pepe	1	23	–	–
Jawa Tengah	Premulung	1	25	–	–
Jawa Tengah	Sroyo	4	89	–	–
Jawa Timur	Kali Brantas	14	612	–	–
Jawa Timur	Kalı Lesti	3	132	–	–
Jawa Timur	Kali Porong	2	100	–	–
Jawa Timur	Kali Surabaya	10	518	–	–
Jawa Timur	Kanal Mangetan	1	51	–	–
Jawa Timur	Kali Mediun	–	–	6	140
Kalimantan Timur	Mahakan	8	147	–	–
Lampung	Way Pangubuan	4	80	–	–
Lampung	Way Seputih	1	20	–	–
Lampung	Way Pegadungan	–	–	5	50
Lampung	Way Sekampung	–	–	6	81
Lampung	Way Terusan	–	–	2	24
Lampung	Way Tul. Bawang	–	–	5	59
Sumatera Selatan	Kramasan	1	15	–	–
Sumatera Selatan	Musi	16	257	–	–
Sumatera Selatan	Ogan	2	33	–	–
Sumatera Utara	Asahan	5	129	–	–
Sumatera Utara	Deli	6	143	–	–
Sumatera Utara	Merbau	2	54	–	–
Sumatera Utara	Semayang	2	52	–	–
D.I. Aceh	Langsa	–	–	3	37
D.I. Aceh	Tamiang	–	–	3	39
Kalimantan Barat	Kapuas	–	–	5	119
Kalimantan Barat	Kapuas Kecil	–	–	5	119
Riau	Siak	–	–	15	269

Table 3
Coverage of Datasets per Province

PROVINCE	1990 — 1994			1991 – 1994		
	Number of Prokasih plants in 1990	Number of Prokasih plants in dataset	% coverage	Number of New Prokasih plants in 1991	Number of Prokasih plants in dataset	% coverage of new plants
Jawa Barat	100	0	0	226	0	0
DKI Jakarta	96	0	0	97	0	0
Jawa Tengah	44	23	52.3	0	0	–
Jawa Timur	39	30	77.0	6	6	100
Lampung	9	5	55.5	21	18	85.7
Sumatera Selatan	33	19	57.5	0	0	–
Kalimantan Timur	30	8	26.6	0	0	–
Sumatera Utara	30	15	50.0	0	0	–
Kalimantan Selatan	0	0	–	0	0	–
Riau	0	0	–	18	15	83.3
D.I. Aceh	0	0	–	14	6	42.8
D.I. Yogyakarta	0	0	–	0	0	–
Kalimantan Barat	0	0	–	15	10	66.6

BOD concentration of plant i's effluent in year t. Similarly, let F_{it} be a measure of flow rate by plant i in year t, and $\bar{F}_{it}$ be the average daily flow rate for plant i in year t. Let BOD_{it} be the BOD load of plant i in year t measured in kg/day. Then, BOD_{it} is given by:[17]

$$BOD_{it} = \frac{\bar{C}_{it} \cdot \bar{F}_{it}}{1000}$$

Finally, let N_j be the number of PROKASIH plants discharging in river j. Let $BODj_t$ be the total BOD load by PROKASIH plants, in river j in year t, measured in kg/day. Then, BOD_{jt} is simply:

$$BOD_{jt} = \sum_{i=1}^{N_j} BOD_{it}$$

We examine the evolution of the variable BOD_{jt} for both the 1990–94 and 1991–94 dataset, along each of the PROKASIH river. Results are presented in Table 4 and Table 5 for each dataset, and then grouped into three categories in Figures 1, 2 and 3 according to whether aggregate BOD discharges increase, decrease or are uncertain along each of the river. As can be observed, the evolution of total BOD load is of a similar nature for both datasets: there are strong indications that total BOD discharges from PROKASIH plants have been significantly reduced in 18 of the 34 rivers in our dataset. However, in 9 rivers, BOD discharges by PROKASIH plants have reached higher levels in 1994 than in 1990 or 1991. In the aggregate, total BOD discharges fell significantly over the period of analysis. In Table 4, while aggregate BOD discharges by the 100 plants were 65 077 kg/day in 1990, these discharges fell to 41 846 kg/day in 1994, a decline of 36.25%; in Table 5, total discharges fell from 106 147 kg/day in 1991 to 59 489 in 1994, a reduction of 44%.

That such reductions were achieved by PROKASIH plants is certainly of clear interest to BAPEDAL. However, of potentially greater significance for BAPEDAL is the clear indication, in Figure 1, that BOD load is on an upward trend in 1993 and 1994. Though additional data will reveal whether or not this trend persists, it is worth pointing out that a number of factors may explain this development. First, it should be noted that total BOD discharges increase, ceteris paribus, with actual production. The important economic growth rate currently experienced by Indonesia may therefore explain this

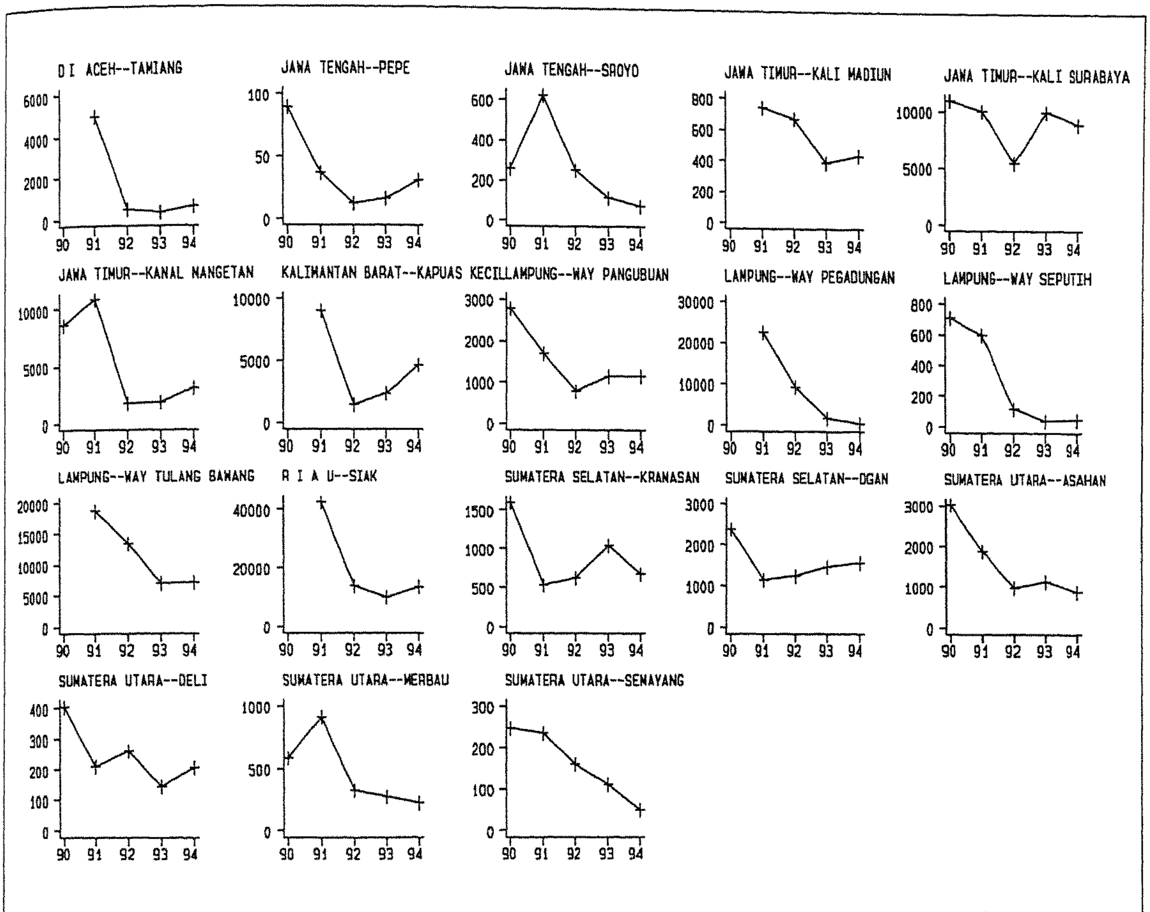

Fig. 1 PROKASIH rivers where average BOD load per day declined 1990–94 and1991–94 (BOD in kg per day).

increase in BOD discharges. It is important to note that these increases could take place *despite* greater pollution control efforts by PROKASIH plants. This is why we examine, in the next section, BOD emissions *per unit of output* (pollution intensity), instead of total BOD discharges. Second, for some rivers, the number of participating plants in our dataset is small. Finally, this upward trend could also indicate that there may be a limit to the ability of a programme of the nature of PROKASIH (in which agreements to reduce emissions are not legally binding) to induce *persistent* pollution control efforts on the part of the firms. This may be particularly the case in a situation where industrial growth is rapid, and where the enforcement of the environmental regulation has traditionally been, and to a large extent remains, lacking.[18]

In the next section, we analyse the data at the plant level, and seek to identify the individual contribution of the plant to the overall BOD reduction measured above.[19] We also examine changes in pollution intensity and suggest, through counterfactual analysis, that the impact of PROKASIH may be larger than measured above.

CHANGES IN BOD LOAD AND POLLUTION INTENSITY AT THE PLANT LEVEL

In this section, we analyse the pattern of plant-level responses, using pooled data across rivers from the 1990–94 dataset.[20] First, we examine changes in BOD load, and then analyse changes in pollution intensity.

BOD load

Before looking at the details of the plant-level re-

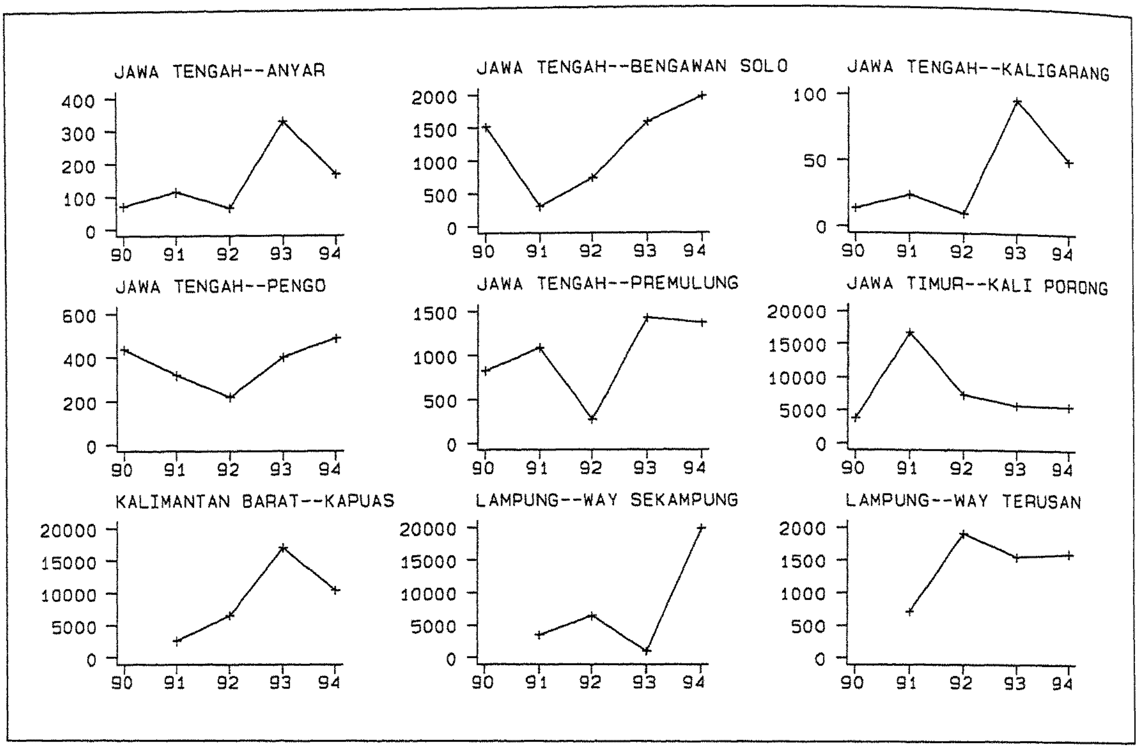

Fig. 2 PROKASIH rivers where average BOD load per day increased 1990–94 and 1991–94 (BOD in kg per day).

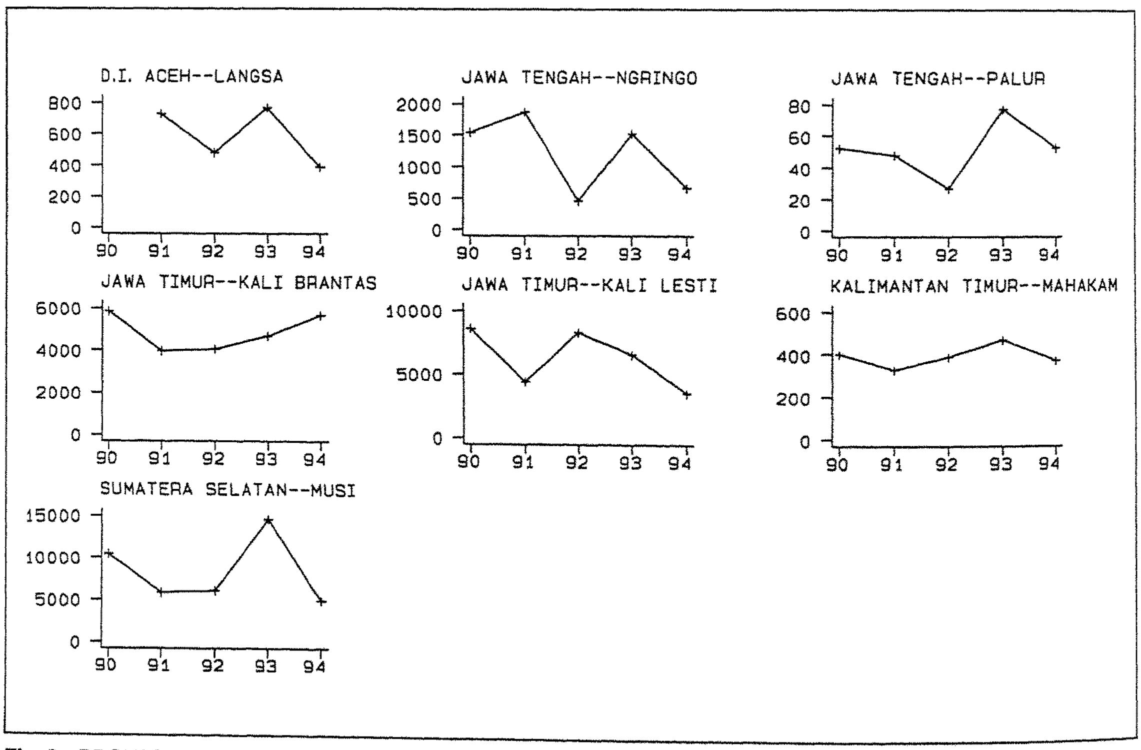

Fig. 3 PROKASIH rivers where average BOD load per day trend is uncertain 1990–94/1991–94 (BOD in kg per day).

Table 4
Percentage Change of BOD Load by River (1990–94)

Province	*River*	*1990 kg/day*	*% change 1990–91*	*% change 1990–94*
Jawa Tengah	Anyar	70	62	141
Jawa Tengah	Bengawan Solo	1519	–80	29
Jawa Tengah	Kaligarang	14	79	277
Jawa Tengah	Ngringo	1542	21	–57
Jawa Tengah	Palur	52	–9	1
Jawa Tengah	Pengo	436	–27	11
Jawa Tengah	Pepe	89	–58	–65
Jawa Tengah	Premulung	826	31	65
Jawa Tengah	Sroyo	255	143	–73
Jawa Timur	Kali Brantas	5842	–32	–3
Jawa Timur	Kali Lesti	8624	–49	–59
Jawa Timur	Kali Porong	3771	346	51
Jawa Timur	Kali Surabaya	10913	–8	–18
Jawa Timur	Kanal Mangetan	8575	26	–63
Kalimantan Timur	Mahakan	400	–18	–7
Lampung	Way Pangubuan	2784	–39	–59
Lampung	Way Seputih	709	–16	–94
Sumatera Selatan	Kramasan	1599	–66	–58
Sumatera Selatan	Musi	10406	–44	–53
Sumatera Selatan	Ogan	2391	–52	–35
Sumatera Utara	Asahan	3022	–38	–71
Sumatera Utara	Deli	405	–48	–49
Sumatera Utara	Merbau	586	56	–62
Sumatera Utara	Semayang	247	–5	–80

Table 5
Percentage Change of BOD Load by River (1991–94)

Province	*River*	*1990 kg/day*	*% change 1991–92*	*% change 1991–94*
Jawa Timur	Kali Mediun	743	–10	–41
Lampung	Way Pegadungan	22670	–59	–98
Lampung	Way Sekampung	3463	85	473
Lampung	Way Terusan	717	166	124
Lampung	Way Tul. Bawang	18627	–28	–61
D.I. Aceh	Langsa	729	–34	–47
D.I.Aceh	Tamiang	4993	–90	–87
Kalimantan Barat	Kapuas	2594	153	306
Kalimantan Barat	Kapuas Kecil	9024	–83	–48
Riau	Siak	42587	–67	–68

sponses, it is interesting to rank the PROKASIH plants in terms of their individual contribution to total BOD discharges. In order to do so, we have computed an index that is similar in nature to the Lorenz curve developed in industrial organization.[21] Let BOD_{90} be the total BOD load, in 1990, by the 100 plants of the 1990–94 dataset:

$$BOD_{90} = \sum_{i=1}^{100} BOD_{i90}.$$

Then rank the plants such that $BOD_{190} > BOD_{290} > \cdots > BOD_{10090}$. The curve in Figure 4 represents the ratio $= \sum_{i=1}^{n} BOD_{i90}/BOD_{90}$ accounted for by the fraction n / 100 of the largest plants in the dataset. When computed for the entire dataset (n = 100), the ratio is equal to 1. In Figure 4, the x-axis represents the cumulative proportion of plants, while the y-axis represents the cumulative proportion of total BOD accounted for by these plants. If each plant were contributing equally to aggregate discharges ($BOD_{190} = BOD_{290} = \ldots = BOD_{10090}$), the computation of the ratio described above would yield a straight line diagonal in Figure 4. The black curve indicates very clearly, however, that this contribution is far from being uniform: 50% of total BOD discharges is accounted for by less than 10% of the plants; 20% of the plants accounts for approximately 75% of total BOD discharges in 1990. Without any doubt, this suggests that most of PROKASIH's impact on total BOD discharges crucially depends on the behaviour of a relatively small number of plants. A large reduction in BOD discharges by the largest 10% of the plants would significantly reduce pollution emissions. On the other hand, if 50% of the plants at the bottom end of the distribution were abating their emissions from current levels to zero, total discharges would fell by less than 5%.

There are various ways by which one can analyse the contribution of each individual plant to *changes* in total BOD load during the period of observation, and identify the extent to which these

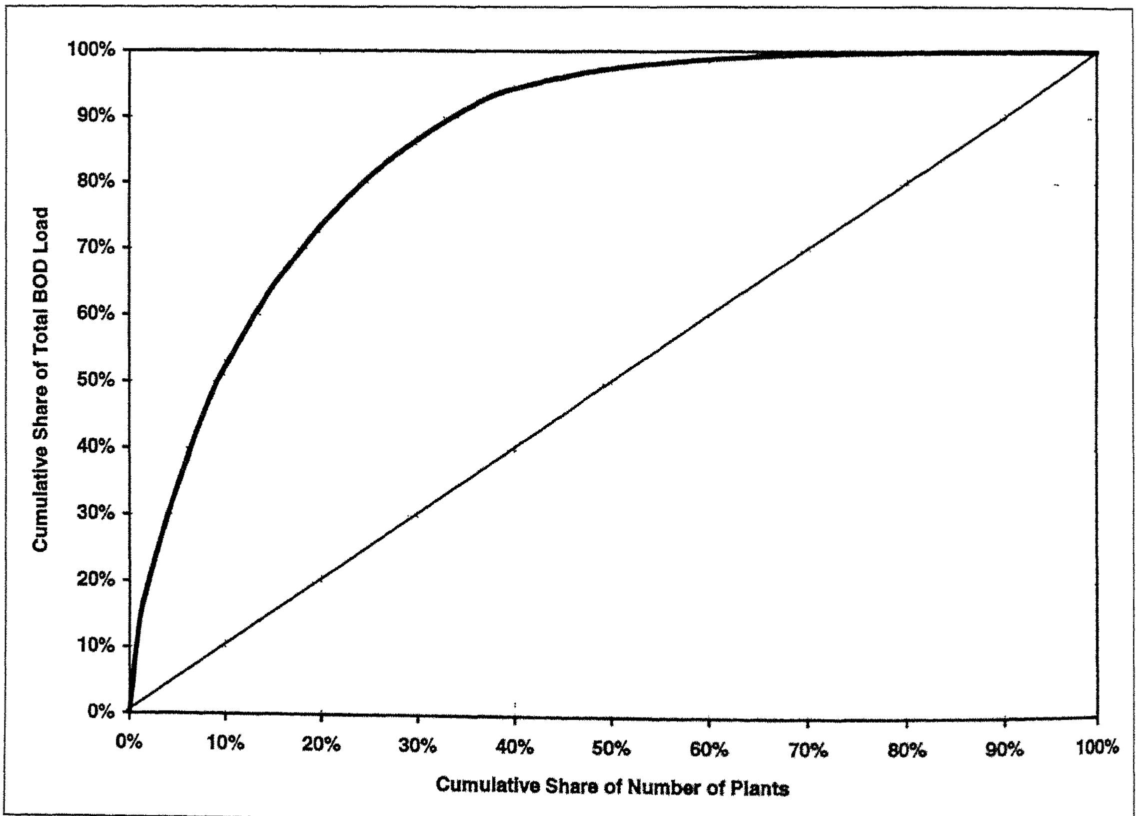

Fig. 4 Distribution of BOD load-1990.

changes are driven by the behaviour of a relatively small number of plants. In order to account for the large variation in the BOD discharges across plants, an interesting way to analyse the contribution of individual plant to changes in total BOD load is to express the change in total BOD discharge between 1990 and any given subsequent year t (%DBOD$_t$), as a weighted sum of the changes by each individual plant (%DBOD$_{it}$), with the weight being the plant's contribution to total BOD discharge in 1990 (s_i). The percentage change in total BOD discharges between 1990 and any subsequent year t is given by:

$$\%\Delta BOD_t = \frac{BOD_t - BOD_{90}}{BOD_{90}}$$

After some manipulation, this can be rewritten as:

$$\%\Delta BOD_t = \sum\left[\frac{BOD_{it} - BOD_{i90}}{BOD_{i90}} \bullet \frac{BOD_{i90}}{BOD_{90}}\right]$$

which becomes:

$$\%\Delta BOD_t = \sum_i s_i \bullet \%\Delta BOD_{it}$$

Hence a large variation in the BOD load of a plant which accounts for only a small portion of total BOD discharges will have only a small effect on total BOD load. Conversely, large changes from plants accounting for a large share of total BOD load in 1990 will have a significant impact on the total measure. To illustrate, we have arranged the contribution of individual plants in descending order, from the largest *positive* contribution to changes in total BOD discharges (i.e. firms increasing their BOD load) to the largest negative contribution (firms decreasing their BOD load).[22] Results appear in Figure 5.

From the figure, it appears clearly that many plants did not meet the terms of their pollution reduction agreements. Indeed, over the period 1990–91 and 1990–94, approximately 10 plants increased their BOD load significantly. The figure also suggests an extremely skewed distribution of plant contributions to total changes in BOD discharges. In particular, the bulk of the reduction in BOD load is explained by less than 20 plants. Most strikingly, more than 65% of the plants had a negligible impact on the change in BOD load.

As a result of these changes, the distribution of BOD load across the 100 plants of our dataset changes significantly from 1990 to 1994. This is illustrated in Figure 6 where the dotted line represents plants' share of total BOD load in 1990, ranked from the plant with the largest share (in 1990) to the plant with the smallest share.[23]

In 1990, the plant with the largest share ex-

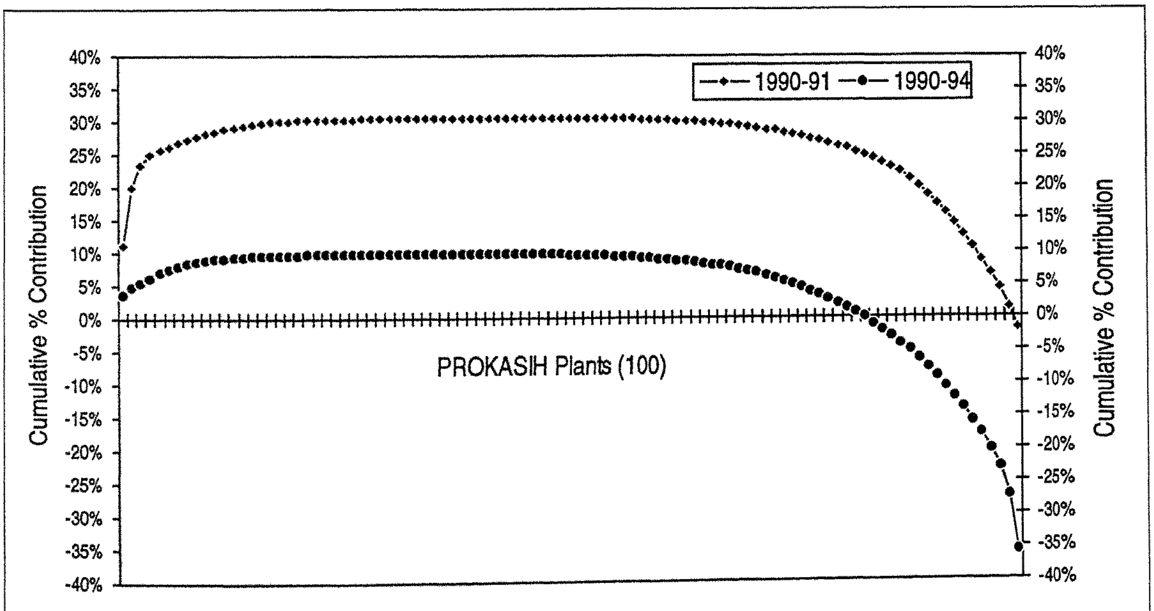

Fig. 5 Change in BOD load contribution-share by plant.

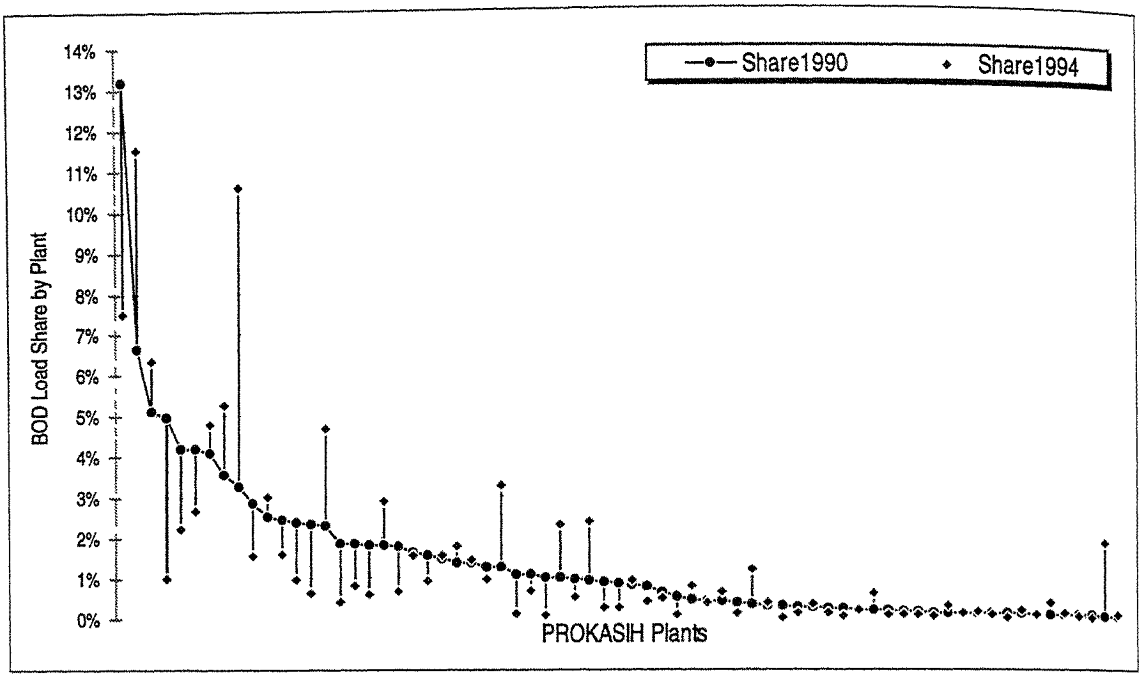

Fig. 6 BOD load share trend by plant.

plained approximately 13% of the total BOD load of the plants in our dataset; this same plant explains 7.5% of total BOD load in 1994. In general, the 'pollution share' of individual plants fell significantly between 1990 and 1994. However, some plants exhibit a very sharp increase. For example, plant number 9 went from 3% of BOD share in 1990 to almost 11% in 1994. Such plants would obviously be prime targets for further intervention if so desired.

We have noted before that BOD load by PROKASIH plants in our dataset fell significantly from 1990 to 1994. The current results, however, strongly indicate that the overall reduction in BOD discharges is actually driven by a small number of plants in the dataset. Indeed, some plants have increased their discharges and a large proportion of the plants did not have any significant impact on BOD load (either because of their small size or because indeed their BOD load has not changed). Hence, though one may claim that PROKASIH has been successful at reducing total BOD load in the PROKASIH rivers, a closer examination reveals that the plants' response to PROKASIH varies considerably across plants.

Thus far, we have simply compared the BOD discharges in 1990 to the discharges in subsequent years. Since the regulator is primarily concerned with ambient quality of the receiving waters, changes in BOD load is clearly of relevance. Such a comparison ignores the fact that were it not for the programme, BOD discharges could have been much higher than those observed. Indeed, total BOD discharges are a function of both the plant's scale of activity (ceteris paribus, the higher the level of output, the higher the level of discharges), and the BOD intensity (BOD load / total output). Changes in total BOD discharges will reflect changes in both of these parameters. Therefore, an important indicator of the impact of PROKASIH is changes in pollution intensity: constant BOD discharge from a rapidly-growing plant (which can happen only if pollution intensity falls) is clearly a sign of environmental progress.

Changes in pollution intensity

In this section, we first want to examine changes in pollution intensity, and on the basis of these changes, provide a counterfactual analysis indicating that the impact of PROKASIH on BOD discharges may be larger than measured above. In order to perform this exercise, we must first identify plants for which production data is available and then calculate pollution intensity for each of the years of interest. As noted before, for the purpose of this analysis we are forced to use 1993 as the end year instead of 1994 since we have access to production data only up to 1993. From our 1990–94 dataset, we are able to identify 73 plants in the statistical data base for which production data is available. For each of those plants we have calculated pollution intensity for each of the year over the period 1990–93, and then normalized the median 1990 pollution intensity to 100. Results are depicted in Figure 7, and are stunning. Despite the increase from 1992 to 1993, the median BOD intensity fell by approximately 55% between 1990 and 1993. This is very significant. It suggests that considerable pollution control effort can be generated from a subset of plants even in circumstances where resources devoted to monitoring and enforcement activities are lacking.

That PROKASIH had an impact on pollution intensity can be supported, to a certain extent, by looking at plants' investment in primary and secondary effluent treatments after PROKASIH was launched in June 1989. In Figure 8, it appears clearly that installation of wastewater treatment systems increased significantly since 1989. The lack of data does not allow us to link unambiguously this activity to the introduction of PROKASIH. However, such activity is consistent with what we have observed in terms of reduction of pollution load and pollution intensity over the period 1990–94.

The change in pollution intensity, as observed above, suggests that we may have underestimated the impact of PROKASIH on total BOD discharges. Indeed, let us assume that without PROKASIH, pollution intensity in 1993 would have been the pollution intensity observed in 1990. Then it is easy to show the extent by which we have thus far under-estimated the impact of PROKASIH. This is illustrated in Figure 9. In the figure, the curve labelled BOD_0 (or BOD_1) represents every combination of intensity and output that yield a BOD load equal to BOD_0 (or BOD_1). Note that $BOD_1 > BOD_0$. Let us suppose a plant in 1990 with a pollution intensity I_0 and an output Q_0 thus yielding a BOD load equal to BOD_0. This is represented by the surface $0I_0AQ_0$. Let us suppose that this same plant increases its output to Q_1 in 1993 while decreasing its pollution intensity to I_1, yielding a pollution intensity equal to BOD_1. This is represented by the area $0I_1BQ_1$. If we simply compare BOD_1 to BOD_0, we would conclude, as we did in the previous section, that BOD load *increased* despite the presence of PROKASIH. However, if we take into account the impact of PROKASIH on pollution intensity, then this conclusion is wrong. Indeed, if pollution intensity in 1993 had remained at the 1990 level, that is I_0, then given the output level Q_1, this plant would have produced a total amount of BOD represented by the area $0I_0CQ_1$. Hence, the impact of PROKASIH is actually to *reduce* BOD load by the shaded area I_1I_0CB. In other words, though we may observe an increase in BOD load in 1993 (from BOD_0 to BOD_1), without PROKASIH actual BOD discharges would have

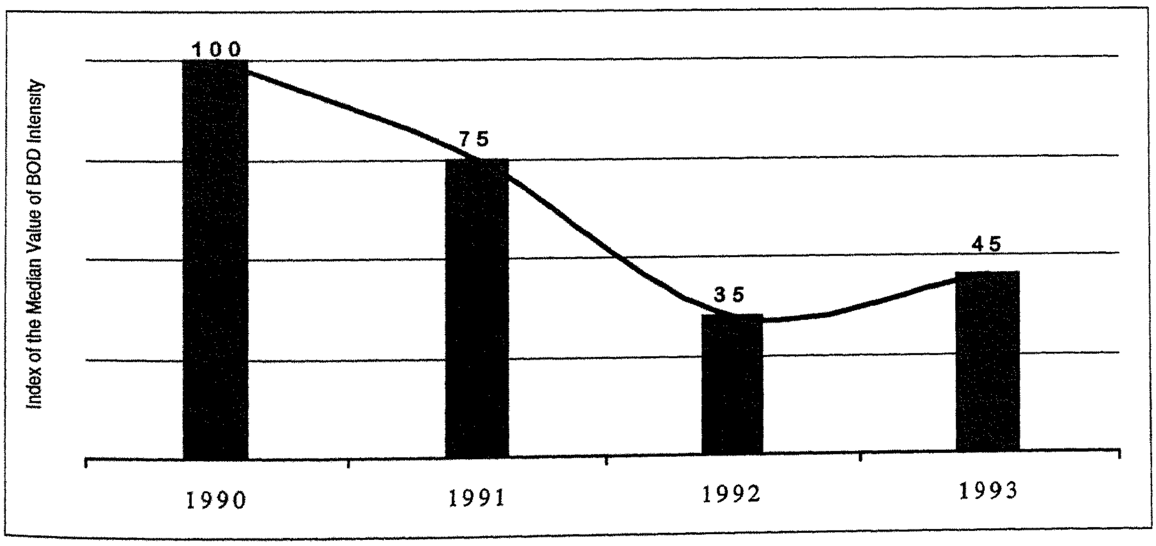

Fig. 7 Changes in median value of BOD intensity (index 1990 = 100).

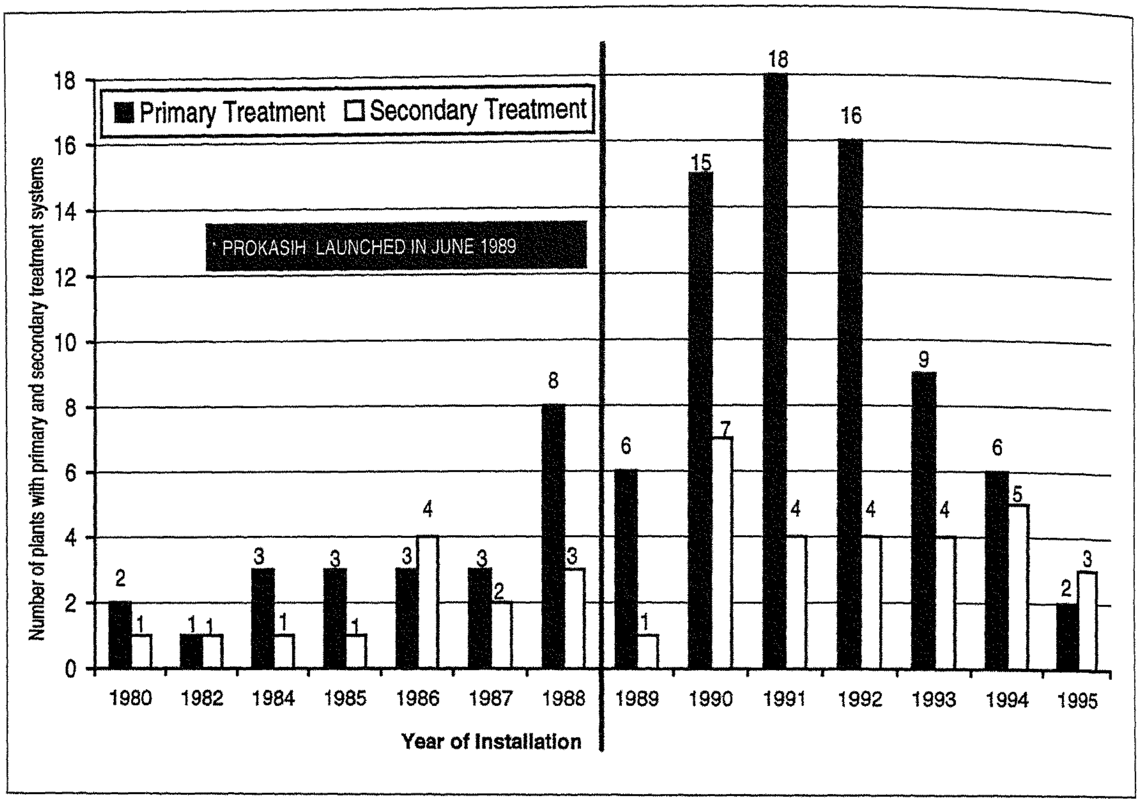

Fig. 8 Installation of new waste water treatment system.

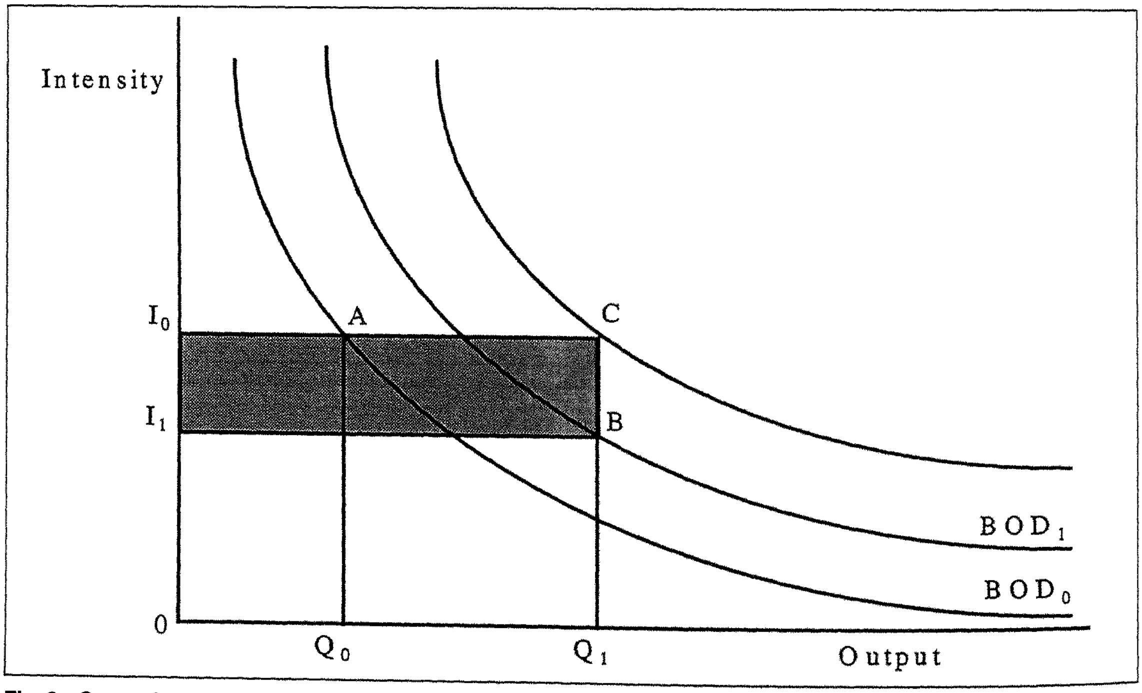

Fig. 9 Counterfactual analysis.

been even higher than BOD_1. The impact of PROKASIH can therefore be measured by the difference between 'what would have been', and 'what is'.

It is possible to obtain an estimate of the amount by which we underestimate the impact of PROKASIH plants in the dataset by looking solely at those plants that have shown a decrease in pollution intensity between 1990 and 1993.[24] Of those 73 plants, 40 exhibited a reduction in pollution intensity, and 33 an increase. If we simply calculate the BOD load in 1990 and 1993 for those 40 plants, we observe a reduction of 21 596 kg per day. However, assuming that these plants would not have exhibited a decrease in pollution intensity, this reduction becomes 65 687 kg per day. This, therefore, indicates that we underestimate the impact of PROKASIH by a considerable margin. Though this is obviously a gross estimate of what may really be the impact of PROKASIH, the purpose of the exercise performed above is to indicate that the simple comparison of BOD load in any two given years is likely to yield a distorted image of that impact.

DISCUSSION

Our analysis of the PROKASIH experience, though based on limited observations, suggests that there does exist a group of plants that have exerted effort to control pollution emissions despite the absence of a reliable regulatory framework and credible monitoring and enforcement capability. However, our analysis also shows that there also exists plants which despite their participation into PROKASIH, have typically not exerted such effort. A significant contribution of a programme like PROKASIH is to delineate plants willing to exert pollution control effort from those less inclined to do so. Indeed this division should provide useful information for BAPEDAL, and set the stage for further and more focused intervention if needed. Moreover, the desire to control and monitor closely the environmental performance of a limited number of plants, confronts the regulator to the need of setting and implementing a system by which performance is going to be measured and analysed reliably. It forces the regulator to confront issues of *implementation* of the objectives of the programme, and more broadly, of the objectives of environmental regulations. Issues of self-reporting, information, inspections, compliance assessment, etc. must be dealt with. Such a compliance system is lacking in most developing countries, and to a large extent, is still lacking in Indonesia.

PROKASIH has now reached a point in its development where a certain number of issues have to be dealt with, whether BAPEDAL wishes to focus its effort on current PROKASIH plants or to expand the number of participating plants. Important issues include, among others, the reliability of the data collected by the PROKASIH teams in each of the provinces; the possibility for these teams and BAPEDAL to process and analyse the information; and the monitoring capability of PROKASIH teams. It is important to point out once again that the analysis performed above relies heavily on information provided by provincial PROKASIH teams to BAPEDAL. Though it is possible, as we have done so, to evaluate the quality and reliability of the data reported, the frequency at which PROKASIH teams collect information about the pollution content of the polluters' effluents remains very low. It shall be remembered that out of the 778 plants that have joined the programme in 1990 and 1991, only 155 provided sufficient reliable data on which to base our analysis. Though we hope this dataset to be representative of the entire populaiton, clearly much work has to be done to improve plants' self-reporting as well as PROKASIH teams' data collection system. This is particularly a source of concern given the possibility of mistakes in the sampling and analysis of the plant's effluents. Similar mistakes can obviously be performed by PROKASIH teams themselves when sampling a plant's effluents. Finally, given the limited monitoring and enforcement capacities of BAPEDAL, the expected costs of under-reporting true emissions levels, or simply avoiding self-reporting may be small.

BAPEDAL must face these issues to preserve and augment the integrity of its PROKASIH programme. Plants participating in PROKASIH must be expected to submit measures of the quality of their effluents at regular and frequent intervals; these measures must be performed according to a given set of rules to minimize the possibility of sampling errors; the way in which these measures are reported to PROKASIH teams must be standardized so as to minimize the costs of information processing; and PROKASIH teams must have the resources necessary to perform sufficient sampling and analysis to validate the plants' self-reports. To summarize, a compliance management system must be set to collect data from the plants participating in PROKASIH, and to process, analyse and validate the data thus collected. This must be done without significantly increasing the costs for plants which participate in PROKASIH. The reliability of such a management system is crucial to establish PROKASIH's credibility and to allow PROKASIH to achieve fully its role and impact. PROKASIH forces BAPEDAL to confront those issues. Once this framework is in place, BAPEDAL will be in a position to expand its programme to other plants. It will also be in position to use a broader mix of instruments aimed at controlling industrial pollution, such as pollution charges.

BAPEDAL has recently adopted a programme known as PROPER PROKASIH. The purpose of this programme is to announce publicly the environmental performance of plants, and in particular to indicate, through a colour scheme, how the plant deviates from the environmental standards defined in KEP03/MENKLH/II/1991. The programme was introduced partly as a response to the trend observed in the 1993 and 1994 total discharges of PROKASIH plants. The viability and reliability of this programme crucially depends on BAPEDAL's ability to set in place a comprehensive compliance management system.

CONCLUSION

In this paper, we have analysed the impact of Indonesia's PROKASIH programme on BOD discharges. We have shown that total BOD discharges from a subset of participating plants have been significantly reduced since the introduction of PROKASIH. We have also shown that if it were not for PROKASIH, total BOD discharges would most likely have been considerably higher than the levels observed in 1990. However, we have also shown that this overall performance is the result of a very heterogeneous response by a small number of individual plants. Indeed, less than 25% of the plants accounted for the observed reduction in total BOD load; most of the plants did not have any significant impact on overall reduction of BOD discharges.

The Indonesian experience suggests that a programme like PROKASIH can be a feasible and cost-effective strategy in the initial stages of the development of a comprehensive framework of public intervention to improve environmental quality. They can lead to significant pollution reduction within a relatively short period of time, and at the same time set into motion the development of a *compliance management system* that is necessary to implement any programme aimed at reducing industrial discharges to improve environmental quality.

A correct measure of the full impact of PROKASIH remains to be developed. In particular, as pointed out above, a large number of plants have failed to report their emissions. This needs to be improved. Moreover, though the ultimate objective of PROKASIH is to prevent a further decline in ambient quality of important rivers in Indonesia (or to prevent their further deterioration), we are unable at this point in time to link changes in emissions by PROKASIH plants to changes in environmental quality. The location of PROKASIH and non-PROKASIH plants along every PROKASIH river is known. However, data on discharges of non-PROKASIH plants and non-industrial facilities is clearly insufficient to isolate the impact of discharges by PROKASIH plants. The location of monitoring stations would also have to be modified for this impact to be accounted for. However, given the objective of PROKASIH, its long-term sustainability may very well depend on its ability to demonstrate that ambient quality is improving as a result of the programme. Finally, we have not analysed the characteristics of the plants that have participated in the programme (versus not participated), and of those that have reduced their BOD load (versus increased). These issues remain the object of on-going research.

ACKNOWLEDGEMENTS

We are grateful to everyone in the PROKASIH team who have allocated time and effort to answer our numerous questions, and assemble the data necessary to conduct this analysis. We also thank the two anonymous referees, John Patterson, David Wheeler, David Witzel, and Muhammad Zakaria for valuable comments and suggestions. The usual disclaimers apply.

NOTES

1 Cropper and Oates (1992) provide a survey of each of these issues.
2 Bohm and Russell (1985) summarizes the relative advantages of each approach.
3 For example, economic instruments are not easily tailored to location-specific environmental damages. In such circumstances, interventions of a CAC nature may complement the use of economic instruments. See Hahn (1989), Hahn and Hester (1989) and OECD (1989, 1991) for more details. Moreover, the use of an emission charge to meet a given target requires information that is not readily available. Baumol and Oates (1971) suggests a simple iterative process to achieve a given level of emissions reduction in the absence of information on marginal abatement costs. However, this process ignores the fact that firms undertake significant investment when facing a given charge, and that this investment may not be optimal once the charge is changed. There could therefore be large costs associated with changing the tax rate. Moreover, the process proposed by Baumol and Oates ignores the fact that firms engage in strategic behaviour vis-à-vis the regulator. The welfare properties associated with this strategic interaction has been recently analysed by Karp and Livernois (1994).
4 It should not be implied that monitoring and enforcement issues have been solved in the United States (and more generally in developed countries). Russell (1990) writes: 'What is missing is a commitment of resources to checking up on whether those covered by the law and regulations are doing (or not doing) what is required of (or forbidden to) them.' (p. 243). In a recent study, the General Accounting Office (1993) concludes that the EPA cannot ensure the accuracy of the pollution data reported by polluters. In Quebec, while 59 pulp and paper plants were in operation during the period 1985–1990, there has been a total of only 54 sampling inspections by the Ministry of the Environment (Laplante and Rilstone (1995)).
5 See O'Connor (1994) for more details.
6 Per capita income was US$50 in the late 1960s. It was estimated to be US$650 in the late 80s. Poverty fell drastically (from 70 million individuals to approximately 27 million); life expectancy rose from 41 years in 1960 to 61 years in 1990; primary school enrolment nearly tripled and secondary school enrolment increased eight-fold.
7 Total industrial output has increased 8-fold since 1970. This development was accompanied by a rapid increase of Indonesia's urban population from 15% to 30% of total population. This was particularly true on the Island of Java, which accounts for 60% of the Indonesian population with a population density that is among the highest in the world. For more details on Indonesia's economic development, see World Bank (1994).
8 Water is estimated to be an important factor of disease in Indonesia as most water sources are considered unsafe to drink. The benefits of solely reducing the diarrhea-related mortality by 50% were estimated to be in the order of US$300 million in 1990 (World Bank, 1994). This number ignores the gains from reducing the effects of water pollution on morbidity. Air pollution and toxic wastes are also important issues. However, in this paper we focus solely on water pollution.
9 Because of its limited resources, BAPEDAL created a programme called JAGATIRTA whose purpose is to respond to complaints raised by local communities. The programme is therefore extremely focused, and a follow-up is made only on those complaints judged by BAPEDAL to be significant.
10 On the role and impact of information provision programmes, see Hamilton (1995), Kennedy, Laplante and Maxwell (1994), Laplante (1995), Laplante and Lanoie (1994), and Muoghalu et al. (1990).
11 Arora and Cason (1995) analyse the characteristics of the plants participating in the 33/50 programme. In particular, they show that large plants are most likely to participate.
12 We use the expression 'PROKASIH plants' to identify plants that are participating in the programme.
13 Four new provinces became PROKASIH provinces in 1995/96: Bali, Sulawesi Selatan, Manado, and Jambi.
14 Appendix 1 describes the process by which BAPEDAL collects information from PROKASIH plants.
15 These guidelines are available upon request.
16 In view of the data limitation, our results and conclusions as to the impact of PROKASIH should be interpreted with care and applied only to those PROKASIH plants that have reported a sufficiently large number of reliable data. Without further information, it is not possible to say the nature of the bias we have introduced by selecting plants along the criteria mentioned above. However, we have taken care to delete data that would have led us to overestimate the impact of PROKASIH.
17 (mg / litre) * (cubic metre / day) = (mg / litre) * (1000 litres / day) = kg / day.
18 As mentioned earlier, currently most enforcement actions are undertaken through JAGATIRTA following complaints of local communities. The number of such actions is very limited.
19 It should be noted at this point that no attempt is made in this paper to obtain a measure of the relationship between ambient concentration at any given point along the rivers and BOD discharges of individual plants; nor is an attempt made at measuring in dollars the impact of BOD discharges in any given river by any given plant. If the PROKASIH plants in our dataset were the only sources of BOD discharges, this exercise could be performed, albeit obtaining a dollar measure of marginal damages would still be problematic. However, (1) we have eliminated a significant number of PROKASIH plants due to a lack of data; (2) PROKASIH plants are not the only industrial sources of BOD discharges along a river; and (3) one must also account for non-industrial sources of BOD discharges. These are the object of ongoing research.

20 For the purpose of this section, we are solely using the 1990–94 dataset since it offers a longer period of observations. This is particularly important for the analysis of pollution intensity since we have output data up only to 1993. The 1991–94 dataset would thus offer only 3 years of observation.

21 The Lorenz curve shows the percentage of total industry sales accounted for by any given fraction of the firms of the industry, with the firms ranked in decreasing order of market share.

22 In other words, we have ranked the plants so that s_1 %$DBOD_{1t}$ > s_2%$DBOD_{2t}$ > ... >s_N%$DBOD_{Nt}$. It shall be understood that the plant with the largest positive contribution is not necessarily the plant that has increased the most its BOD discharges since our index accounts for the plant's share in total BOD discharges in 1990.

23 For the purpose of clarity, we have truncated the figure at n = 64. The individual share of the plants not represented in Figure 6 is close to zero in both 1990 and 1994.

24 For the plants whose pollution intensity has increased in 1993, it becomes hazardous to calculate the extent of the under-estimation. Indeed, if the impact of PROKASIH is to reduce pollution intensity, then we can only conclude that in those circumstances, the intensity would have been even higher than the one observed. However, it would be difficult to identify what would have been that pollution intensity. We therefore prefer simply to ignore these situations and work solely with the plants that have shown a decrease in pollution intensity.

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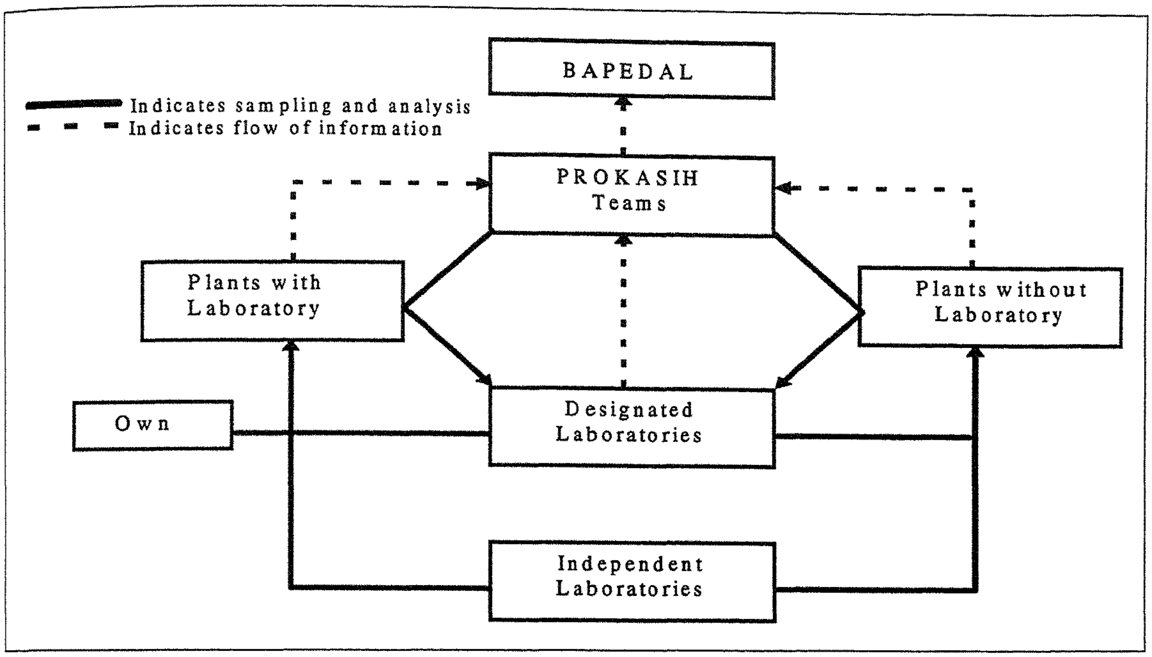
APPENDIX 1

Information Collection by BAPEDAL



Upon agreeing with BAPEDAL on a target level of pollution, it is understood that plants will periodically measure the pollution concentration of their effluents, and flow rates (m^3 of water/day). Plants without laboratory facilities must have their samples analysed by independent laboratories or by PROKASIH-designated laboratories; plants with laboratory facilities can also use these independent and designated laboratories. PROKASIH teams collect information from two different sources. First, they have access to the data collected by the plants themselves (whether analysed by independent, designated or plants' laboratories). This is in some sense similar to a system of self-reporting, the difference being that PROKASIH teams must visit the plants and collect the information. Second, they can themselves perform a sampling and analysis of the plant's effluents. The information collected from these two sources is then transferred to BAPEDAL.

Revisiting Community Forestry Developments in Nepal: A Selected Review of Performance

Niaz Ahmed Khan

ABSTRACT

Of late, Nepal experienced an unprecedented enthusiasm for 'community forestry' (hereafter, CF) development. CF's lofty goals included 'empowerment' of and greater 'social equity' for local communities through their increased participation in the decision making, management and benefit sharing of the afforestation schemes. However, the achievement of CF's lofty goals have been insignificant and marginal. Although there has been some progress in the achievement of physical targets (e.g. plantation establishment, nursery raising, seedling distribution), the more crucial participatory goals (e.g. the promotion of social equity, participation, or empowerment) have largely remained unrealized. The paper argues that CF's performance is conditioned by the socio-institutional context, within which CF projects operate. The paper sheds light on certain unfavorable contextual factors (e.g. social relations, power structures, state forestry organization, local institutions); and concludes that, notwithstanding the national propaganda, CF as it is practised in the field, is yet another routine bureaucratic rural development programme.

Keywords: *community forestry, forestry organization, Nepal, participatory goals, physical goals, social relations*

INTRODUCTION

Nepal has a land area of 147 181 km^2 and a population of about 19 million (Kayastha 1991:12); 42.8% of the total land area is either forest or shrub land (Bartlett 1992:96). The natural forest was reduced by about 570 000 ha between 1964 and 1985; reforestation (as compared to the deforestation-rate) was a meagre 47 000 ha (Bhattarai 1990: 68). In face of the crises in the forestry sector, of late, there has been unprecedented enthusiasm for community forestry (hereafter referred to as CF) in Nepal. The government has attached paramount priority to CF; and elaborate policy and legislative provisions have been formulated to promote CF activities throughout the country (HMGN 1988; also see different articles in Banko Janakari 1993). CF's goals have been somewhat all-encompassing and perhaps, highblown. The major goals included the empowerment of local communities (especially the 'weaker sections' and women) through increased participation in the decision making and benefit sharing of afforestation schemes; creation of a 'participatory environment' for local people and government officials (especially of the forest staffs) within which to cooperate and jointly perform; fulfilment of local demands; creation of more avenues of income and employment for local people; and the promotion of

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'social equity' (see, e.g. HMGN 1988, Kayastha 1991, Task Force 1987, Bartlett 1992, Bhattarai 1990, Poffenberger 1990). CF projects also endeavoured to meet certain common physical (and quantitative) targets, such as nursery raising, plantation development, and seedling distribution among the participating local communities.

In a retrospective exercise, this paper reviews the general achievement and performance of CF in Nepal against its stated goals. The purpose of the review is to trace the practical nature of CF operation, and the level and significance of its achievements.

Assessing the working context and performance of CF is, by any standard, a herculean task. I intend to see the functioning of CF in its socio-institutional setting. Therefore, an understanding of the contextual factors, which regulate the working of CF and ultimate performance thereof, is imperative. To keep the discussion to a reasonable proportion, the paper follows a fairly simple framework of analysis. The first section, the 'achievement of physical goals' focuses on the quantitative and physical targets of CF projects. Second, the 'achievement of participatory goals' probes into the achievement of more qualitative goals, such as participation and social equity. The third heading, the 'regulators of performance', traces certain crucial social and institutional variables which, as I will argue, shape CF's performance. For the purpose of this paper, the essence and applied distinction of the terms 'physical goals' and 'participatory goals' are borrowed from Poffenberger (1990a:9).

ever, were not always 'fair' or 'just'; but they were efficient in meeting the subsistence demands of local communities and served local purposes through generations. For example, the Talukdari system was 'conservative' (Khan and Hasan 1995:53) and was oriented towards meeting the interests of the hereditary Rana regime (Gronow and Shrestha 1991:2). But, as far as local rights and freedom were concerned, there was little interference by the regime into the activities and survival strategies of poor farmers (villagers); and therefore, the subsistence needs of local people were ensured. Thus, as Gronow and Shrestha (1991:2) argued, these traditional systems were 'unfair [but] effective'. Many studies, including Bartlett (1992), Adhikari (1990), Bartlett and Malla (1992), have confirmed that the involvement of local communities in forest management was not a new or recent phenomenon in Nepal; and that there existed efficient indigenous forest management systems in different parts of the country. The Nepalese government until about the mid-twentieth century showed little interest in forest management, and forests were managed by these traditional systems. Prior to 1950, the state's attitude towards forestry was, what King et al. termed, of 'general indifference' (1990:2).

A turning point in the history of forestry development in Nepal was the introduction of the Private Forest Nationalization Act, 1957 and the Forest Act, 1961 which brought all forests under state control, and provided legislation for administration through the Forest Department (Gronow and Shrestha 1991, Adhikari 1990). The Forest Department was assigned to perform a policing and licensing role. These legislations were seen by local people as a means of destroying the traditional forest management system and of increased exploitation of local forests (Adhikari 1990:260). Furthermore, the Forest Preservation Act of 1967 defined a wide array of forest offenses; and prescribed more stringent penalties, aiding the forest department to further intensify its 'policing and law enforcing' role. In the process, mutual hostility and distrust between state officials and local communities shot up. By the mid 1970s, the failure of the nationalization policies became evident and could be attributed primarily to two reasons: first, the institutional incapability of the forest department; and second, local people's perception that their traditional rights of access had been curtailed by the government (Bajracharya 1983, Adhikari 1990, Gronow and Shrestha 1991). In the last two decades — realizing the failure of mass-scale forest nationalization and the government's limitation in handling its newly acclaimed territories singlehandedly — the efforts in decentralizing forest management were intensified. For example, the Decentralization Act 1982 empowered the panchayats to form local 'consumer committees' to use forests for the purpose of afforestation and management (Gilmour et al. 1989).

Against this background, CF in Nepal emerged, first, as a response to the failure of previous public policies; and second, to reorient local people, who looked on forest nationalization as a means of deprivation of their rights on a resource which they enjoyed for generations; and third, to improve the relationship between state foresters and the people. CF in Nepal 'formally commenced in 1978' (Bartlett 1992:95), when the government introduced a set of radical rules (the Panchayat Forest Rules 1978 and the Panchayat Protected Forest Rules 1978) to create community managed forest called the panchayat forest (PF) and the panchayat protected forest (PPF). Under these rules, any forest area which had two-thirds of the land requiring replanting could be designated PF. All the income from such forests went to the panchayat. Forest land which required protection and enrichment was called PPF. Each panchayat could have 125 ha of PF and 500 ha of PPF (Foley and Barnard 1984:215–216, Task Force 1987:75–77, Adhikari 1990:260–261). The subsequent legislation created further provisions for decentralization of forest management and for specification of the nature of community control over forests. After the recent political and administrative reshuffling of the country and abolition of the panchayat system (as per the new government regulations of 1990), forests have been directly handed over to the 'user groups', instead of the panchayats (Barlett and Malla 1992). The Forest Act 1993 was the latest legislation which attached primary importance to CF. It enshrined detailed provisions concerning the handover of (parts of) the national forests as community forests (to the user groups); the formation and rights of the user groups, and its relation with the forest department; the management and utilization of community forests (Kanel 1993:2–5)

Thus, there has been a great policy shift in favour of CF in Nepal; and the government appeared to be very enthusiastic to compensate the failures of the past policies, and to remedy its long mistrust with the locals. CF has 'received the highest priority in the forestry sector in Nepal' (Sharma 1993:9). It has also received corresponding support from the international agencies. Shrestha observes that 'there are more . . . donors involved in the [CF programmes] than in any other programme' (1993:6). A number of major CF and watershed projects were launched with assistance from various international donors, notably, the Nepal-Australia Forestry Project, the Hill Forest Development Forest, and the Community Forestry Development Project (for an overview of major CF projects in Nepal, see, Kayastha 1991 and Banko Janakari 1993).

In what follows, I will examine the level and significance of CF's achievements, in light of the great national propaganda, policy support and the ambitious official formulations.

ACHIEVEMENT OF THE PHYSICAL GOALS

In line with the general experience of other south Asian countries, the physical targets, especially of raising plantations and distributing seedlings were mostly achieved in Nepal (Foley and Barnard 1984:215–216, Gronow and Shrestha 1991:2–3, Task Force 1987:77, Magno 1986:56–58). Gronow and Shrestha noted that in various districts 'progress [was] made in establishing new plantations' (1991:3). Similarly, Foley and Barnard observed that

> the Community Forestry Development Project made substantial progress . . . Virtually the whole of the planned 400 nurseries were operational. Some 3700 hectares of panchayat forests had been established, together with 300 hectares of protected panchayat forest. Seedling distribution for private planting was just over 1 million, more than was planned for the whole project . . . (1984:216).

While the general progress in reaching the physical targets was satisfactory, a number of major problems were also observed, including wrong choice of species without regard to local factors; poor survival rate of the seedlings distributed (about 65%, in the case of the Community Forestry Project); and inadequate nursery-maintenance (Task Force 1987:77, Foley and Barnard 1984:216).

As regards the formation of the user groups, delegation of management responsibilities, and negotiation of operational plans with the user groups (which constituted the primary focus of CF), 'the progress on a national basis', as Bartlett noted, 'had been rather slow' (1992:98). About 880 forest user groups have been established by the forest department in 63 districts; but only 400 operational plans have been negotiated with these groups (Bartlett 1992:98). About 100 000 ha of government forests was handed over as community forests out of 3.5 million ha of land, potentially available for CF (Tamrakar and Nelson 1991 cited in Bartlett 1992:98). Kanel has also clearly noted that the CF programmes 'are neither effective in handing over nor efficient in input utilization' (1993:4). Similarly, in the Terai region, during 1991–92 only 7 out of 16 districts managed to form the user groups as targeted; the achievement on operational plan preparation was only 32%, and handover of forests was below 30% (Shrestha and Budhathoki 1993:24).

ACHIEVEMENT OF THE PARTICIPATORY GOALS

As regards local peoples' participation, the performance of CF was insignificant. People remained largely unaware of the changes in forestry policies and of the potential benefits of CF. Koirala (1985), for example, found that 80% of the villagers were simply unaware of the policy changes in forest legislation and 92% were skeptical as to who would ultimately benefit from CF. From a survey of Terai region, Shrestha and Budhathoki found that 'local people were still doubtful about [CF] programme [and they apprehended that] the government might take the forests back during the period of harvest' (1993:26). Besides, the locals, especially the 'weaker sections', rarely participated in the forest committees. Baral noted that:

> the participation of real users in general assemblies [of forest user committees was] always very poor. Very few women participate[d] in discussion. Proposals mainly emerge[d] from dominant users (1993:14).

Hobley noted that these committees were 'largely ineffective, unrepresentative and had virtually no control or responsibility' (1991:112). The percentage of 'dominant users' ('the rich and political persons') in forest committees was 'always high in comparison to others' and the government 'listen[ed] to the ideas of the dominant users only' (Baral 1993:13–14). Bartlett et al. (1992), from their survey of 12 forest user groups, concluded that only 4 could be considered effective.

Poffenberger (1990:34–36) raised a number of equity issues as regards the operation of the forest user committees. First, as discussed before, the user groups were managed by dominant 'clan groups'; and they did not represent all classes of villagers. Second, the share of CF's benefits was not 'equitable' in the sense that the benefits were not distributed according to the varying needs of rural households and their level of forest-dependence (Poffenberger 1990:36). Third, similar to the experience of many regions of India (see, Poffenberger 1990, WBFD 1989, Arnold et al 1988, 1990), it was found that when forests were closed for CF, it had profound affect on the poor households. In most cases, the poor had to migrate to cities in search of alternative income; and women faced increased burden of work and responsibility. In the above context, Gronow and Shrestha concluded:

> progress [of CF] across the various districts of Nepal so far been disappointing. Progress has been made in establishing new plantations, but rarely have people participated in the planning decisions . . . or management of forests (1991:3).

THE SOCIO-INSTITUTIONAL CONTEXT OF COMMUNITY FORESTRY: REGULATORS OF ITS PERFORMANCE

The marginal performance of CF in meeting its stated goals can largely be explained by the unfavourable socio-institutional context within which CF projects operate. Certain crucial social and institutional factors seem to have constrained CF's achievement, including the role of the Forest Department (as the principal regulatory agency for CF development), the local-level planning and management environment; the role of local political institutions; and the surrounding social relations and structures. In this brief paper, it is impossible to address all the major contextual variables which regulate the functioning of CF. This section concentrates only on the more important factors (as noted above), which have immediate implications for CF's performance.

At the forestry organization level, there was still a strict adherence to the top-down bureaucratic pattern of forest management (see, different articles in Banko Janakari 1993). The 'catalytic, technical and advisory' (Kanel 1993) roles which the forest department was supposed to play in the promotion of CF, remained a far cry. Gronow and Shrestha, among many others, noted that, 'most staff continued their 'policing' role: trying to maintain some control over the forests, at times apprehending villagers (often the poorer) and harassing them' (1991:7). Foresters still remained 'tree oriented and not people-oriented' (Agarwal 1986:112). Shrestha and Budhathoki also noted that 'authoritarian attitude of the field staff', 'wide gap between the local people and forestry staff' and 'inadequate extension activities' — were some of the principal problems of CF in the country (1993:25). Mirroring the general experience of other south Asian countries, the government, especially the Forest Department, suffered from major institutional problems which constrained CF's performance. The problems included the purely technical and bureaucratic attitude to forest management; the 'revenue and policing' mode of service orientation; lack of participatory environment within the forest department; strictly hierarchical flow of command; absence of a motivation system, erratic and inefficient transfer and promotion systems; and widespread corruption and connivance (Baral 1993, Gronow and Shrestha 1991, Agarwal 1986, Khan and Hasan 1995, Nurse et al. 1993, Shrestha and Budhathoki 1993).

Considering its great significance to CF, the participatory management plan for the communally managed local forests (commonly known as the 'micro planning practice') deserve particular mention. A number of major problems of planning were observed which were inimical to CF. First, it was noted that local people were rarely consulted during the project design and planning. Even in cases where they were consulted, only the voices of the rich and dominant section were heard (Baral 1993, Hobley 1991). Second, field officers who were immediately responsible for carrying out the programmes were inadequately consulted by the central planning authorities of the government (Baral 1993, Nurse et al. 1993, Gronow and Shrestha 1991). Third, in many cases, CF planners failed to appreciate the contextual realities of the field; and consequently, policies were often devised based on erroneous conceptions. For example, the Nepal Australia Forestry Project assumed that, 'local community' and 'local forest users' were synonymous, and the poorer sections of forest users would participate in the public meetings, and the forest committees would be able to perform their desired role properly. But, as Hobley (1991) eventually found, the communities were complex and heterogenous, the weaker sections virtually had no voice in them, and such committees tended to be biased towards the powerful, and reflected the local power structure. Similar cases of erroneous assumptions about the nature of local community and its involvement in CF, were also reported by King et al. (1990). Fourth, the 'operational plans' at the user-group level suffered from delayed approval by the forest department, inadequate technical and logistic support, and a plethora of complex bureaucratic formalities (Baral 1993). Bista et al. also noted that 'the government-approved format for management planning was too technical for the village people to understand'; and they had little 'sense of ownership and belonging to the planning process' (1986 cited in King et al. 1990:2). The broader macro-policy framework also was not conducive to smooth operation of CF activities in the field. A survey on 20 district forest officers showed that all the officers considered 'unclear and inconsistent policies' to be the principal problem for Nepal's CF (Shrestha and Budhathoki 1993:24–25).

The social milieu and the role of local institutions also impeded the achievement of CF's goals. The Nepalese society, as in other south Asian states, is characterized by rigid class and caste differentiation, highly unequal social relations, and skewed pattern of asset and resource distribution. High caste and elite dominance over social groupings or institutions is a regular feature of the society. Accordingly, local institutions concerned with CF activities were no exception. The forest committees in particular and the panchayats in general, were reported to be dominated by the upper castes (namely, Brahmins and Chetries), and reflected the interest of the rich and powerful (Sharma 1991, Baral 1993, Poffenberger 1990). The performance of the user committees has been already discussed. As regards the nature of operation of the panchayat, Poffenberger noted that:

> [it] was often not the most appropriate social unit for carrying out management tasks [of CF]. Many village panchayats lacked both experience and operational capacity to manage resources, while the composition of organization leaders did not . . . reflect resource users (1990:32).

Access to resources was, to a large extent, shaped by patronage relations between the poor (weak) and the rich (powerful). These grave social realities led Hobley to conclude that:

> in a country [Nepal] where personal relations with patrons determines access to resources and power, a committee composed of low castes and women and so, with no access to higher levels of bureaucracy, could not function . . . without [certain degree] of social change (1991:116).

Wignaraja also noted with dismay that 'a truly participatory development process [such as CF] cannot be generated spontaneously given the existing power relations at all levels and the deep rooted dependency relationships' (1984:8). He opined that catalytic support was needed to help the people to break 'this vicious circle' (Wignaraja 1984:8). Even within the government bureaucracy patronage links were very much active. Bista noted that 'the present bureaucratic culture is based more on a client and patron relationship than on work performance' (1991 cited in Kanel 1993:4).

EPILOGUE

In sum, as the above review reveals, in terms of 'peoples' participation' 'empowerment' and 'social equity', very little headway was made in CF practices in Nepal. The only notable positive impacts were the generation of some employment opportunities in various plantations and nurseries, and the major change in forest policies at the macro level. The radical policy shifts, however, did not seem to appreciate the contextual realities in the field, and failed to produce any large-scale impact towards empowering local communities. In fact, the Nepalese experience is by no means unique. Some probing studies, reported from different regions of south Asia, are increasingly drawing our attention to the insignificant achievement of participatory forestry programmes amidst the unfavourable socio-institutional context. They have also revealed the substantial gap between real achievement and the 'cloud of rhetoric' (Cernea 1985) which surrounds CF projects (see, for example, Shiva et al. 1987, Fernandes and Kulkarni 1983, Locke 1995, Fernandes et al. 1988, Khan 1994, 1996, Khan and Hasan 1995).

Thus, notwithstanding the stated goals and national propaganda, the Nepalese CF in reality functioned as a routine government-sponsored rural development programme, administered by a collaborative alliance between the bureaucrats and local political elite, which produced some marginal benefits to local people. The following comment by Baral aptly sums up the true nature of CF in Nepal:

> Quite often Department of Forest (DOF) staffs simply view the community forest plantation programme as another form of state forestry. The intended beneficiaries are rarely consulted in any decision making. The DOF staff independently produce seedlings, select plantation sites, plant the sites and finally provide a watcher to take care of the plantation . . . [T]he intended beneficiaries rarely know why and for whom the plantations were created (1993:67).

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Tai Po Kau Nature Reserve, New Territories, Hong Kong: A Reafforestation History

Barry Nicholson

ABSTRACT

The Tai Po Kau Nature Reserve in Hong Kong is widely regarded as the territory's most important woodland area The reserve is the product of an intensive reafforestation effort, dating back to the early part of the present century. It supports a rich fauna and flora and is a valuable resource for biodiversity conservation in Hong Kong The history of the reserve is examined in order to achieve a better understanding of its present-day characteristics and to determine what practical lessons can be drawn with respect to reafforestation and ecological restoration techniques.

Keywords: *Hong Kong, reafforestation, nature reserves, trees, woodland*

INTRODUCTION

Tai Po Kau Nature Reserve[1] is one of the best developed and most diverse woodlands in Hong Kong (Thrower 1984, Dudgeon and Corlett 1994). Initially the product of deliberate tree planting, over the years the woodland has developed many of the characteristics of a natural forest. It has become a key site for biodiversity conservation in Hong Kong, being noted amongst other things for its rich bird, mammal, butterfly and dragonfly faunas (Chalmers 1986, Viney et al 1994, Goodyer 1992, Bascombe 1995, Wilson 1996) and for the presence of a number of rare plant species (G. Barretto, pers. comm.). Tai Po Kau provides a graphic demonstration of the value of reafforestation in a territory largely stripped of its natural forest cover.

This paper has been compiled from a variety of information sources and draws heavily on unpublished material kindly made available by the Agriculture and Fisheries Department (AFD) of the Hong Kong Government. It attempts to reconstruct the history of Tai Po Kau and achieve a better understanding of its development and present characteristics.

BACKGROUND

Tai Po Kau Nature Reserve lies in the central part of the New Territories of Hong Kong, approximately 2.5 kilometres south-east of Tai Po New Town (Figure 1). Extending over some 460 hectares, the nature reserve covers a steeply sided stream catchment, ranging in altitude between 100 m and 350 m. The underlying solid geology is mostly Upper Jurassic volcanic rocks of the Repulse Bay Group, overlain by Quaternary colluvial deposits in valley bottoms. Compartment records show that for the most part the soils are shallow, sandy, acid and nutrient poor, with frequent rocky outcrops and boulders. Valley bottom soils derived from colluvium are deeper, relatively moist and contain a higher proportion of organic matter. Most of the area is now forested, a

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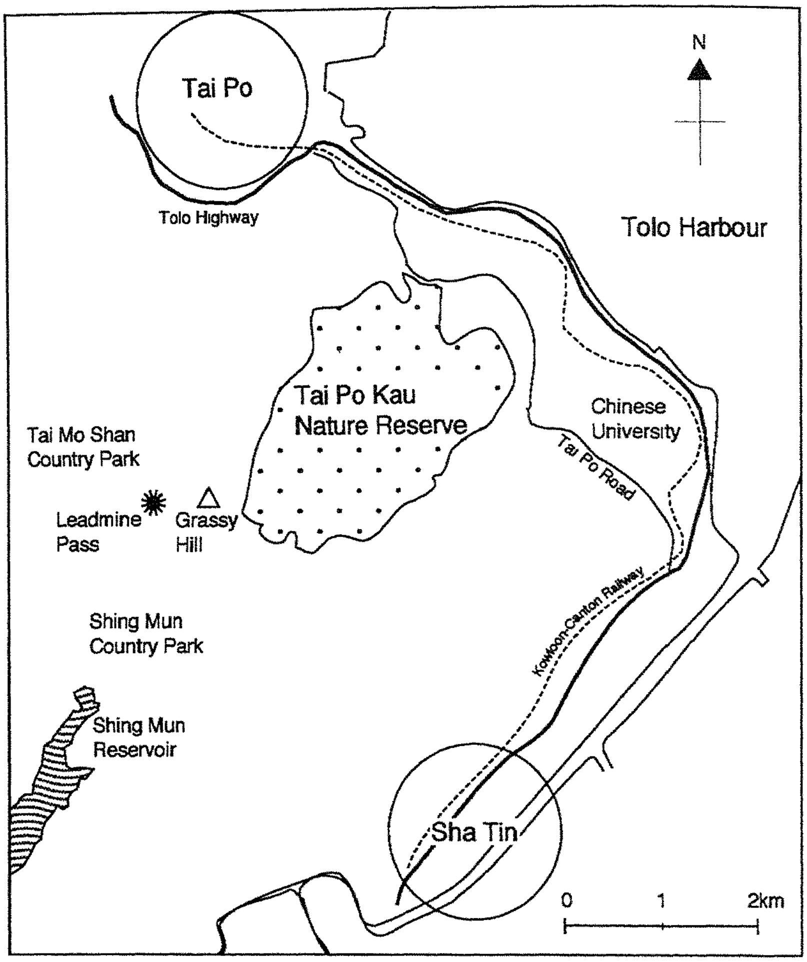


Fig. 1 Location of Tai Po Kau.

mosaic of mixed broadleaved woodland interspersed with areas of single species plantation, giving way to scrub and grassland on some of the higher slopes.

HISTORY

The Early Years (1898 – 1924)

When the New Territories were acquired under lease from China in 1898, Tai Po was a rural area, with scattered villages set in a landscape of grass-covered hillsides and cultivated valleys. Forest clearance over earlier centuries meant that woodland was largely restricted to small areas around villages. These were the 'Fung Shui' woodlands, which had spiritual as well as practical significance (Thrower 1976). In addition, remnants of natural forest possibly survived along some of the more remote and inaccessible ravines. Although individually small, these woodland areas covered a total area of some 389 hectares in the Tai Po South Forest Area, which encompassed Tai Po Kau (HK Govt. 1909).

Maps from this period show that the Tai Po Kau area contained a small village — Wang Lo Ha — located between two arms of the main stream in the south-west of what is now the reserve. Below the village, strung out along the banks of the streams, were a series of cultivated fields, presumably mostly rice paddies. Rising above these were steep hill slopes, probably grass covered and used for grazing and fuel cutting by the village. Woodland (or trees) are shown forming narrow belts along several of the side streams and also forming a larger block on the hill slopes immediately behind the village — possibly its Fung Shui wood.

Under the British administration, a programme of forestry planting was soon initiated in the New Territories, commencing first around the newly established police stations. Records for 1901 state that a total of 8121 trees were planted in the Tai Po area, over an area of 2.7 hectares, largely native Chinese Red Pine *Pinus massoniana* and exotic Brisbane Box *Lophostemon confertus*. The forestry service continued to extend these plantations over the next 25 years or so, concentrating along the recently constructed Tai Po Road. Chinese Red Pine remained the predominant species, often sown in situ by broadcasting the seed, but a small number of broadleaves were also included in the plantings, principally Camphor *Cinnamomum camphora* and Brisbane Box (Table 1). Although the Tai Po Road plantations were close to Tai Po Kau, it is unclear whether any of the early plantings were within the bounds of the present nature reserve. Records for 1907 refer to plantations on the hillside between 60 and 120 metres near the village of Cheung Shue Tan, which would have been just outside of the reserve boundary. If any of the early plantations were within the reserve, it is unlikely that they formed more than a narrow belt along its north-western margins.

Tai Po Forestry Reserve (1924 – 1941)

The development of the Tai Po Kau forest really begins in 1925, with the official creation of the Tai Po Forestry Reserve. No information is available regarding the size of the reserve at this time — it is simply referred to as 'a large area' — but a survey completed in 1939 recorded the area as 136.4 hectares. The objective was, in due course, to fill the whole area with tree plantations (HK Govt. 1926). The rationale for the Forestry Reserve appears to have been principally protection of a water catchment area (Daley 1976), but the potential of the plantations as a strategic timber reserve, to be used as fuel in times of emergency, was also recognized (HK Govt. 1926). A further stated aim was to conduct forestry research, by laying out experimental plantations of trees of economic potential. The importance of the area for nature conservation was also recognised — 'the native flowers, which in other parts of the colony are in danger of being exterminated, will be preserved and as far as possible grouped within view of the service path which has been made over the whole length of the reserve'.[2] Two species of protected flower are specifically mentioned as growing freely in the reserve, the Chinese Lily *Lillium brownii*, which was found on low hills, and the Nun Orchid *Phaius grandifolius* (now *P. tankervilliae*) in wet ravines.

Table 1
Early Planting in the Tai Po Area

Year / Species	1901	1902	1903	1904	1905	1920	1923	Total
Pinus massoniana	5350		27558	4667	53578	d.s.	d.s.	91153
Cinnamomum camphora	47		2781	911				3739
Eucalyptus spp.	488							488
Lophostemon confertus	2063		180	983				3226
Aleurites spp.	143	81						224
Pterocarpus indicus		120						120
Castilla spp.			112					112
Unspecified						250		250
Total	8091	201	30631	6561	53578	250		99312

d.s. = direct seeding of unspecified numbers of seed

Source: Hong Kong Government Annual Reports

A large tree nursery was established on old paddy fields within the reserve, which raised a variety of species for planting at Tai Po Kau and other afforestation sites. Information about the number of trees planted during this period is patchy. Published annual reports, and information held in AFD files, indicate that Chinese Red Pine was the most widely used species (Table 2). Some pine were planted as nursery grown saplings, but most seem to have been seeded directly onto the grassy hillsides or into prepared pits, sometimes mixed with seed of Monterey Pine *Pinus radiata* and White Popinac *Leucaena leucocephala*. A variety of other species were also planted, chief amongst which were China Fir *Cunninghamia lanceolata*, *Pinus insularis*, Acacia *Acacia confusa*, Camphor and Candlenut *Aleurites moluccana* (Table 2). Compartment records also show that Brisbane Box and Paper Bark *Melaleuca quinquenervia* were extensively planted, but the numbers involved went largely unrecorded. Much experimentation was carried out in this period, with a wide range of species being planted on a small scale (Appendix 1). As well as trees and shrubs, experiments were also carried out with bamboo under the supervision of Mr G.A.C. Herklotts, and just before the Second World War some 600 culms were planted in an attempt to lay the foundations of an economic bamboo plantation . The pre-war tree plantations were concentrated in the valley bottoms and lower slopes, in what is the northern part of the present-day nature reserve (Figure 2).

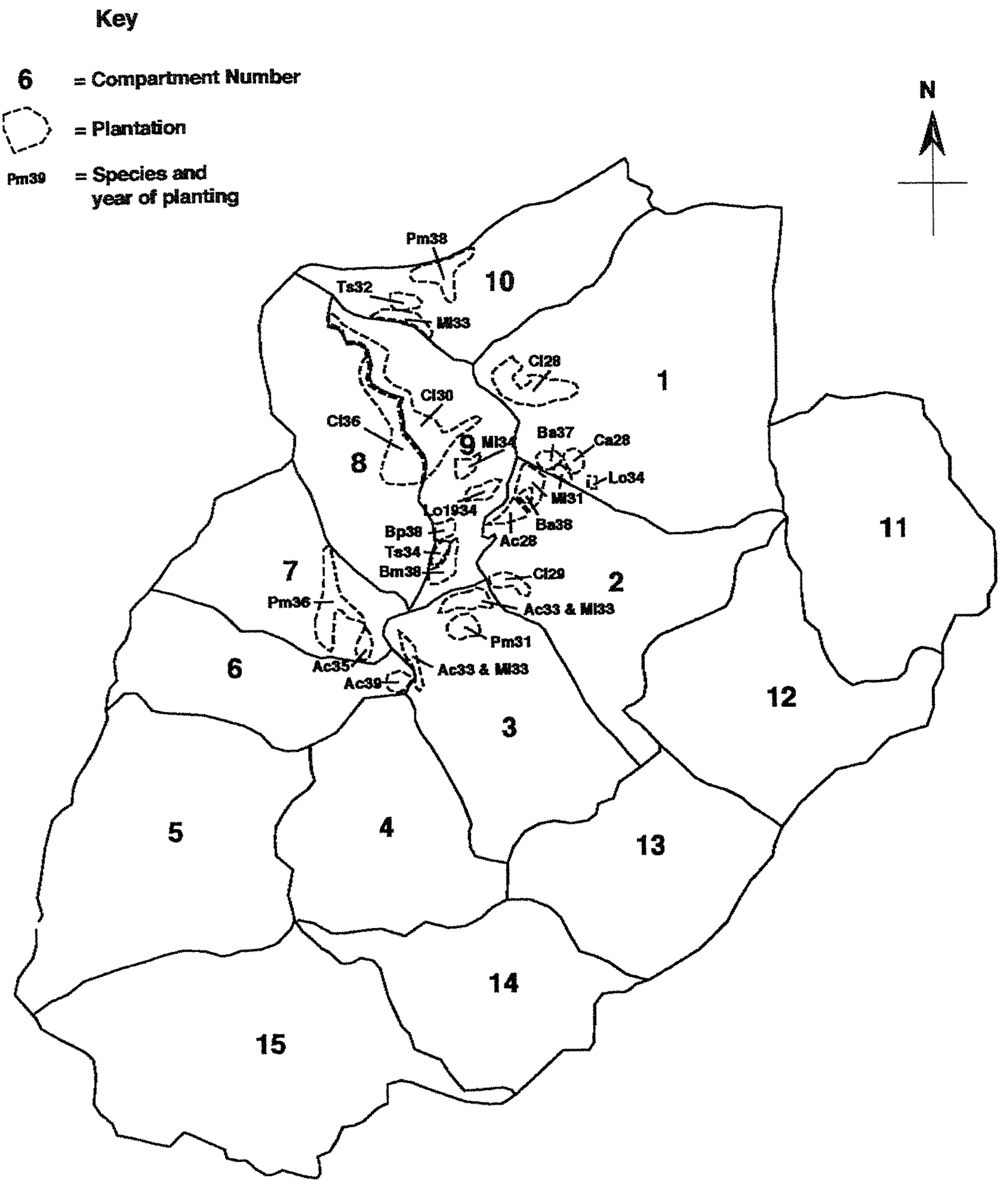
Ground for tree planting was cleared by burning or cutting, but rapid regrowth of grasses and fern competed with the young trees. In an effort to control competition with the trees, local villagers were allowed to cut the grass for fuel under the supervision of foresters. Other problems faced by the foresters included attacks of Pine Tree Caterpillar *Dendrolimus punctatus*, illegal cutting of trees for fuel or timber, and the raking of pine needles from the forest floor, which was thought to seriously impair regeneration. Penalties for people convicted of forestry offences could be quite severe, with persistent offenders facing banishment from the territory. Fire, as in the present day, was a constant threat to the young plantations, and a network of forest paths and fire barriers was laid out to protect the reserve.

Table 2

Major Species Used in Pre-War Planting at the Tai Po Forestry Reserve

							Numbers planted									
Year of planting	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	Total
Species																
Pinus massoniana	146500	d.s.	d.s.	d.s.	d.s.	d.s.	d.s.	d.s.	*	d.s	d s.	*		*		146500
Pinus insularis			d.s.										6000	154		6154
Aleurites moluccana		1840														1840
Aleurites montana					*	*	*	*		*	*			120	458	578
Artocarpus integrifolia		390				d.s.							10			400
Cinnamomum camphora		2300	*	*	*	*		*		*						2300
Cunninghamia lanceolata			d.s. & *	*	10000d.s.	*	*	12000		*	*	8000				20000
Acacia confusa			d.s. & *	*	*	*	*	*	*	*	*	2600			*	2600
Lophostemon confertus			*		*	*		*		*	*			*		?
Melaleuca quinquenervia					*		*	*	*	*				*		?
Unspecified									2567			1700				4267
Total	146500	4530						12000	2567			12300	6010	274	458	184639

d.s. = direct seeding of unspecified numbers
* = planting of unspecified numbers
Source: Hong Kong Government Administrative Reports and Agriculture & Fisheries Department Records



Ts - *Tutcheria spectabilis*
Ml - *Melaleuca quinquenervia*
Pm - *Pinus massoniana*
Cl - *Cunninghamia lanceolata*
Ba - *Bambusa spp.*
Bm - *Bambusa multiplex*
Bp - *Bambusa pervariabilis*
Ca - *Cinnamomum camphora*
Lo - *Lophostemon confertus*
Ac - *Acacia confusa*

Source: AFD plans dated Dec. 1977 held at Tai Po Kau Management Centre

Fig. 2 Tai Po Kau (Map showing distribution of pre-war plantations).

The Japanese Occupation (1941 – 1945)

During the Japanese occupation, Hong Kong faced severe shortages of fuel and timber. As a result extensive tree felling is reported to have taken place within the territory, both to supply timber for export to Japan and for local fuel use. Tai Po Kau was certainly affected by wartime and immediate post-war felling — according to the annual report of the Forestry Department for 1946–47, all trees of an exploitable size or suitable for firewood were felled during the first half of 1945, with extraction still in progress at the time of the Japanese surrender. However it would appear that Tai Po Kau suffered less than some other woodland areas. Compartment records indicate that the wartime cutting in the Forestry Reserve was selective and variable in its effects — a summary of the losses is given as: 'a small proportion of *Acacia confusa* and *Cunninghamia*, a great majority of pine trees (only a small proportion in Compartment 8 was left uncut)' and 'all *Aleurites montana* in compartment 23'.[3] It is likely that many of the pre-war plantations were still not sufficiently well grown to be worthwhile felling, at least for timber. It has also been suggested that Tai Po Kau benefited from the protection of Japanese troops, who discouraged firewood cutting by local villagers — sentries were posted throughout the area since it was regarded as a strategic location, and several houses were occupied by troops (G. Barretto, pers. comm.).

Post-war Development (1946 – 1976)

Initial work in Tai Po Kau after the reoccupation concentrated on clearing the fire barriers and forestry paths and rebuilding the staff quarters. The nursery was restocked but, due to inaccessibility, was largely abandoned in 1950 and planted with China Fir to provide Christmas trees for government departments. A scaled down facility was kept, to supplement the main nursery at Lai Chi Kok in producing plants for amenity planting and afforestation. A series of public walks were laid out in 1949–50, which reflected an increasing emphasis on public recreation. The reserve was extended during this period, a survey of forestry areas in 1953–54 reporting that Tai Po Kau covered an area of 280.6 hectares, divided into 10 management compartments. By 1959 the reserve had been extended again to cover some 448.6 hectares, rearranged into 15 management compartments.

Post-war planting within the reserve was slow to get underway . A small amount of planting took place in the late 1940s and early 1950s, including extensions to the bamboo areas, but large scale planting did not commence until the mid 1950s (Table 3). This may have been due to a lack of resources during the immediate post-war years, including the need to re-establish tree nurseries to raise the necessary planting material, or it perhaps reflects adequate stocks in the existing plantations. Whatever the reasons for the delay, the adoption of a formal forestry review by government in 1953 provided a new impetus to reafforestation in Hong Kong (Daley 1976), and large scale planting at Tai Po Kau commenced in the same year.

The bulk of the post-war planting (in terms of area and numbers planted) took place in the new compartments (Figure 3), where Chinese Red Pine, Brisbane Box and Acacia have been the main species used. Planting within the pre-war plantations has been small scale, and appears to have been undertaken in an attempt to diversify the existing pine areas by inter planting with a variety of broadleaves and conifers. The major species used for the latter task have been Chestnut Oak *Castanopsis fissa* and Camphor, but a wide range of other trees have also been used in small quantities (Appendix 2).

Surviving records from this period are much more detailed and show that afforestation in the area was no easy process. A variety of planting techniques were tried with the principal species, Chinese Red Pine, including broadcast seeding onto the hillsides, direct seeding into prepared pits, notch and pit planting using bare-rooted saplings and pit planting with tube-grown saplings. Aftercare was usually undertaken and involved periodic weeding and fertiliser applications. Nevertheless results were mixed and failure rates of more than 50% were not uncommon, particularly with seeding and bare-root planting techniques. Replanting and beating up were therefore routine operations. Low success rates with broadcast seeding and bare-root planting gradually led to the use of tubed seedlings becoming standard practice (Daley 1976).

Success rates were generally higher with other species but there were some notable exceptions. Thus results with various species of Gum *Eucalyptus* spp., Horsetail Tree *Casuarina equisetifolia* and Tallow Tree *Sapium discolor*, planted on a trial basis in 1954, were regarded as very poor, although Paper Bark planted with them performed well. Cypress Pine *Callitris* spp. were also disappointing.

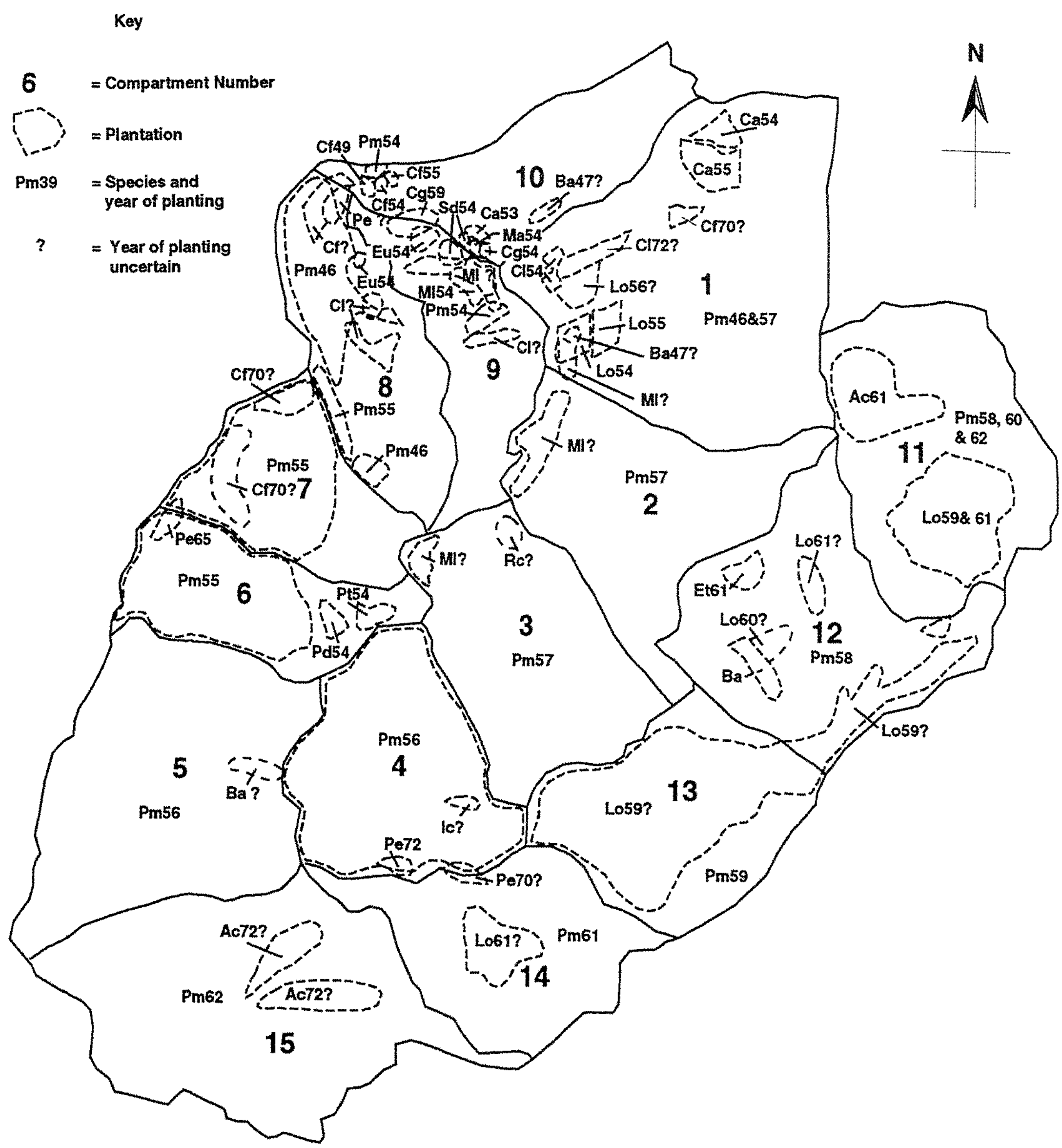
Table 3
Major Species Used in Post-War Planting at Tai Po Kau Nature Reserve

Year of Planting	1949	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1964
					Number planted							
Species												
Pinus massoniana			385	104279	298494	271186	149100	210815	46212	13981	16754	
Pinus elliottii												
Lophostemon confertus			620	970	915			20975	6225	37649		
Acacia confusa									351	19530		
Eucalyptus teriticornis										5780		
Liquidambar formosana												
Castanopsis fissa	200		475	193	343	450						
Cunninghamia lanceolata		510	290					150				
Callitris sp.		350										
Cinnamomum camphora			100	551	695		16				263	
Sapium discolor			200									
Cryptomeria japonica			164					20				
Melaleuca quinquenervia				350								
Casuarina stricta				100								
Eucalyptus robusta				100								
Machilus breviflora							268					
Machilus velutina							182					
Callitris glauca							585	72	146			
Cedrela odorata												200
Bauhinia blakeana												
Bombax malabaricum												
Total	200	860	2234	106543	300447	271636	150151	232032	52934	76940	17017	200

Year of Planting	1965	1966	1970	1972	1973	1974	1975	1979	Total
			Number planted						
Species									
Pinus massoniana		1781		280					1113267
Pinus elliottii	6314		5825	7260	6655	6500	6050		38604
Lophostemon confertus					4255		6050		77659
Acacia confusa			4130	11360	24100	35700	32100	116500	243771
Eucalyptus teriticornis									5780
Liquidambar formosana		1210	1200						2410
Castanopsis fissa			1200	1210					4071
Cunninghamia lanceolata			110	270					1330
Callitris sp.									350
Cinnamomum camphora									1625
Sapium discolor									200
Cryptomeria japonica									184
Melaleuca quinquenervia			50						400
Casuarina stricta									100
Eucalyptus robusta									100
Machilus breviflora									268
Machilus velutina									182
Callitris glauca									803
Cedrela odorata									200
Bauhinia blakeana		80							80
Bombax malabaricum			40						40
Total	6314	3071	12555	20380	35010	42200	44200	116500	1491424

Source: AFD Records

Source: AFD Records



Ml	- *Melaleuca quinquenervia*
Pm	- *Pinus massoniana*
Pe	- *Pinus elliottii*
Pt	- *Pinus thunbergii*
Pd	- *Pinus densiflora*
Cl	- *Cunninghamia lanceolata*
Ba	- *Bambusa spp.*
Ca	- *Cinnamomum camphora*
Cf	- *Castanopsis fissa*
Lo	- *Lophostemon confertus*
Ac	- *Acacia confusa*
Cg	- *Callitris glauca*
Ic	- *Itea chinensis*
Eu	- *Eucalyptus spp.*
Et	- *Eucalyptus tereticornis*
Sd	- *Sapium discolor*
Rc	- *Rhodoleia championii*

Source: AFD plans dated Dec. 1977 held at Tai Po Kau Management Centre

Fig. 3 Tai Po Kau (Map showing distribution of post-war plantations).

Added to the problems of plant establishment were periodic fires which destroyed areas of young plantation. Although fire precautions have meant there have been no large hill fires in Tai Po Kau, a number of small conflagrations are recorded, ranging in size from less than 0.1 hectare to over 16 hectares. Fires have been attributed to a variety of causes including deliberate burning to encourage spring grass growth for cattle, accidental fires started by visitors and by burning of joss sticks and paper during festivals. Fire barrier maintenance was therefore an important on-going management operation.

Recent History (1976 – present)

The designation of Tai Po Kau as a Special Area under the Country Parks Ordinance of 1976 saw a shift in the emphasis of management. From about this time it came to be known as the Tai Po Kau Nature Reserve, which better reflected its new primary function as a conservation area. In line with this, the development of visitor facilities has been carefully planned to ensure that recreational use does not conflict with conservation objectives. Footpaths have been improved, trails waymarked and picnic sites provided (no barbecues are allowed due to the risk of fire). Visitor numbers averaged more than twenty thousand per annum during the 1980s.

Educational activities have been encouraged at the site. Interpretative facilities have been developed, including a 0.7 kilometre nature trail which explains aspects of woodland ecology, and a birdwatching site with taped bird song and identification panels. Guided educational walks are arranged for school groups. Tai Po Kau has also become an important ecological research site in recent years, the forest stream complex in particular having been the focus of pioneering studies in tropical hydrobiology (Dudgeon 1992).

In the early 1980s large numbers of pine trees at Tai Po Kau and elsewhere in the territory started to succumb to pine wilt disease. Caused by the nematode worm *Bursaphelenchus xylophilus* and spread by longicorn beetles, the advent of this disease has virtually eliminated the native Chinese Red Pine at Tai Po Kau. Slash Pine *Pinus elliottii*, an exotic species from North America (the presumed native range of *B. xylophilus*), appears much less susceptible (Dudgeon and Corlett 1994) and survives in good numbers. Fortunately, native broadleaved trees were already beginning to replace the pine through natural regeneration and succession (Thrower 1984, Chan and Thrower 1986) and the death of the pines probably merely acted to speed up a process that was already in-train. There has therefore been little need for replacement planting.

Some limited annual tree planting still occurs, for example to replace trees lost through fire or to enrich existing plantations by introducing more native broadleaves, but the major focus for new planting has moved outside of the reserve to adjacent areas of Tai Mo Shan Country Park. In addition there have been on-going efforts to create a 'Green Belt' around the reserve, to protect the forest from fire (Appendix 2 and Figure 3). To this end a belt of Acacia, up to 30 metres wide, has been planted around the margins of the area, the theory being that the dense evergreen canopy acts to suppress and retard any fires approaching from outside. This is coupled with traditional open fire breaks, which are maintained by cutting and controlled burning, and with fire lookouts, patrols and warning notices. To provide additional fire fighting capacity, eight 5200 gallon water tanks were installed around the reserve in 1986–87.

DISCUSSION

Tai Po Kau clearly demonstrates the ecological benefits which can derive from a well conceived and implemented reafforestation programme. The maturing woodlands have provided a valuable refuge for native forest wildlife and have facilitated recolonisation by several species which were formerly extinct in the territory. For example, Bascombe (1995) notes how the butterflies *Neope muirheadii*, *Limenitis dudu* and *Cyrestis thyodamas*, re-established themselves at Tai Po Kau starting in the 1950s and have since expanded to other woodland areas in Hong Kong. Breeding bird surveys conducted by the Hong Kong Birdwatching Society also suggest a pattern of continuing colonization (Viney 1989, 1990, Turnbull 1992, 1993), although the picture is complicated by birds escaped from captivity or deliberately released in the forest (Chalmers 1990). An estimated 35–45 species now breed in the reserve (Turnbull 1993). They include species which were presumably present in the original forests of Hong Kong, for example Grey-throated Minivet *Pericrocotus solaris*, Scarlet Minivet *Pericrocotus flammeus*, Chestnut Bulbul *Hemixos castanonotus*, Hainan Blue Flycatcher *Cyornis hainana* and Red-headed Tit *Aegithalos concinnus*, which have now re-established breeding populations, possibly in response to the increasing maturity of the forest (Chalmers 1986, Turnbull 1993, Viney et al 1994).

Several lessons can be drawn from the experience gained at Tai Po Kau, which could be of value in planning other reafforestation projects in Hong Kong and elsewhere in the region. There appear to be good grounds for the use of a pioneer nurse crop to pave the way for natural colonisation and regeneration. These should be of species which can be cheaply produced and planted in large numbers. The past use of Chinese Red Pine as a pioneer species in Hong Kong seems to have provided ideal conditions for forest regeneration in this way. Large areas of the reserve, particularly in the newer southern and eastern compartments, have never been planted with anything else, yet today carry mixed stands of native broadleaves. The vigorous regeneration of native broadleaves below the open canopy of mature pine at Tai Po Kau and elsewhere was described by Chan and Thrower (1986). This natural regeneration presumably accounts for the present abundance of species such as Ivy Tree *Schefflera octophylla*, Tallow Tree and species of *Machilus*, which were little used in the afforestation programmes. Woodland understorey species like Wild Coffee *Psychotria rubra* and Red Beauty-berry *Callicarpa rubella* similarly cannot be accounted for by planting and must have spread into the plantations, either from small remnant patches of semi-natural woodland within the reserve or from woodland areas outside. Most of these species produce fruits attractive to frugivorous birds (Corlett 1992), which suggests a likely mechanism for their dispersal into the forest.

The advent of pine wilt disease probably precludes the future use of Chinese Red Pine as a nurse crop in Hong Kong, but Slash Pine may be an acceptable alternative if not planted too densely. Selected native broadleaves, for example species which play a pioneer role in natural communities, may also have potential to be planted as nurse trees and deserve further investigation. The use of Ivy Tree and Tallow Tree has been suggested in this respect — being highly attractive to fruit-eating birds, their use would have the added benefit of assisting natural colonization by other bird-dispersed species (Corlett 1992).

Reafforestation efforts must be accompanied by effective measures to prevent fire. Dry season fire remains a serious threat to plantations in Hong Kong, particularly during their early years of establishment, and is the primary factor inhibiting natural succession and regeneration. Indeed the exclusion of fire from hillside grassland and scrub is often sufficient to facilitate woodland regeneration, and may obviate the need for tree planting altogether in some cases. Effective fire precautions include clearance of fire breaks along roads, paths etc. and, possibly, the planting of green belts of Acacia. Constant vigilance during periods of high fire risk, maintenance of adequate fire fighting capability and continuing public education about fire hazards, are also vital.

Whilst the naturally regenerated woodlands at Tai Po Kau are rich and ecologically valuable, the scarcity of climax species suggests that they do not closely reflect the original primary forest cover of the area. For example, native oaks are rare in the present-day Tai Po Kau (with the exception of Chestnut Oak — which has been deliberately planted). Along with members of the Laurel family (Lauraceae), trees of the Oak family (Fagaceae) are thought to have been common or dominant in the natural sub-tropical monsoon forests of the region (Thrower 1984). Members of this family have large seeds adapted to dispersal by mammals (or in some cases large birds) and it has been suggested that their contemporary scarcity in Hong Kong is due to lack of suitable animal dispersers (Corlett and Dudgeon 1984). Given the present paucity of oaks, their presumed importance in the original forest cover, and the impediments against natural colonization, enrichment planting with species of this family (for example Hairy Chestnut *Castanopsis concinna*, Smooth Tanbark *Lithocarpus glaber*, and Edith's Oak *Quercus edithae*) would be worthy of consideration in the future development of Tai Po Kau and in the planning of other reafforestation efforts. Enrichment planting using native trees has been successfully used in the past, particularly with rare but visually attractive species such as Rhodoleia *Rhodoleia championii* and Hong Kong Camellia *Camellia hongkongensis* (Thrower 1984). Extensive areas of single species plantation still remain within the reserve, which would benefit from such an approach.

CONCLUSION

The Tai Po Kau forest of today is the culmination of a long and intensive reafforestation effort. Starting with Chinese Red Pine, but subsequently making widespread use of a range of native and non-native tree species, most parts of the reserve have been planted with trees at one time or another. However, the effects of enrichment planting, the death of pine trees due to disease, and most particularly the vigorous regeneration of native trees, have so modified the planting pattern that in many parts of the reserve it is now difficult to discern the original plantations. These various factors have combined to produce an ecologically diverse forest cover, with extensive areas of a semi-natural character. The forest has aquired a rich associated wildlife and provides a valuable demonstration of what can be achieved in terms of reafforestation and ecological restoration in a severely deforested landscape. Large areas still remain in the uplands of Hong Kong which would lend themselves to similar reafforestation efforts and the lessons also have relevance to other parts of southern China and Southeast Asia where the effects of past deforestation are apparent.

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NOTES

1 Although Tai Po Kau is called a nature reserve, the title does not have any legal significance. Tai Po Kau is, officially, a Special Area, designated under the Hong Kong Country Parks Ordinance of 1976.
2 Section N11, Hong Kong Administrative Report for the Year 1925.
3 File Note in AFD file TP/TPK 602. Note that compartment numbers refer to the old pre-war compartments, which differ from the current compartments.

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APPENDIX 1: DETAILS OF EARLY PLANTING CARRIED OUT IN THE TAI PO FORESTRY RESERVE

Year	Compartment*	Species		Family	Notes
1927	?	Chinese Red Pine	*Pinus massoniana*	Pinaceae	Pit-sown
	?	Ginkgo	*Ginkgo biloba*	Ginkgoaceae	Balled plants - unsuccesful
1928	1 2, 8	China Fir	*Cunninghamia lanceolata*	Taxodiaceae	
	1	Chinese Red Pine	*Pinus massoniana*	Pinaceae	
	1	Camphor	*Cinnamomum camphora*	Lauraceae	
	1	Atalantia	*Atalantia hindsii*	Rutaceae	
	?	Kassod Tree	*Cassia siamea*	Caesalpiniaceae	
	2	Acacia	*Acacia confusa*	Mimosaceae	
1929	?	Paper Bark	*Melaleuca quinquenervia*	Myrtaceae	
	?	Acacia	*Acacia confusa*	Mimosaceae	
	?	China Fir	*Cunninghamia lanceolata*	Taxodiaceae	c 10,000 seeds broadcast
	?	Bamboo	*? Bambusa sp ?*	Gramineae	Transplanted from Sokunpo area
1930	9	China Fir	*Cunninghamia lanceolata*	Taxodiaceae	
	?	Breadfruit	*Artocarpus sp*	Moraceae	Several hundred seeds broadcast
	?	Tutcheria	*Tutcheria spectabilis*	Theaceae	
	?	Wood-oil Tree	*Aleurites montana*	Euphorbiaceae	
	?	Rhodoleia	*Rhodoleia championii*	Hamamelidaceae	
1931	3	Chinese Red Pine	*Pinus massoniana*	Pinaceae	
	?	Indian Fir	?	?	Balled - unsuccesful
	?	Long-leaved Ironwood	*Casuarina stricta*	Casuarinaceae	
	?	Chinaberry	*Melia azederach*	Meliaceae	
	?	Chinese Hackberry	*Celtis sinensis*	Ulmaceae	
	?	China Fir	*Cunninghamia lanceolata*	Taxodiaceae	
	?	Wood-oil Tree	*Aleurites montana*	Euphorbiaceae	
	1, 2	Paper Bark	*Melaleuca quinquenervia*	Myrtaceae	
	?	Acacia	*Acacia confusa*	Mimosaceae	
1932	10	Tutcheria	*Tutcheria spectabilis*	Theaceae	
1933	3, 10	Acacia	*Acacia confusa*	Mimosaceae	
	3 10	Paper Bark	*Melaleuca quinquenervia*	Myrtaceae	
1934	1, 9	Brisbane Box	*Lophostemon confertus*	Myrtaceae	
	?	Camellia	*Camellia spp*	Theaceae	
	9	Paper Bark	*Melaleuca quinquenervia*	Myrtaceae	
	9	Tutcheria	*Tutcheria spectabilis*	Theaceae	
1935	7	Acacia	*Acacia confusa*	Mimosaceae	
	?	Oak	*Quercus spp*	Fagaceae	c 100 seeds broadcast
1936	8	China Fir	*Cunninghamia lanceolata*	Taxodiaceae	
	7, 9	Chinese Red Pine	*Pinus massoniana*	Pinaceae	
	?	Acacia	*Acacia confusa*	Mimosaceae	Pit sown
	?	Pine	*Pinus spp*	Pinaceae	
1937	1	Weavers Bamboo	*Bambusa textilis*	Gramineae	
	1	Lesser Yellow Bamboo	*Bambusa mutabilis*	Gramineae	
1938	10	Chinese Red Pine	*Pinus massoniana*	Pinaceae	
	?	Wood-oil Tree	*Aleurites montana*	Euphorbiaceae	
	?	Acacia	*Acacia cofusa*	Mimosaceae	In vicinity of nursery
	?	Paper Bark	*Melaleuca quinquenervia*	Myrtaceae	In vicinity of nursery
	2	Weavers Bamboo	*Bambusa textilis*	Gramineae	Planted by GAC Herklots
	2, 9	Punting Pole Bamboo	*Bambusa pervariabilis*	Gramineae	Planted by GAC Herklots
	2, 9	Lesser Yellow Bamboo	*Bambusa mutabilis*	Gramineae	Planted by GAC Herklots
1939	6	Acacia	*Acacia confusa*	Mimosaceae	

* Compartment numbers refer to modern management compartments

Sources Agriculture & Fisheries Department records held at Tai Po Kau Management Centre

APPENDIX 2: DETAILS OF POST-WAR PLANTING CARRIED OUT AT TAI PO KAU NATURE RESERVE

Year	Compartment *	Species		Family	Notes
1946	8	Chinese Red Pine	*Pinus massoniana*	Pinaceae	
1947	?	Bamboo	*Bambusa pervariabilis*	Gramineae	171 culms planted
	?	Bamboo	*Bambusa textilis*	Gramineae	500 culms planted
	?	Bamboo	*Dinochloa sp.*	Gramineae	15 culms planted
1949	10	Chestnut Oak	*Castanopsis fissa*	Fagaceae	200 trees
1959	Nursery	China Fir	*Cunninghamia lanceolata*	Taxodiaceae	Nursery abandoned & planted with China Fir
1953	1	China Fir	*Cunninghamia lanceolata*	Taxodiaceae	510 trees
	10		*Callitris glauca*	Pinaceae	350 trees
1954	1	Camphor	*Cinnamomum camphora*	Lauraceae	100 trees
		China Fir	*Cunninghamia lanceolata*	Taxodiaceae	290 trees - replacing 1953 planting
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	620 trees
	6		*Pinus thunbergii*	Pinaceae	
			Pinus densiflora	Pinaceae	
	9	Horsetail Tree	*Casuarina equisetifolia*	Casuarinaceae	
		Tallow Tree	*Sapium discolor*	Euphorbiaceae	
		Paper Bark	*Melaleuca quinquenervia*	Myrtaceae	
		Swamp Mahogany	*Eucalyptus robusta*	Myrtaceae	
		Forest Grey Gum	*Eucalyptus tereticornis*	Myrtaceae	
			Eucalyptus grandis	Myrtaceae	
		Lemon-scented Gum	*Eucalyptus citriodora*	Myrtaceae	
	10	Chinese Red Pine	*Pinus massoniana*	Pinaceae	385 trees
		Chestnut Oak	*Castanopsis fissa*	Fagaceae	475 trees
		Tallow Tree	*Sapium discolor*	Euphorbiaceae	200 trees
		China-berry	*Melia azederach*	Meliaceae	
		Peacock Pine	*Cryptomeria japonica*	Taxodiaceae	164 trees
1955	1	Camphor	*Cinnamomum camphora*	Lauraceae	551 trees, pit planted
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	970 trees, pit planted
	6	Chinese Red Pine	*Pinus massoniana*	Pinaceae	38,963 pit sown, 7,100 pits re-sown & 13,138 trees planted
	7	Chinese Red Pine	*Pinus massoniana*	Pinaceae	31,953 pit sown, 9,620 replaced with seedlings
	8	Chinese Red Pine	*Pinus massoniana*	Pinaceae	3,072 pit sown on 1.2 ha. &1000 replaced with seedlings
	9	Paper Bark	*Melaleuca quinquenervia*	Myrtaceae	350 replacement trees planted in 1954 plantation
		Long-leaved Iron Wood	*Casuarina stricta*	Casuarinaceae	100 trees
		Swamp Mahogany	*Eucalyptus robusta*	Myrtaceae	100 trees
	10	Chestnut Oak	*Castanopsis fissa*	Fagaceae	193 trees pit planted
1956	1	Camphor	*Cinnamomum camphora*	Lauraceae	490 trees
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	915 trees
	4	Chinese Red Pine	*Pinus massoniana*	Pinaceae	78,269 bare-rooted trees and 41,760 replacements planted over whole cmpt.
	5	Chinese Red Pine	*Pinus massoniana*	Pinaceae	130,435 bare-rooted trees and 14,250 replacements planted
	6	Chinese Red Pine	*Pinus massoniana*	Pinaceae	22,930 trees replanted in1955 plantation
	7	Chinese Red Pine	*Pinus massoniana*	Pinaceae	9,405 trees replanted in1955 plantation
	8	Chinese Red Pine	*Pinus massoniana*	Pinaceae	1400 replacement trees planted in 1955 plantation
	10	Chestnut Oak	*Castanopsis fissa*	Fagaceae	343 balled trees & 55 replacements
		Camphor	*Cinnamomum camphora*	Lauraceae	205 trees pit planted

APPENDIX 2 (cont.)

Year	Compartment*	Species		Family	Notes
1957	1	Chinese Red Pine	*Pinus massoniana*	Pinaceae	20,000 bare rooted trees on 7.7 ha. & 16,250 replacements notch planted
	2	Chinese Red Pine	*Pinus massoniana*	Pinaceae	41,570 bare-rooted trees on 15.4 ha.
	3	Chinese Red Pine	*Pinus massoniana*	Pinaceae	56,372 bare-rooted trees & 36,500 replacements planted on 20.2 ha.
	4	Chinese Red Pine	*Pinus massoniana*	Pinaceae	20,720 replacement trees planted in 1956 plantings
	5	Chinese Red Pine	*Pinus massoniana*	Pinaceae	66,614 used to replant 44.5 ha. of 1956 plantation
	6	Chinese Red Pine	*Pinus massoniana*	Pinaceae	13,160 trees replanted in1955 plantation
	10	Chestnut Oak	*Castanopsis fissa*	Fagaceae	450 balled trees planted
1958	1	Chinese Red Pine	*Pinus massoniana*	Pinaceae	9,910 bare-rooted replacements notch planted
	2	Chinese Red Pine	*Pinus massoniana*	Pinaceae	17,940 replacement trees planted in 1957 plantation
	4	Chinese Red Pine	*Pinus massoniana*	Pinaceae	11,500 bare-rooted trees used to replant 26.7 ha.
		Short-flwrd. Machilus	*Machilus breviflora*	Lauraceae	268 trees
		Wooly Machilus	*Machilus velutina*	Lauraceae	182 trees
	5	Chinese Red Pine	*Pinus massoniana*	Pinaceae	33,600 bare-rooted trees used to replant 44.5 ha. of 1956 plantation
	10	Camphor	*Cinnamomum camphora*	Lauraceae	16 trees pit planted
		Cypress Pine	*Callitris glauca*	Pinaceae	585 trees pit planted
	11	Chinese Red Pine	*Pinus massoniana*	Pinaceae	21,100 bare-rooted trees notch planted on 12.1 ha.
	12	Chinese Red Pine	*Pinus massoniana*	Pinaceae	40,200 bare-rooted trees & 14,850 replacements planted on 12.1 ha.
1959	1	Chinese Red Pine	*Pinus massoniana*	Pinaceae	9,890 bare-rooted and tubed trees used to beat up Pine plantations
	2	Chinese Red Pine	*Pinus massoniana*	Pinaceae	13,610 trees replacement trees planted in 1958 plantings
		Chinese Red Pine	*Pinus massoniana*	Pinaceae	14,910 bare-rooted trees used to beat up 1957 plantings
		Chinese Red Pine	*Pinus massoniana*	Pinaceae	9,000 tubed replacement trees planted to replace failures
	3	Chinese Red Pine	*Pinus massoniana*	Pinaceae	13,850 replacement trees planted in 1958 plantings
	5	Chinese Red Pine	*Pinus massoniana*	Pinaceae	25,000 trees to replant 1958 plantings
	10	Cypress Pine	*Callitris glauca*	Pinaceae	72 trees pit planted
		China Fir	*Cunninghamia lanceolata*	Taxodiaceae	150 trees pit planted
		Peacock Pine	*Cryptomena japonica*	Taxodiaceae	20 trees pit planted
	11	Chinese Red Pine	*Pinus massoniana*	Pinaceae	12,400 trees to beat up 1958 plantation
		Chinese Red Pine	*Pinus massoniana*	Pinaceae	900 trees planted on 3 ha.
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	5,110 tubed trees planted
	12	Chinese Red Pine	*Pinus massoniana*	Pinaceae	15,980 bare-rooted & 10,160 tubed replacements planted on 5.3 ha.
		Chinese Red Pine	*Pinus massoniana*	Pinaceae	17,970 bare-rooted trees to beat up 1958 plantation
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	12,160 trees planted on 9.1 ha.
	13	Chinese Red Pine	*Pinus massoniana*	Pinaceae	23, 240 trees planted on 7.8 ha. & beat up with a further 6350 trees

APPENDIX 2 (cont.)

Year	Compartment*	Species		Family	Notes
1959 (cont.)	13	Brisbane Box	*Lophostemon confertus*	Myrtaceae	3,705 tubed trees planted on 2.8 ha.
	14	Chinese Red Pine	*Pinus massoniana*	Pinaceae	37,555 bare-rooted trees notch planted on 12. 5 ha.
1960	1	Chinese Red Pine	*Pinus massoniana*	Pinaceae	5,390 tubed trees to beat up Pine plantation
		Chinese Red Pine	*Pinus massoniana*	Pinaceae	2,567 tubed and bare-rooted trees replanted in 1.4 ha burnt in 1959 fire
	2	Chinese Red Pine	*Pinus massoniana*	Pinaceae	2,355 tubed trees to beat up 1957 plantings
	3	Chinese Red Pine	*Pinus massoniana*	Pinaceae	3,640 tubed trees to beat up 1959 plantings
	9	Acacia	*Acacia confusa*	Mimosaceae	351 balled trees in fire burnt area
	10	Cypress Pine	*Callitris glauca*	Pinaceae	146 trees pit planted
	11	Chinese Red Pine	*Pinus massoniana*	Pinaceae	11,850 trees planted on 4 ha.
		Chinese Red Pine	*Pinus massoniana*	Pinaceae	5,750 tubed trees to beat up 1958 & 1959 plantations
	12	Chinese Red Pine	*Pinus massoniana*	Pinaceae	6,000 trees to beat up 1958 plantation
		Chinese Red Pine	*Pinus massoniana*	Pinaceae	8,660 trees to replant 2.8 ha. burnt in 1959 fire
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	3,325 tubed trees planted on 2.5 ha.
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	2,900 trees to replant 1.6 ha. burnt in 1959 fire
1961	11	Brisbane Box	*Lophostemon confertus*	Myrtaceae	3,243 tubed trees pit planted on 2 ha.
		Acacia	*Acacia confusa*	Mimosaceae	6.1 ha. planted with 19,530 tubed trees amongst 1958 Pine plantation
	12	Brisbane Box	*Lophostemon confertus*	Myrtaceae	9,856 tubed trees planted on 4.2 ha.
			Eucalyptus tereticornis	Myrtaceae	5,780 tubed trees planted on 3.4 ha.
	13	Brisbane Box	*Lophostemon confertus*	Myrtaceae	19,677 tubed trees planted on 11.7 ha.
	14	Chinese Red Pine	*Pinus massoniana*	Pinaceae	13,981 tubed trees planted on 4.6 ha.
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	5,773 tubed trees planted on 3.4 ha.
1962	8	Camphor	*Cinnamomum camphora*	Lauraceae	263 balled trees planted
	11	Chinese Red Pine	*Pinus massoniana*	Pinaceae	2,106 tubed trees to beat up 1960 plantation
	14	Chinese Red Pine	*Pinus massoniana*	Pinaceae	3,648 tubed trees to beat up 1961 plantation
	15	Chinese Red Pine	*Pinus massoniana*	Pinaceae	11,000 trees planted
1964	1	West Indies Cedar	*Cedrela odorata*	Meliaceae	200 trees interplanted into Melaleuca plantation
1965	1	Slash Pine	*Pinus elliottii*	Pinaceae	4,840 tubed trees replanted in 1957 fire burnt area
	6	SlashPine	*Pinus elliottii*	Pinaceae	1,474 trees planted
1966	4	Chinese Red Pine	*Pinus massoniana*	Pinaceae	47 tubed trees planted on landslide area
	7	Chinese Red Pine	*Pinus massoniana*	Pinaceae	1,490 tubed trees planted with grass on landslide area
	10	Chinese Red Pine	*Pinus massoniana*	Pinaceae	244 tubed trees planted on landslide area
1967	1	H K Orchid tree	*Bauhinia blakeana*	Caesalpiniaceae	80 trees
	3	Sweet Gum	*Liquidambar formosana*	Hamamelidaceae	110 trees pit planted
	9	Sweet Gum	*Liquidambar formosana*	Hamamelidaceae	1100 trees pit planted
1970	1	Sweet Gum	*Liquidambar formosana*	Hamamelidaceae	200 trees
		Chestnut Oak	*Castanopsis fissa*	Fagaceae	200 trees
		Slash Pine	*Pinus elliottii*	Pinaceae	125 trees

APPENDIX 2 (cont.)

Year	Compartment*	Species		Family	Notes
1970	4	Acacia	*Acacia confusa*	Mimosaceae	1,540 trees planted as fire barrier
(cont.)	7	Chestnut Oak	*Castanopsis fissa*	Fagaceae	1,000 trees
		Sweet Gum	*Liquidambar formosana*	Hamamelidaceae	1,000 trees
	10	Acacia	*Acacia confusa*	Mimosaceae	2,590 trees notch planted along forest road
		China Fir	*Cunninghamia lanceolata*	Taxodiaceae	110 trees notch planted along forest road
		Paper Bark	*Melaleuca quinquenervia*	Myrtaceae	50 trees notch planted along forest road
		Cotton Tree	*Bombax malabaricum*	Bombacaceae	40 trees notch planted along forest road
	14	Slash Pine	*Pinus elliottii*	Pinaceae	5,700 trees pit planted
1972	1	Chinese Red Pine	*Pinus massoniana*	Pinaceae	280 trees
		China Fir	*Cunninghamia lanceolata*	Taxodiaceae	270 trees
	4	Slash Pine	*Pinus elliottii*	Pinaceae	1,210 trees
		Chestnut Oak	*Castanopsis fissa*	Fagaceae	1,210 trees
	13	Acacia	*Acacia confusa*	Mimosaceae	5,310 trees pit planted as fire barrier
	15	Slash Pine	*Pinus elliottii*	Pinaceae	6,050 trees pit planted
		Acacia	*Acacia confusa*	Mimosaceae	6,050 trees pit planted
1973	5, 6, 7, 8	Acacia	*Acacia confusa*	Mimosaceae	16,500 trees planted as fire barrier
	6	Slash Pine	*Pinus elliottii*	Pinaceae	2,420 trees replanted
	13, 14	Acacia	*Acacia confusa*	Mimosaceae	3,800 trees as planted fire barrier
	15	Slash Pine	*Pinus elliottii*	Pinaceae	4,235 trees
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	4,255 trees
		Acacia	*Acacia confusa*	Mimosaceae	3,800 trees as planted fire barrier
1974	11, 14	Acacia	*Acacia confusa*	Mimosaceae	22,200 trees planted as fire barrier
	15	Acacia	*Acacia confusa*	Mimosaceae	13,500 trees planted as fire barrier
		Slash Pine	*Pinus elliottii*	Pinaceae	6,500 trees
1975	11, 14	Acacia	*Acacia confusa*	Mimosaceae	32,100 trees planted as fire barrier
	15	Slash Pine	*Pinus elliottii*	Pinaceae	6,050 trees
		Brisbane Box	*Lophostemon confertus*	Myrtaceae	6,050 trees
1977	14	Acacia	*Acacia confusa*	Mimosaceae	Further fire barrier planting
1979	5-8 & 11-15	Acacia	*Acacia confusa*	Mimosaceae	116,500 trees planted as fire barrier

* Compartment numbers refer to modern management compartments

Sources: Agriculture & Fisheries Department records held at Tai Po Kau Management Centre

Epidemiologic and Economic Analyses of the Environment: Examples Dealing With Hong Kong's Air Pollution

Joseph L.Y. Liu and Anthony J. Hedley

ABSTRACT

Many cost-benefit analysts involved in the evaluation of pollution control estimate intervention benefits by extrapolating results from epidemiological investigations or clinical findings in other settings. In many instances, the use of locally relevant epidemiologic data would have been more appropriate. Epidemiologic studies provide quantitative information on the health impacts of pollutant exposure and can play an important role in economic analysis. In 1989–92, a respiratory health survey (RHS) was carried out in two districts of Hong Kong to evaluate the benefits and costs of a government regulation which bans the industrial use of fuels with high sulphur content. The RHS provided a rare opportunity to analyse costs and benefits using local epidemiologic data. Using the RHS as a case study, we argue that an 'epidemiologic-economic' approach towards policy evaluation is superior to the use of either approach alone. There is a need in Hong Kong and elsewhere in Asia to develop better epidemiological databases and exploit them for environmental policy appraisal, development and evaluation.

Keywords: *air pollution, cost-benefit analysis, epidemiology, respiratory health survey, Hong Kong*

INTRODUCTION

Environmental monitoring and regulation are relatively new developments in much of Asia, including Hong Kong. In recent years, numerous pollution abatement ordinances have been enacted by legislators in Hong Kong. Yet, with some notable exceptions (e.g. Peters et al 1996, Hedley et al 1993, Barron et al 1995), there is a lack of locally relevant information about the adverse health effects of the various environmental problems in the territory and the cost-effectiveness of existing regulations in reducing public health risks. There is thus a need to develop locally and regionally, relevant analytical methods for the economic assessment of health effects from exposure to environmental agents.

This paper concentrates on one environmental management problem, ambient air pollution, and outlines the valuable role that epidemiologic research can play in economic assessments of environmental problems. We review the methodological aspects of previous economic appraisal studies on ambient air pollution and then go on to show how findings from a recent epidemiologic survey on respiratory health in Hong Kong can be used to compare the costs and benefits of an air quality intervention. This is the

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first time such an analysis had been conducted on the territory's air pollution problem. We hope to convey to environmental management professionals in Hong Kong and elsewhere in Asia, the need to develop and exploit locally available epidemiologic databases for economic assessment purposes.

THE ROLE OF EPIDEMIOLOGY

Before we discuss the relevance of epidemiology in economic analysis, the curious reader may ask, 'Why are epidemiologic studies needed in the first place?'[1] In a commentary about the state of medical knowledge on respiratory illnesses, Florey and Leeder (1982) said that animal studies and laboratory studies on human volunteers have provided important pointers on possible health effects from environmental exposures, but these results have limited generalizability to human populations. This is partly because the concentrations of pollutant exposures in experimental conditions are typically quite different from those actually experienced by human populations. With animal studies, there is the additional problem of biological differences between species. Clinical investigations of animals and humans are useful for identifying plausible pathogenic pathways of disease and generating biologically justifiable hypotheses for epidemiologic surveys, but the grounds for extrapolating these findings to the general population are tenuous. Appropriately designed epidemiologic surveys, on the other hand, can produce findings which are generalizable to the communities being studied, by comparing the rates of exposure-related illnesses between representative samples of communities exposed to different pollution levels and quantifying the health detriment to the population using suitable risk indicators. Rothman 1986 and Kramer 1988 provide a general discussion on epidemiologic study designs and measures of risk.

McMichael (1989) and Lam et al (1992) examined the epidemiologist's role in setting environmental exposure standards and pointed out that at high levels of ambient air pollutant exposure, the empirical evidence of a causal association with ill-health is compelling. For example, in the 1930s through 1950s, exposures to high peaks of air pollutant concentrations in many cities in the West were consistently found to be strongly associated with excess mortality rates. Goldsmith (1990–91) called this the 'era of air pollution disasters' and cited incidents such as the infamous 1952 London smog and the pollution episodes in the Meuse Valley of Belgium in 1931 and Donora in Pennsylvania in 1948. Stricter regulations and monitoring subsequent to such tragedies had decreased deaths attributable to air pollutant exposures by substantial proportions.

A study by Lave and Seskin (1977) is a case in point. Their investigation was concerned with mortality rates in the 1960s, an era when air pollution levels in the United States were beginning to drop considerably, after the first air quality standards were implemented (Goldsmith 1990–91). They concluded from their models that a 50% decrease in air pollution levels in the United States would result in a 4.7% decrease in mortality. However, as pointed out by Tietenberg (1992), when an independent group of researchers analysed the same set of data, the estimated decline in mortality was only 0.43%.

The above example highlights the problem of assessing mortality effects of chronic exposure to relatively low (compared to the 1930s to 1950s) but still potentially harmful levels of air pollution. For this reason, many epidemiologic investigations in the last 20 years have focused on morbidity effects (e.g. WHO 1978, Ferris et al 1979, Ware et al 1986, Dockery et al 1989, Forastiere et al 1992, Peters et al 1996). Adverse health effects from long term exposure to lower levels of air pollution are smaller and harder to measure (McMichael 1989, Lam et al 1992).

Liu (1994) conducted a survey of the epidemiologic literature on the effects of poor outdoor air quality on the respiratory health of children from 1970 to 1993. This relationship is important because there is some evidence that chronic respiratory conditions in childhood increases the risk of lung cancer in later life (Samet et al 1983, Cooreman et al 1990). For nine out of the thirteen studies reviewed, chronic exposure to ambient air pollution was associated with an increased risk of respiratory illness. The magnitude of the measured risks showed some variation between the studies. Part of this difference in findings might be attributable to sampling variation, but it is likely that a component of the variation arose because the mix of air pollutants and the specific exposure and baseline health experience of communities varied from place to place. Other variations might arise from additional but unmeasured exposures such as environmental tobacco.

The implication is that locally relevant epidemiologic data should be used to explore the health effects of low level air pollution, because findings from other locations might not be applicable to the population being studied. Furthermore, Lam et al (1992) and Bhopal (1992) pointed out that in Hong Kong and Britain, some communities have pressured regulatory authorities for tighter environmental legislation, in the belief that the quality of their living environment was detrimental to health. These subjective assessments should be corroborated by objective scientific evidence (preferably of an epidemiologic nature) that the perceived risks actually exist.

THE EPIDEMIOLOGIC-ECONOMIC PERSPECTIVE

Epidemiologic studies can be used to obtain estimates of health risk for communities living in polluted locations. The effectiveness of an environmental intervention can be measured by obtaining epidemiologic estimates of health risk before and after an intervention. However, measuring effectiveness alone is inadequate if cost-effectiveness is not taken into account. For example, intervention X may be highly effective in reducing the excess risk for disease A but extremely costly to implement, whereas intervention Y might be only moderately less effective but cost much less to implement. In this scenario, Y is the more economically efficient intervention. The logical questions, then are 'what are the appropriate epidemiological methods for assessing the effectiveness of alternative interventions or treatments?' and 'given the epidemiological outcome and risk measures from a particular study, what are the appropriate techniques for measuring the comparative efficiency of the alternative interventions or treatments?'

The most common types of economic appraisal techniques used in the evaluation of environmental policies are cost-benefit analysis and the closely related technique of cost-effectiveness analysis. Cost-benefit analysis identifies efficient policy options through the maximisation of net benefits accrued from each option. Cost-effectiveness analysis compares policies which one considers to be equally effective in achieving an explicit goal on the basis of the cost of attaining that objective. Barron (1991) and Dasgupta and Pearce (1978) pointed out that cost-benefit evaluations should take into account nonmonetary costs and nonmonetary benefits by including them in an implicit valuation. In this formulation, the monetary costs of an action typically are compared with the net nonmonetary benefits. The purpose of the implicit valuation is to make this net money cost versus net nonmoney benefit tradeoff as precise and explicit as possible. The analyst, in effect, says to the decision maker, 'if you value this explicitly identified (and, as possible, quantified) set of nonmonetary benefits *at least as much* as this specified money cost, then the action is appropriate. If you fail to act, you are implicitly indicating that you value the specified nonmonetary impacts at less than this amount of money.' For readers unfamiliar with these techniques, a general treatment of the subject can be found in standard texts such as Dasgupta and Pearce (1978), Mishan (1988) and Gramlich (1990).

In this context, the strength of an economic appraisal is largely dependent on the measured strength of the epidemiologic appraisal. The former is only worth carrying out if a polluting agent is shown by epidemiologic studies to be a significant risk factor, with current clinical knowledge indicating that the observed association is biologically plausible. The specification of alternative intervention options to reduce the identified health risk needs to be carried out by experts in the appropriate fields. Thus, an economic evaluation of public health policies (including pollution control interventions) is inherently a multidisciplinary exercise.

Epidemiologic studies on their own can only provide quantitative information on the health impacts of exposure to a risk factor, in this case air pollution, or the health benefits from reduced exposure as a result of an intervention. Examples of such benefits include cases of illnesses prevented, the number of lives saved, doctor consultations prevented, etc. If left unmonetized, each of these benefits can be used as a unit of effect in a cost-effectiveness ratio. If monetary values can be assigned to one or more of these benefits, cost-benefit analysis can be used. The danger with using only the epidemiologic approach in setting environmental standards is that potential health benefits are overemphasized in policy formulation. According to Marshal (1989), some medical researchers have used their findings to push for stringent environmental standards without considering the policy implications or the attainment costs. Economic analysis on its own (without epidemiologic considerations) can only evaluate abatement options using the a priori assumption that the environmental objective is worth achieving. Using either approach in isolation only provides a partial analysis of the environmental management problem. There is thus an intrinsic link between economic appraisal and epidemiologic risk assessment.

THE COST-BENEFIT LITERATURE

Luken (1985), an economic analyst at the US Environmental Protection Agency (EPA), discussed the evolution of policy evaluation at the EPA, from the adoption of technological feasibility studies, risk-benefit assessments and cost-effectiveness appraisals in the 1970s, to the current emphasis on cost-benefit analysis. He acknowledged the importance of the epidemiologic-economic link, noted the need to strengthen the epidemiologic foundations of the agency's cost-benefit evaluations, and urged epidemiologists to play a more active role in evaluating the potential economic impacts of pollution-related morbidity and to work with economists in deriving better estimates of individuals' willingness-to-pay to avoid ill-health.

Many economic appraisals of air pollution estimate health effects by either using epidemiologic findings from other communities or by extrapolating the results of clinical studies or experiments. For example, a cost benefit analysis conducted by Hall et al (1992) assumed that epidemiologic evidence from Japanese studies on the relationship between ozone exposure and respiratory symptoms was applicable in the context of the ozone pollution problem in southern California. In one of the cost-benefit studies conducted by Krupnick and Portney (1991), nationwide health costs from air pollution exposure in the US were derived by using secondary epidemiologic data to compute a lower-bound estimate and extrapolations from clinical studies to obtain an upper-bound estimate. These proxy measures of health effects are useful in the absence of local epidemiologic data. Some analysts, such as Pearce et al (1983) and Anderson et al (1979), conducted cost-effectiveness evaluations. Given the well known weaknesses of this approach (e.g. in the comparison of programmes with multiple non-monetised benefits), cost-benefit evaluation is the preferred technique if sufficient data are available (see Liu 1994 and Dasgupta and Pearce 1978 for a discussion of the limitations of cost-effectiveness analysis).

Economic appraisals of air quality interventions are often based on the hypothetical removal or reduction of pollutants. For example, Hall et al (1992) predicted that the hypothetical attainment of air pollution standards in the South Coast Air Basin of California would save 1600 lives a year but the benefits of actual attainment were not known. Evaluations of actual interventions are uncommon. One rare example is a study by Ransom and Pope (1993), which evaluated the health costs of particulate emissions from a steel mill by comparing hospital admissions and mortality data before and after temporary closure of the mill. Annual excess hospitalisation costs were estimated to be around US$2 million. The economic efficiency (i.e. the net benefit) of closure was not known because no comparisons were made between the costs of closure and the measured health benefits.

With the accumulated knowledge of these studies in mind, we used the results of a respiratory health survey in Hong Kong as a basis for comparing the costs and benefits of an air quality intervention. Since the details can be found elsewhere (Peters et al 1996, Hedley et al 1993 and Ong et al 1991 for reports on the RHS; Barron et al 1995 and Liu 1994 for detailed methodology and findings of cost-benefit analyses using RHS data) this appraisal is briefly presented below as an example of fruitful collaboration between epidemiology and economics.

CASE STUDY: A COST-BENEFIT APPRAISAL OF AN AIR QUALITY INTERVENTION IN HONG KONG

The Air Pollution Problem in Hong Kong's Kwai Tsing District

In parts of Hong Kong, such as the heavily industrialized Kwai Tsing district in the northwest New Territories, the close proximity of residential housing estates to industrial complexes and traffic congestion leave large segments of the population exposed to industrial emissions of air pollutants (such as sulphur dioxide and respirable suspended particulates) and exhaust emissions from diesel vehicles. In the late 1980s, air quality data from Hong Kong's Environmental Protection Department showed that annual air pollutant levels were substantially higher in Kwai Tsing than in residential areas such as Southern District, with frequent exceedances of the government's air quality objectives (EPD 1990). This meant that Kwai Tsing residents were chronically[2] exposed to high levels of ambient air pollution, especially sulphur dioxide (SO_2) and particulate levels estimated as total suspended particulates (TSP) and the more harmful respirable particulates (RSP).[3] This created a potentially serious public health problem (EPD 1989–1995).

The Low Sulphur Fuel Intervention

On 1 July 1990 a new fuel regulation was implemented in all industrial establishments in Hong Kong. The regulation banned the industrial use of fuel oil with a sulphur content of more than 0.5% by weight. Previously, factories in Hong Kong typically used heavy fuel oil with 2.5% sulphur content. Prior to the restriction, there were about 1100 heavy fuel users in the territory, 13% of which are located in Kwai Tsing (communication with Chan Mai of the Hong Kong Environmental Protection Department on 15 April 1991). The burning of heavy fuel oil produces very high levels of SO_2 and moderate levels of uncombusted carbon in the form of RSP (Hong Kong Productivity Council 1988). After the fuel switch, Kwai Tsing experienced a substantial reduction in SO_2 levels and a moderate decrease in RSP concentrations[4] (EPD 1992). Liu (1994) showed that the cost of the intervention to industry in Kwai Tsing was US$8.3 million.

An Epidemiologic Evaluation of Intervention Benefits

In response to a request by the Kwai Tsing District Board, the Department of Community Medicine at the University of Hong Kong conducted a series of respiratory health surveys (RHS) in 1989–1992 to investigate the relationship between ambient air pollution levels in Kwai Tsing and the health of its residents.

The surveys consisted of questionnaire interviews and objective measurements of representative samples of eight to eleven year old school children[5] in Kwai Tsing District (a high air pollutant area) and Southern District (a residential area with low air pollutant levels). Health questionnaires, which were completed by children and their parents, were adapted for local use from internationally recognized and standardized questionnaires.[6] Information was collected on the following items: the child's symptom and illness history, age, gender, district of residence, socio-economic and demographic indicators, personal smoking history, household smoking, and sources of indoor air pollutants at home. The objective measurements included estimates of lung function and bronchial responsiveness (that is any tendency to narrowing) of airways after inhalation of histamine vapour. This is a measure of the extent to which environmental factors (such as pollens or chemical pollutants) have affected the normal physiology of the airways in the lung.

The first phase of the study (i.e. the pre-intervention RHS) was implemented in 1989–90, before the low sulphur fuel regulation came into effect. The objective was to obtain baseline measures of associations between air pollution and respiratory symptoms in the children of Kwai Tsing district. The second phase of the study (i.e. the post-intervention RHS) was carried out in 1991–92 to measure the improvement (if any) in the health status of Kwai Tsing's children after the regulation.

The pre-intervention RHS results demonstrated that children living in Kwai Tsing were at significantly higher risks of developing chronic respiratory symptoms and seeking medical care for their conditions than their counterparts in Southern District (Table 1). This district health risk was attributed to Kwai Tsing's poor air quality (Hedley et al 1993; Peters et al 1996). The results of the post-intervention RHS showed that when compared with the baseline pre-intervention findings, the measured health risks had substantially declined (Table 1). The improvement in respiratory health for Kwai Tsing children was attributed to the cleaner air in 1992, following the low sulphur fuel regulation (Hedley et al 1993; Peters et al 1996). The survey results were consistent with objective data on bronchial hyperreactivity using the histamine challenge test (Tam et al 1994; Ong et al 1996).

Comparison of Costs and Benefits

Using the risk estimates in Table 1 and census population data, Hedley et al (1993) derived numbers of cases of illnesses in the population which were attributed to air quality levels in Kwai Tsing before and after the intervention. These numbers represent measurements of avoidable health costs, since they can be prevented or reduced, if risk factor exposure was removed or decreased. For all the symptom in-

Table 1
Adjusted Odds Ratio Estimates for Morbidity Indicators in 8 to 11 Year Old Children Who Live in Kwai Tsing District

Morbidity Indicator	*Pre-intervention Odds Ratio 1989/90*	*Post-intervention Odds Ratio 1991/92*
any chronic cough or throat problems	1.22**	1.04
any chronic phlegm symptoms	1.12	1.03
any wheeze or asthmatic symptoms	1.27*	1.11
any chronic nasal symptoms, allergic rhinitis or sinusitis	1.08	1.08
any chronic respiratory symptoms	1.15*	1.04
doctor visit for respiratory condition in past 3 months	1.29**	0.95

* $p<0.05$ ** $p<0.01$

Explanatory Notes:

(1) *Interpretation of Odds Ratio figures*
If odds ratio>1, children in Kwai Tsing district are at a higher health risk than children in Southern District. The higher the odds ratio estimate, the higher the risk of living in Kwai Tsing.
If odds ratio=1, no difference in health risk could be detected between Kwai Tsing and Southern District children. For an odds ratio of 1.27 there is a 27% excess risk of living in the polluted district.

(2) *Source of Estimates*
The odds ratio estimates for symptoms were based on a factor model (1989–92) as reported by Hedley et al (1993).
The odds ratio estimates for doctor visits were based on 1989 and 1992 data as reported by Barron et al (1995).
All the above odds ratio estimates were adjusted to take into account gender, age, cigarette smoking, passive smoking at home, socioeconomic factors and sources of indoor air pollution at home.

dicators, substantial declines in avoidable health costs were reported for Kwai Tsing after the intervention (results not shown but large reductions in health risk as shown in Table 1 imply that this is the case[7]). Similarly, Barron et al (1995) reported significant reductions in avoidable doctor consultations after the intervention. In short, large numbers of symptom episodes were prevented. These reductions in baseline avoidable health costs represent measures of the effectiveness or benefit of the fuel intervention.

The above-mentioned benefit items can be assigned a monetary value using willingness-to-pay data for avoided symptoms and estimated out-of-pocket expenditure for avoided doctor visits. Using RHS findings and sensitivity analysis for unavailable data, Barron et al (1995) compared the benefits (as measured by the RHS) and costs (as estimated by Liu 1994) of the intervention and found that monetary estimates of avoided doctor consultations alone made up for a moderate portion of the intervention costs, with annual net monetized cost estimated at US$6.8 to US$8.3 million. A large fraction was offset when lower-bound willingness-to-pay estimates of avoided symptom episodes obtained from elsewhere were used, with estimated annual net monetised cost at US$3.5 to US$7.3 million (details shown elsewhere[8]). Barron et al concluded that the intervention was likely to have been cost-effective, if data on unmeasured longer term health effects had been available.

Limitations of Exposure Assessment

The measured reduction in health risk after the intervention indicates the existence of a dose-reponse relationship between air pollutant exposure (in terms of sulphur dioxide and respirable particulates) and respiratory symptoms. However, a more refined dose-response function for Hong Kong's air pollution problem could not be derived from the RHS data because of logistic and data limitations. The air quality measurements from the EPD were insufficient for more detailed rankings of the different constituencies within Kwai Tsing in terms of the differences between them in their air pollution levels. The EPD only has one air quality monitoring station in Kwai Tsing district and one in Southern District (EPD 1991). The air pollutant measurements in each district are considered by EPD to be representative of the district as a whole. Because of secondary data constraints and the lack of alternative measurements of exposure, it was not possible to measure the air pollution exposure for each subject. A more precise dose-reponse function would have allowed us to derive a more precise measure of intervention benefits, but the logistical and resource constraints meant that this was the best study design which could feasibly be implemented. We believe, however, that useful policy statements could still be made from a cost-benefit comparison, as shown by this paper.

Limitations of Cost-Benefit Analysis

Some readers may object to the methodological approach of the case study in that too many effects (e.g. long term health benefits and contingent valuation of items such as lost school days) have been left unmonetized. We argue that the concept of economic efficiency requires the comparison of marginal benefits with marginal costs and this must also apply to the valuation (and quantification) process in cost-benefit analysis.

The process of quantification and valuation should continue only so long as the value to decision making of more precise estimates is greater than the costs of developing it. Since the 'value' of additional information to decision making is typically subjective, it will generally not be possible to precisely determine where this point is in any particular case. Yet, as with so much of economic theory, the basic concept is quite useful, even when it cannot be precisely measured in practice. If we continue to ask ourselves the question, *'how much more precise is the problem defined for decision making, if the value of this particular impact is monetized?'* then we are likely to improve the efficiency with which we carry out analyses in support of policy assessments.

In doing this, we need to keep in mind that there will virtually *always* be some residual non-monetized (and often non-quantified) impacts which necessitate some form of tradeoff assessment between the net monetized value and the non-monetized impacts as part of the cost-benefit analysis. The question related to such a tradeoff would be of course, 'are the non-monetized net benefits worth at least as much as the monetized net costs?' If yes, the intervention is justified. This type of *implicit valuation of minimum (or maximum) values* may not be as precise as analysts would like, but it may be *precise enough* for the needs of a policy decision.

DISCUSSION

The above case study serves as one example of how locally relevant epidemiologic risk measures can be used in an evaluation of the cost-effectiveness of pollution-abatement measures. However, an economic evaluation would not be complete without the consideration of alternative intervention options, which may be cheaper to implement but equally effective in reducing excess health risks. In a qualitative assessment of various pollution control instruments, Barron (1992) indicates that the low sulphur fuel intervention is likely to have been the least-cost practical first step towards industrial air pollution abatement in Hong Kong. However, a more detailed marginal cost analysis of alternative intervention options is needed to provide policy makers with a firmer basis for selecting the next step on the supply function for air pollution abatement. The recent debate in Hong Kong on a fuel regulation requiring public transport vehicles to switch from diesel to petrol highlights the need for such an analysis (*South China Morning Post* 13 December 1995). There is also a need for developing new and more precise health benefit indicators for assessing the effectiveness of future air quality interventions which might be derived from the study of high risk groups such as transportation workers and traffic police.

The epidemiologic-economic approach as illustrated by our case study should be of interest to environmental management professionals, given that one of the central concerns of environmental management is to formulate, implement and evaluate pollution control measures.

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NOTES

1 For readers who are unfamiliar with epidemiology, McGuire et al (1988), defined it as a science which is concerned with 'finding the determinants of ill-health, methods of prevention or amelioration, and in measuring the "effectiveness" of medical interventions and health service provision in improving health' by studying the distribution of health problems in human populations.
2 'Chronic exposure' refers to long term exposure, in contrast to 'acute exposure' which refers to high level short term exposure.
3 For a review of the health effects of different types of air pollutants see Peters and Hedley (1994).
4 The decrease in RSP levels was smaller because the major source of particulate emissions in Hong Kong comes from motor vehicles and the fuel switch only reduced industrial emissions (EPD 1992).
5 The focus was on children because: (1) They are considered to be a vulnerable subgroup to respiratory ailments and (2) The health effects of air pollution on adults are harder to measure than for children because of lifetime exposures to passive and active cigarette smoke and occupational exposures (Hedley et al 1990).
6 For details on the development, reliability and validity of the standard questionnaires, see Florey 1982.
7 see Hedley et al 1993 for detailed results on avoided symptom episodes.
8 see Barron et al 1995 for detailed analysis and report of findings.

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WORKSHOP REPORT*

Making Environmental Law in Asia More Effective

Participants' Report from a Regional Workshop, Hong Kong 4–8 March 1996

ABSTRACT

A common complaint in Asia is 'we have good environmental laws, but they are not enforced.' This is an abridged version of the Participants' Report on the outcomes of a regional workshop which addressed both the broad context in which environmental laws are implemented and specific design features of laws and regulations. For example, the participants stressed that unless environmental protection becomes much more effectively integrated into the investment and land use planning process, Asia's fast-paced growth will mean that environmental protection remains *too little, too late* and *unduly expensive*. Environmental protection in the region also would be more effective and cost-effective if industry and the community are brought into a closer working partnership with government in the law design and enforcement process. The workshop also addressed a number of specific considerations related to compliance monitoring and enforcement and environmental impact assessments.

Keywords: *Asia, environmental law, environmental protection, pollution control, environmental management*

INTRODUCTION

The Asian region is undergoing the fastest and most widespread economic development the world has ever experienced. In the process, it is experiencing severe environmental degradation with obvious harm to human health in the near term, and potentially catastrophic consequences for the long term ability of the natural environment to adequately provide the essential services on which our very social and economic systems ultimately depend. While some tradeoff between environment and development is inevitable, the bargain in emerging Asia-Pacific has been a particularly poor one, with much environmental quality being sacrificed for modest (and often poorly distributed) near-term benefits. Yet, with some notable exceptions, the problem is not generally one of the absence of stringent laws. A common complaint in the region is: 'we have good laws, but they are not enforced'.

In March 1996, environmental professionals from 13 Asian economies and from North America came together in Hong Kong for a week of discussions about the underlying nature of the problems and to identify ways to overcome them. The 33 participants included persons from government (cabinet-level ministries, regulatory line agencies, and the judiciary), private industry, academia and voluntary organizations. The participants came from a variety of professional backgrounds, with about half

**Editor's Note: AJEM welcomes abridged versions of workshop reports and conference proceedings on topics related to practical issues of environmental management in Asia. Manuscripts should be about 4000 to 9000 words and include a brief description of the nature of the activity, when and where it took place and who participated, summary coverage of the major outcomes and information on how readers may obtain the full report.*

being lawyers and the others from the fields of sciences, engineering, planning, and economics. The workshop was funded entirely by private sector sponsors from Hong Kong and North America. This paper is an abridged version of *Making Environmental Law in Asia More Effective: Participants' Report from a Regional Workshop*, Hong Kong, March 4–8, 1996. A complementary copy of the full report may be obtained by writing to: *The Centre of Urban Planning and Environmental Management, The University of Hong Kong, Pokfulam Road, Hong Kong.*

One noteworthy aspect of the discussions at the workshop was the identification of a considerable common ground among the participants from private industry, government and the non-governmental organizations. Over the course of the week, a consensus emerged that where there is an adequate *level of trust* among the regulated community, government regulators and the community at large, opportunities for more effective and more cost-effective environmental protection are likely to emerge. Aside from the improvements in the specific forms of environmental regulation, the development of a more *cooperative* and *participatory* approach to environmental law making in the Asian region would do much to improve on the poor development-environment bargain which is now all too typical.

WORKSHOP CONCLUSIONS/ RECOMMENDATIONS

To facilitate the exchanges of ideas, the week-long workshop was divided into separate sessions focused on particular themes: (1) the institutional context, (2) land use planning, (3) compliance monitoring issues, (4) compliance enforcement issues, (5) the role of different types of policy instruments, (6) the design and use of environmental impact assessments, and (7) international trade agreements as these affect national and sub-national environmental controls. Despite some inevitable overlap, this framework proved to be an effective one.

The findings and recommendations of the workshop relate to both the broad context in which environmental management takes place, and specific aspects of law design and the appropriate context for its implementation. Table 1 lists the full set of recommendations and findings. Selected recommendations and findings are then elaborated in the following section of this paper.

ELABORATION ON SELECTED RECOMMENDATIONS AND FINDINGS

Unless environmental policy is more effectively integrated into overall planning and investment promotion, environmental protection in the Asian context will be inadequate and needlessly costly.

Two distinguishing features of the Asian region are the role of government in promoting specific forms of development and the absence of effective integration of environmental concerns into the goals of planning ministries, investment agencies and the like.

> Without such integration, the environmental agencies are left largely with the task of *mitigation rather than prevention*. This is both ineffective and inefficient. It leaves end-of-pipe clean-up as the basic strategy, placing the burden of environmental protection all the more heavily on *existing* industry, transport, and others who must undertake increasingly stringent and expensive steps to reduce their own environmental impacts, even as the benefits of such efforts are overwhelmed by poorly planned growth.

Effective integration of environmental considerations into planning and investment decisions needs to occur at a number of levels, but principally with respect to:

(i) the type of economic development promoted or allowed,
(ii) the type of infrastructure (e.g. sewage treatment),
(iii) incentives to new industry to be more environmentally sound and
(iv) land use planning decisions.

Wherever corruption presents a major concern, environmental laws and regulations should be as non-complex and as transparent as feasible.

A point which surfaced time and again during the workshop is the problem posed by corruption. As the region has grown rapidly there has been an undermining of older institutional and social values. There is also a widening gap between public sector wage levels and those of the private sector, as well as between the rich and poor generally. These factors, among others, have made the use of illicit compensation to public servants to either perform their duties or to purposely fail to perform them, a growing problem in Asia, though by no means is this problem unique to the region.

Table 1
Recommendations and Findings

Broad, Contextual Issues

(I) Unless environmental policy is more effectively integrated into overall planning and investment promotion, environmental protection in the Asian context will be inadequate and needlessly costly.

(ii) Wherever corruption is a major concern, environmental laws and regulations should be no more complex than absolutely necessary and as transparent as possible.

(iii) The most important environmental decisions often are collective ones and citizens can only exercise responsibilities for deciding on the type of environment they are able and willing to pay for when they have access to adequate information.

(iv) In Asia generally, there is a need for greater consolidation of environmental responsibilities in government or, where such consolidation is not feasible, for much better coordination among responsible agencies.

(v) Land use planning is a vastly underutilised tool in the region for lessening the environmental consequences of development and this has tended to undermine success in reducing environmental damage from existing sources.

(vi) Considering the importance of international trade to Asia's economic development, it is particularly incumbent on those designing environmental laws for this region to ensure that these laws do not present arbitrary or unjustifiable discrimination or serve as a disguised barrier to trade.

Compliance Monitoring

(vii) Environmental laws must be designed with compliance monitoring needs and capabilities clearly in mind.

(viii) Careful assessments of what to monitor and how to monitor it are essential in building an effective and workable system of environmental law.

(ix) Monitoring systems are more effective and more cost-effective when government monitoring activities are supplemented by well-designed self-monitoring and information from the local community.

Compliance Enforcement

(x) Monitoring should provide both positive and negative feedback with results being made freely available (within the bounds set by the legitimate needs for confidentiality).

(xi) Alternative approaches to dispute resolution are needed in the Asian context because cultural factors may weaken the effectiveness of approaches adapted directly from elsewhere.

(xii) In Asia generally, there is a need to give greater scope for citizen-brought cases of environmental protection and perhaps the greatest obstacle to doing so is the desire of government to limit its own vulnerability to citizen suit.

Type of Policy Instrument

xiii) Selection of environmental policy instruments should be based on an assessment of its (i) effectiveness in limiting environmental damage, (ii) cost-effectiveness, (iii) administrative ease, (iv) fairness, and (v) political acceptability.

(xiv) While the Polluter Pays Principle must be employed, there are circumstances in which subsidies or other positive incentives deserve consideration.

Approaches To and Use of EIAS

(xv) While EIA can be a useful planning tool, the EIA itself will not provide clear-cut answers on the acceptability of impacts. Policy decisions drawing on the findings of the EIA still require difficult choices.

(xvi) In order to be effective, an EIA must be conducted as early as possible in the planning process and impacts of individual projects evaluated within the context of the larger development process.

(xvii) While a considerable variety exists in the types of EIAs employed and how they are used in the region, in general, the EIA process in Asia involves inadequate public consultation and transparency.

(xviii) EIAs should be conducted by independent, unbiased analysts and be done in a timely manner.

(xix) EIA should not be restricted to narrowly defined environmental concerns. It should embrace, where appropriate, aesthetic factors and also cultural considerations, including those of ethnic minorities.

(xx) An EIA should include recommendations for post-implementation monitoring and reporting.

In environmental management, corruption may be exhibited in a variety of ways from high level *ad hoc* exemptions to industrial plant siting restrictions in environmentally sensitive areas, to the granting of operating permits before emission controls are in place, to the falsification of monitoring records, and so on.

> Corruption in various forms is a fundamental problem which requires basic changes in social and economic conditions (e.g. better accounting by public agencies, provision of liveable wages to public employees). Until that happens, the issue at hand is how to minimize the potential for corruption to undermine effective implementation of environmental laws.

In the face of the potential for corruption, drafters of environmental laws should design laws in a manner which:
(i) minimizes the number of *points of administrative intervention* and
(ii) makes *performance accounting* at these points as *transparent as possible.*

The most important environmental decisions often are collective ones and citizens can only exercise responsibilities for deciding the type of environment they are able and willing to pay for when they have access to adequate information.

If people are to be able to take responsibility for deciding the type of environment they are able and willing to pay for, they must have access to information to be able to make informed decisions. Hence, the planning process should be as open as possible and allow for periodic consultation as planning progresses from initial option review to final design. One major potential advantage of greater participation is that citizens will tend to *buy in* more to programmes which they feel they can influence. This increases political support and may make it easier to 'sell' programmes which require the support of the public at large (e.g. fare increases for cleaner public transport). Where such formal possibilities are non-existent or not effectively implemented in practice, the citizenry will tend to feel distant from decisions and to consider them only from the viewpoint of their own narrow self-interest. In such cases, getting public support for broad-based efforts for environmental protection will be more difficult.

The absence of effective formal channels of communication may also tend to lead to a feeling on the part of particular interest groups (e.g. those living close to a polluting factory) that only by highly publicized tactics (and if need be, ones disruptive to business as usual) will their concerns be seriously considered. Such an atmosphere of antagonism makes administration more difficult and may lead to poor decisions stemming from the desire of the political leadership to quickly end any such disruptions.

There is a natural fear on the part of developers and government that more consultation means delay and financial cost — especially in a region developing as rapidly as this one, and where consultation with the public is often not part of the traditional government ethos. But fuller consultation is likely to mean more informed decision making, which ultimately should lead to better decision making. Government will usually have all the relevant information available (it certainly ought to have it available for its own decision making), and provided the public is informed in good time that consultation will take place, periods available for consultation need not be long. Of course, the later in the planning process that the consultation takes place, the more concrete plans will be and the more resistance from developers and government planners there will be to changing them.

Land use planning is an underutilized tool in the region for lessening the environmental consequences of development and inadequate land use planning may undermine success in reducing environmental damage from existing sources.

Although many people may tend to think of environmental damage as something which is absolute, in fact, it typically depends to a relatively large extent on the proximity of a damaging activity to 'sensitive receivers', whether these be human settlements, other ecosystems, or in some cases, local geophysical features (e.g. smog in famous scenic areas). The same type and level of pollution occurring near a large population centre or in proximity to important natural eco-systems e.g. (coastal wetlands) will usually be far more serious and involve far higher environmental 'costs' than the same level of pollution in areas of low population or biological importance. This is not to say that pollution or other forms of environmental damage in less sensitive areas is not a matter of potential concern, but simply that its significance is less.

> Land use planning — and especially industrial and infrastructure siting decisions — should be a *starting point* for environmental management.

While the above statement may be stating the obvious, the precept seems mostly to be honoured in the breach. Many of the workshop participants come from countries which have not often engaged in comprehensive land use planning. Clearly, other considerations (e.g. industrial growth, the location of existing infrastructure) may appear to be quite compelling when it comes to such matters as where to put an industrial plant, a sewage treatment facility, or a new housing development. Putting such developments 'close in' to an existing population centre tends to lower transport and certain types of infrastructure costs. Filling in coastal wetlands may be the cheapest way to acquire the necessary land. And putting a luxury housing development in an area excised from parkland may allow government to capture much higher land prices due to the amenity value of the location.

Yet in each case, there are substantial offsetting costs in the form of environmental damages (e.g. health effects, the loss of fish spawning areas, the weakened integrity of the park system) and these may continue far into the future in contrast to the typically near-term nature of the financial benefits. This makes the decision a bad bargain from an overall economic standpoint.

If the environmental consequences of land use planning decisions are not explicitly considered along with other factors such as land costs, transport distances, etc., then the planning process is seriously flawed, resulting in higher losses of environmental quality in the near-term and unnecessary costs for clean-up and restoration in the future. With this noted, the participants stressed that it is obvious that environmental considerations should not always dominate land use planning, since that would be both unrealistic and inappropriate.

Environmental laws must be designed with compliance monitoring clearly in mind.

The first step is the setting by government of clear standards (e.g. allowable pollutant emissions) and a system of permits for emissions so that those subject to compliance know what is expected of them and those doing the monitoring know what to look for. In this regard, standards set by international organizations (e.g. the World Bank) or the older industrialized nations (e.g. the USA, Japan) may serve as benchmarks and guidelines.

How closely should the standards set by law and the permitting system match the capacity of the monitoring system to track compliance? One approach is to set up a comprehensive set of standards and permitting, even if at present, the resources available for compliance monitoring fall well short of what would be needed to actually check compliance in all aspects. An alternative approach is to set standards which can be adequately monitored from the start. The former approach has the advantage of alerting polluters that their emissions are a matter of regulatory concern, but it may undermine respect for a law which regulators are yet capable of enforcing.

The manner in which monitoring is carried out must suit the local situation, particularly with regard to the size and number of emission sources. Whereas large facilities might be monitored continuously and for a wide range of pollutants, this is unlikely to be feasible (or cost-effective) for many relatively small emission sources. For these smaller sources the standard-setting and the monitoring programme perhaps should be based on process or equipment requirements rather than point-of-discharge measurements.

Because of expected continued economic expansion and the desire to attain higher levels of environmental quality, it is likely that emission standards from each source may need to be periodically tightened. The likelihood of periodic changes in the standards should be taken into account when deciding how compliance will be measured.

Careful assessments of what to monitor and how to monitor it are essential in building an effective and workable system of environmental law.

One important development in the older industrialized countries is integrated, multi-media monitoring and permitting. Strict control focused on a single medium (e.g. air) may result in significant increases in another form of pollution (e.g. solid waste). In addition, it is now recognized that rigid emission standards sometimes may be needlessly costly and add little additional environmental protection.

For some important forms of pollution, standards based on a *probability of exceedance* may be more effective and more cost-effective than ones based on compliance defined as anything less than the standard and non-compliance defined as *any* exceedance however brief or minor. Pollutant emissions are sometimes highly erratic and it may be that what we are most concerned about is the total amount of pollution released within a given time.

Hence, rather than setting a specific maximum level (which may tend to allow higher than desired *total* emissions), it may better serve the environment (and the emitter's ability to comply) if compliance was measured with regard to lower average emissions and a limit on the sampling distribution determined *probability* of some higher level occurring. For example, rather than setting allowed emissions at 100 tonnes per hour, it may be more appropriate to set the level at 80 tonnes per hour with the requirement that higher levels occur with less than a 5% probability. Clearly, such an approach requires more sophisticated monitoring and analysis than a simple maximum permitted level. But where feasible, the benefits in terms of cost-effective environmental management could be quite significant.

Finally, it is becoming increasingly recognized that clean production technologies are likely to be a more cost-effective way to reduce pollutant emissions and other forms of waste, than end-of-pipe clean-up. Monitoring the actual use of the cleaner production process may allow reduced emissions monitoring.

Of course, using such sophisticated approaches to the standard setting sometimes adds to the complexity of compliance monitoring and hence are only appropriate where the technical and administrative capability are adequate. However, where they are feasible, such approaches may substantially increase the usefulness of monitoring for effective environmental protection, while lowering the costs of the monitoring system itself and lower the cost of compliance to the regulated community.

> Monitoring systems must be carefully designed with respect to:
> (i) the type of standards in place (e.g. single medium, multi-media) and how the permit specifies that compliance is to be judged (e.g. absolute allowed levels, probability of exceedance-based sampling), with these decisions being made in light of the expected number and size of the sources;
> (ii) the extent of sampling needed to obtain an adequate level of certainty for detecting significant non-compliance (e.g. continuous, periodic, or random spot checks);
> (iii) the parameters actually to be measured (e.g. sometimes a surrogate measure, such as chemical oxygen demand (COD) might be tracked in place of another such as biological oxygen demand (BOD), because it can be done more readily than the parameter of actual greatest concern);
> (iv) the resources available for data analysis (i.e. data collection should be in line with what can be effectively analysed and reported), and
> (v) skill and capabilities for monitoring personnel and analysts.

As so often in these findings, the above statements are perhaps all too obvious. Yet, often they are not followed. When a monitoring system is poorly designed, it will be more expensive than necessary and less informative than it could be.

Finally, there are important training needs for monitors and analysts in the rapidly growing lower income economies, where monitoring systems must be quickly put into place or greatly expanded. Training programmes, along with holding of qualifying examinations and licensing of monitors, are important needs and here, foreign assistance would be particularly useful.

Monitoring should be used to provide both positive and negative feedback and such results should be made as widely available as possible but consistent with legitimate confidentiality issues.

Public access to the results of monitoring is essential. When the results are not released or released only after long delays, the potential exists for corruption in the form of lack of action on violations. However, if raw, unverified data were to be routinely released, there is considerable potential for misinterpretation and possibly even for the data to be of use to competitors.

> Data should not be released until it has been checked, and the released information should be aggregated in a manner which will not raise confidentiality concerns. With that noted, the results of compliance monitoring should generally be routinely released in a timely manner (e.g. within weeks or months — not years) and include not only summary results but also relatively disaggregated information where such detail would be of importance to the public in judging the significance of reported levels of compliance.

While monitoring is typically viewed as a 'stick' to help keep polluters in compliance, its results may also be used to provide a 'carrot' (or as one participant suggested 'candy' rather than 'pins'). Firms which develop good track records for low emissions or which initiate specific forms of in-house clean up (perhaps as part of ISO 14000 certification), might be rewarded with greater flexibility in meeting emission standards or with reduced environmental reporting requirements. In this regard recent programmes of the USEPA might provide useful guides.

When the monitoring results show repeated and prolonged violations, this information should be used to prosecute the plant managers and senior officers of the company. Such prosecution would likely be far more effective when penalties include prison terms as well as fines.

One feature of the regional context which frequently came into the workshop discussions was the importance of public appearances (or as it is often referred to 'the matter of face'). From this the idea that verified failure to comply should result in swift public disclosure of such failure. In Ho Chi Minh City for example, there is a published 'black book' of the worst polluters (and now a 'green book' of the cleanest ones).

Alterative approaches to dispute resolution are needed in the Asian environmental law enforcement context because cultural factors may weaken the effectiveness of the approaches adapted directly from elsewhere.

Even among societies which draw on common legal traditions there are often considerable differences with regard to the willingness of people to go to court, and how willing courts are to impose sanctions against particular legal transgressions. Obviously, such differences are potentially much greater when societies come from different legal traditions. Likewise, the prevalence and form of corruption will vary from place to place. Hence, enforcement approaches which work reasonably well in one place may not be the best in another.

> When enforcement is not effective in a particular situation, it is important to explore alternative measures. These might be relatively formal (e.g. People's Courts, court-mandated or sanctioned arbitration or mediation), or informal (e.g. public exposure/censure, or ad hoc private party negotiations on damages and penalties between polluters and those most immediately and seriously affected).

In some situations the threat of public exposure and subsequent loss of face or public censure may by itself be a more effective tool for promoting compliance than the threat of fines or other sanctions applied with little public notice. Particularly as an economy advances and companies look to the international market, *image* (both locally and to overseas buyers) becomes an important asset. When this happens or when a company has a long-standing role in a community, it may well move to 'clean up its act' in the face of strong public reaction to negative publicity about the manner in which it appears to casually disregard environmental damage in the way it conducts its business.

Alternative dispute resolution measures involving arbitration or private party negotiations will generally be most effective when (1) public exposure or censure is of potential concern to those being challenged and (2) an institutional and social context exists in which negotiations could take place. In arbitration (and also in some forms of private negotiation), concerned parities must also accept third party mediators.

> The point is not that alternative approaches should necessarily play the major role in compliance enforcement in Asia, but simply that they deserve greater consideration as a supplement to the legal enforcement approaches used elsewhere.

While EIA can be a useful planning tool, the EIA itself will not provide clear-cut answers on the acceptability of impacts and policy decisions — drawing on the findings of the EIA still require difficult choices.

An EIA *can* be a useful tool. However, it is equally important to recognize that the mere existence of a system of EIA does not ensure that it will be useful. Indeed, there can be a risk that the mere existence of institutionalised EIA leads to complacency — an attitude of 'We are all right, we have an EIA system' with the result then being 'green washed' (i.e. used to make a bad project look acceptable).

> Government and NGOs alike must not lose sight of the limits of their system and must ask:
> - what projects are included in the EIA system?
> - is there discretion to dispense with the requirement?
> - how often is the discretion used?
> - what factors can the proponent be required to take into account?
> - is there a requirement to take into account not only the impact of the immediate project but the cumulative impacts along with other current and projected activities and situations?
> - how extensive are EIAs required to be in practice?
> - can the resultant statement be readily understood by those who have to comment on it or even by the developers themselves?

- is there a proper system of scrutiny of the EIA process and how it is being implemented in particular cases?
- is there appropriate public involvement?
- is there consideration of a full range of alternatives to the favoured development strategy, including the 'no build' or 'no action' option?
- is there effective post–project monitoring?

Only if there are positive answers to these and other questions is it right to feel some satisfaction though not complacency.

In order to be effective, an EIA must be conducted as early as possible in the planning process and impacts associated with a particular project must be evaluated within the context of the larger development process.

The purpose of an EIA is to allow planners to better assess the acceptablity of various impacts and, where they are judged to be unacceptable, to look for ways to reduce or avoid them. In this regard, public projects should be held to the same standards as private ones. Also, for an EIA to be potentially most effective, it is also vital that as much scope as possible remain for avoiding or lessening environmental damage.

> The further the EIA is pushed back in the planning process, the narrower the range of options for keeping negative impacts within acceptable levels at a reasonable cost.

Most basically, the EIA should be conducted with consideration of (and guidelines for EIAs should require) a 'no-build' or 'no-action' option. In other words, the very necessity of the project should be brought into the equation, rather than assuming that the project is desirable. If, as is often the case, the EIA is left until after project approval has been given, then the no-build option tends to be given little serious consideration. Further, if the EIA is not part of the early planning process, then basic changes in project design also become difficult to consider.

The desirablity of either the no-build option or of making basic changes to project design often depend on how a particular project fits into the larger development picture. For example, the loss of a single wetland may have very different ecological impacts depending on whether it is one of many remaining ones or — as is more often the case — wetlands in a particular area are under widespread and pervasive threat. Hence, in evaluating a project and its potential impacts, it is essential that the EIA assess the significance of the project-specific impacts with respect to the *cumulative impact* of the individual project and of other projects and activities going on or being planned.

The EIA itself should include recommendations for post-implementation impact monitoring and reporting.

If EIA is truly to be an important tool for environmental protection, it is essential that its findings are used to ensure that impacts remain within acceptable limits. Initially, this means that the way the project is designed and implemented must reflect the findings of the EIA. Over the longer term it means that there must be a system for monitoring on-going impacts and for reporting these to an authority with the power to ensure compliance.

> It is critical that there be a requirement for post-project monitoring to see that the EIA's prognoses were accurate and undertakings for impact mitigation are followed.

Such information may provide valuable lessons for future EIAs, while also ensuring that the developer sticks to what has been promised under the conditions imposed by government on grant of permission to develop. Monitoring of condition performance should be accompanied, where necessary, by an enforcement mechanism with teeth. This could include a bond which is forfeited on non-compliance, as well as revocation of permission for the project.

As noted earlier, one way of achieving this is to require self-monitoring on the part of the developer, coupled with self-reporting. Conditions imposed on development can require reporting on specific questions at specified intervals and the reports should be publicized. Where the nature of the development is such that it will involve future monitoring by the environment protection authorities (such as manufacturing installations which may cause water, air or waste problems), the authorities which carry out the monitoring should take into account the undertakings made and the conditions imposed at the development approval stage. But not all possible impacts are caught this way. It should be possible to check that mitigation measures which were promised have been carried out, that a project which was said to look good does look good.

If consultants who carry out EIAs are unable accurately to predict (within reasonable parameters) what the impacts will be, or developers do not carry out measures which they promised or were bound to take, they should not be permitted to carry out future EIAs, or future developments. A bond also may be appropriate for the consultants who prepare the EIA.

CONCLUSION

This workshop proved to be quite valuable in terms of (1) the practicality of the recommendations, (2) the ability of the participants from varied backgrounds to identify major areas of common ground and (3) for the 'networking' which the workshop facilitated. Strengthening of such channels communication — and indeed trust — should do much over the long term to make it possible to develop more effective approaches to environmental law making.

It is inevitable and appropriate that emerging economies will look to the older industrialized economies for models of environmental law. Yet, given Asia's unique history and culture, it is vital that such 'borrowings' be carefully tailored to best meet local needs and resources. One important feature of this workshop was that most of the participants were

Table 2
Workshop Participants

CANADA
- Julia Deans, Tory Tory DesLauriers & Binnington

CHINA
- Zhang Hongjun, Environmental Protection & Resources. Committee of the National People's Congress

HONG KONG
- William Barron, CUPEM, The University of Hong Kong
- Louis Chiu, Ciba-Geigy (Hong Kong) Ltd.
- Jill Cottrell, Faculty of Law, The University of Hong Kong
- Daniel Hwang, Caltex Services Corp.
- Patrick Lei, Environmental Protection Department, Government of Hong Kong
- Fred Luk Shu Keung, Cathay Pacific Airways Ltd.
- Mei Ng, Friends of the Earth Hong Kong
- K.N. Tam, The Hong Kong Electric Co. Ltd
- Catherine Yeung, China Light & Power Co. Ltd

INDIA
- Veera Kaul Singh, Centre for Environmental Law, WWF-India

INDONESIA
- Nurlini Kasri, Office of State Minister for Population & Environment
- Mas Achmad Santosa, Indonesian Center for Environmental Law

JAPAN
- Takahiro Ichinose, Faculty of Economics, Saga University

KOREA
- Joon Soek Hong, Ministry of Environment
- Sang Don Lee, College of Law, Chung-Ang University

MALAYSIA
- Yang Zaimey B Yang Ghazali, Attorney-General's Chambers

PHILIPPINES
- Victoria Loanzon, Clean & Green Foundation Inc.
- Antonio Oposa, Oposa Law Office

SINGAPORE
- Koh Kheng Lian, Faculty of Law, The National University of Singapore
- Lye Lin Heng, Faculty of Law, The National University of Singapore

TAIWAN
- Sheau-Pey Chen, Judge, The Taiwan High Court
- Jay Fang, Green Consumers' Foundation
- Dennis Tang, Academia Sinica

THAILAND
- Chukiert Ratanachaichan, Office of the Council of State

USA
- Karl Bourdeau, Beveridge & Diamond, P.C.
- Eric Esler, Asia Counsel CIEL (1996 with UNDP in Cambodia)
- Tad Ferris, Beveridge & Diamond, P.C.
- Peter Illig, independent consultant
- Durwood Zaelke, Center for International Environmental Law (CIEL)

VIETNAM
- Nguyen Ngoc Ly, CEST, Hanoi University of Technology
- Le Thac Can, National Research Programme On The Environment

from the region and most of the others are long-term residents. The point is that this was truly a regional gathering of environmental professionals, where the concern was to first identify what is different about the environmental law context here and then to assess how law making and other considerations (e.g. investment planning) should be designed to better reflect the regional context.

Follow-on workshops on more focused topics would be of considerable value. In this, prospective organizers might consider the potential for private sector funding, since better environmental management generally would include more cost-effective approaches to compliance. For this particular workshop, industry sponsorship provided funding adequate to cover all venue rentals, airfare and hotel and other out-of-pocket expenses for each of the 33 participants from throughout the region and several persons from North America. About two-thirds of the funds were raised from sponsors in Hong Kong and the remainder from those in North America. Table 2 lists the workshop participants.

Center of Environmental Sciences (CES), Peking University

The Center of Environmental Sciences (CES), Peking University was formally established in 1982. It is a comprehensive institute which involves environmental education, scientific research and social service. Its activities are jointly supervised by the National Environmental Protection Agency (NEPA) and by Peking University. CES is responsible for organizing and coordinating environmental studies of all relevant departments, institutes and centres in Peking University.

CES consists of ten research divisions: Environmental Chemistry, Environmental Aerodynamics, Pollution Meteorology, Environmental Planning and Management, Environmental Economics, Environmental Information, Ecology, Environmental Law, Environmental Impact Assessment, and Aquatic Environment. In addition, various laboratories and training programmes are also branches of CES. These include: the Sub-Laboratory of Atmospheric Environmental Simulation, the State Key Joint Laboratory of Environmental Simulation and Pollution Control (ESPC), and the Senior Training Program of NEPA. The Research Center of China Sustainable Development of Peking University has been set up in CES and shares main faculty members and other resources with CES. In the last decade, CES has successfully accomplished numerous key projects of the state, provinces, departments, and of the National Natural Science Foundation.

EDUCATION

CES offers more than 60 courses on environmental sciences as part of masters, doctoral, post-doctoral programmes and professional development programmes. Each year about 15-20 master candidates, 5–10 doctoral candidates, and 1–2 post-doctoral fellows are enrolled in CES. In addition, CES accepts 10–15 part-time master degree students in a programme especially set up for environmental professionals. The Senior Training Program provides training for environmental administrators through diploma and non-diploma courses.

SCIENTIFIC RESEARCH

CES conducts research in a wide variety of areas including:

- chemical formation mechanism, transportation and regional control strategies of acid deposition;
- pollution of urban automobile exhaust and its control strategies;
- sources and sinks of important trace gases in the troposphere;
- the role of aerosols in acid deposition and climate change;
- studies on atmospheric chemistry of CFC substitutes;
- the country programme for the phase-out of ozone depletion substances and relevant policies;
- aerodynamics of dust emission and deposition in the lower troposphere;
- characteristics of pollution meteorology in the atmospheric boundary layer;
- regional atmospheric environmental planning;
- theory and methods of environmental planning and their application;
- environmental policies and laws;
- environmental value assessment and economic approaches;
- environmental information systems;
- theory and method of sustainable development;
- theory and implementation of scientific and technological assistance in poor regions of China;
- urban ecology and ecological engineering.

FURTHER INFORMATION

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Vietnam Environment and Sustainable Development Center (VNESDC)

BACKGROUND

The Vietnam Environment and Sustainable Development Center (VNESDC) was created in 1995 by the Vietnam Association for the Protection of Nature and Environment (VAPNE), a non-governmental national organization of scientists and managers in the field of environmental protection. Vietnam is entering a period of rapid economic growth in which Gross Domestic Product per capita has risen at an average annual level of over 8% since 1991. The pace of growth is expected to accelerate in the future with industry leading the way, followed by services and agriculture. This process will create the foundation for improved living standards and also create the basis for industrialization and modernization of Vietnam in the twenty-first century. Yet, it will also clearly put great pressure on natural resources and the environmental quality of the country, and this in turn will affect the living environment of all people in Vietnam, both in rural and urban areas. VNESDC was created in response to this challenge.

MISSION

VNESDC's mission is to provide a bridge among the activities of people, communities and governmental agencies in environmental protection and to promote sustainable development. In particular it seeks to facilitate community participation in environmental policy and decision making. VNESDC assists central and local environmental authorities in mobilizing larger and sounder channels for public participation in the implementation of national and local environmental protection policies, programmes and projects, especially those aimed at safeguarding and improving local socio-economic development and sustainability.

TASKS

VNESDC implements its mission by carrying out the following tasks:

- education, training and promotion of public environmental awareness;
- research and extension, including technology transfer for the solution to national and local environmental sustainable development problems;
- advice and consultancy services, evaluation of the local state of environment, and conducting of and review of environmental impact assessment reports;
- participating in international and regional cooperation in environmental protection.

ORGANIZATION

VNESDC is headed by a Founding and Steering Committee, with Professor Le Quy An, ex vice-minister of Science, Technology and Environment as Chairman, Professor Vo Quy, UNEP and IUCN prizes recipient, Dr. Nguyen Ngoc Sinh, Director of the National Environmental Agency, and Professor Le Thac Can, Chairman of the National Research Programme on Environment and Director of VNESDC, serving as Deputy-Chairmen. VNESDC's Deputy-Directors are Professor Nguyen Thuong Hung, General Secretary of the Vietnam Association of Geosciences, and Professor Pham Binh Quyen, Head of Department of Entomology, Hanoi National University. VNESDC has two divisions: (1) Education and Training, and (2) the Research, and Extension Division, and a Center's Office.

ACTIVITIES

Current education and training activities include:

three short term training courses in Environmental Management and Environmental Impact Assessment in three provinces in the Mekong River Delta and in the Central Vietnam Plateau. Two similar courses are in preparation for the Red River Delta and for North Central Vietnam.

Current research projects include: (1) an impact assessment of the Son La Hydropower Plant, (2) a study of rational water resources use in Ninh Thuan province, and (3) elaboration of Environmental Indicators for national and provincial levels of environmental reporting. VNESDC is also preparing a Manual on Environmental Management Experience and a book on Environmental Impact Assessment Guidelines.

PUBLICATIONS

In cooperation with the National Research Programme on Environment, VNESDC has published Proceedings of the First National Seminar on Environmental Protection and Sustainable Development Research (1993), and Proceedings of the Second Seminar on Environmental Protection and Sustainable Development Research (1995). In cooperation with the Hanoi Open University, VNESDC published the Introduction to Environmental Sciences (1995) and Environmental Economics (1996)

FURTHER INFORMATION

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