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## Contents




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# Foreword

The publication of the *Asian Journal of Environmental Management* is an important expression of The University of Hong Kong's commitment to the study of environmental problems, not just in Hong Kong but in the region as a whole. It is a timely initiative for a number of reasons. As the recent United Nations Conference on Environment and Development in Rio has shown us all, it is imperative that we gain a better understanding of the environmental problems that confront us in the 1990s, and of the options that exist to overcome these problems. Nowhere are these problems more pressing than in Asia. The loss of tropical forests and their indigenous species, pollution of aquatic environments, both marine and freshwater, rapidly deteriorating urban air quality resulting from the widespread use of fossil fuels and the need to adjust to a changing global climate are just some of the problems that command our attention. An effective response to these problems requires better channels of communication among researchers in the environmental field. Hence the importance of a new journal which will provide an opportunity for researchers working in Asia to bring their findings to a much wider international audience.

I am particularly pleased that the inaugural issue of this journal is being published during our 1992-93 academic year as this coincides with the University's 80th Anniversary Celebrations. Since its establishment in 1911, The University of Hong Kong has been dedicated to the transfer and exchange of ideas and knowledge between East and West. By providing a base for this new journal, the University is fulfilling part of a long-established mission. We have chosen as our theme for the Anniversary Celebrations 'Living in Hong Kong in the Year 2001', a theme in which environmental concerns figure very prominently. Hong Kong has enjoyed enormous economic success over the past 20 years but at considerable cost to its environment. Only recently have we been able to make significant progress in responding to the environmental problems that higher living standards and economic growth have imposed upon us. There is much to be learned from the Hong Kong experience and I hope this journal will provide opportunities from time to time for aspects of this experience to be analysed for the benefit of an international audience.

As befits a journal in this field, the *Asian Journal of Environmental Management* is an interdisciplinary initiative. It is being managed by the University's Centre of Urban Planning and Environmental Management with the assistance of staff from various other departments. The journal is a valuable complement to our many other academic activities which focus on scientific, technical and policy-related aspects of the environment. These include both undergraduate and postgraduate degree programmes, as well as doctoral studies. The University of Hong Kong is very conscious of the role that institutions of higher learning throughout the region will play in the environmental field during the 1990s and has made a determined effort to ensure that the environment is strongly represented in the curricula that it offers.

It is my hope that this new journal will help to enhance our understanding of Asia's rapidly changing environment. Our ability to manage these changes over the coming decades will undoubtedly influence the economic fortunes of the region and the well-being of its people. Our task will be greatly assisted by improving the flow of knowledge and information. The *Asian Journal of Environmental Management* is intended to serve this important objective. I wish the Journal every success in the years ahead.

Professor Wang Gungwu
Vice-Chancellor
The University of Hong Kong

# From the Editor

The Centre of Urban Planning and Environmental Management of The University of Hong Kong is proud to launch the *Asian Journal of Environmental Management (AJEM)*. This twice yearly journal is intended to serve as a vehicle for the exchange of information among environmental professionals and others in government, academia, research institutions, business, non-governmental organizations (NGOs), and individuals from throughout Asia and those elsewhere with a strong interest in the region. *AJEM* is an inter-disciplinary journal with the *Asian environment* as its theme and *management* of the environment as the unifying concern among the diverse subjects addressed in the individual articles.

As the world becomes more integrated economically, it is natural to look globally for lessons which might be learned or techniques which might be applied to solve problems close to home. While such a global outlook certainly has its place, it is important to remember that regions of the world still differ in certain respects, and within various parts of the same region there may be important similarities not commonly found elsewhere.

In Asia, the world's fastest growing region, development-environment tradeoffs are occurring at an unprecedented pace and often in ways which differ from those which characterized the earlier development of the older industrialized economies. For example, the industrial sectors of many Asian economies (even the higher income ones) are often characterized by both state-of-the-art large-scale facilities *and* by thousands of small-scale, low-technology factories, concentrated within a single urban area. The environmental management issues associated with such industries are vastly different from those which have become the major concern in North America and Europe. Likewise, the rate of growth in transport in many Asian cities, the composition of vehicle types, and the associated problems require innovative management approaches which go beyond those tried elsewhere.

These and other examples which come readily to mind, suggest that lessons learned from management efforts in one part of Asia may be particularly relevant in other parts of the region. Hence, there is considerable value in strengthening information channels among environmental management professionals from within Asia and those from outside with particular interest in Asian development and environment issues.

## THIS INAUGURAL ISSUE

This first issue starts with an introduction by Professor Wang Gungwu, Vice Chancellor of The University of Hong Kong and Chairman of the Hong Kong government's Environmental Pollution Advisory Committee. We are also pleased to have a commentary by Professor Qu Geping of the National Environmental Protection Agency of the People's Republic of China on the evolution of environmental management approaches in China.

The other articles in this first issue further suggest the diversity in geographical focus, professional backgrounds of authors, and range of topics which we hope *AJEM* will continue to represent. Jamie Allan, an environmental journalist, compares and assesses the availability of environmental data in eleven Asian economies. S.T. Mok, former head of ASEAN Forestry, assesses issues and recommends approaches for sustainable forest management in Southeast Asia. Gordon Ng, General Secretary of a Hong Kong NGO, examines the role of NGOs at the June 1992 Rio de Janeiro Environmental Conferences. David Coates weighs the benefits and risks of stocking rivers in Papua New Guinea with fish to increase protein supplies. Evita Yeung and James Ness examine the workings of the private sector recycling industry in Hong Kong.

## FUTURE ISSUES

The second issue of *AJEM* (November 1993) and those which follow will extend the topical coverage to additional important areas (for example, energy-environment and impact monitoring systems) and to the treatment of specific issues within a variety of

individual Asian settings. In particular, future issues will seek a balance between papers dealing with broad topical areas or wide geographical coverage, with ones focused on particular management issues or specific geographical settings.

## OTHER FEATURES

In addition to its articles, *AJEM* hopes to facilitate information exchanges in a number of ways. These include institutional profiles, conference/meeting announcements, and publication listings (including limited circulation documents).

## TO PROSPECTIVE SUBSCRIBERS, AUTHORS, COMMENTATORS

We hope that *AJEM* will continue to draw the interest of subscribers and prospective authors from not only the academic and research communities, but also government agencies, businesses, NGOs, and concerned individuals. Subscription information is included in the back pages of this issue.

*AJEM* welcomes manuscripts dealing with Asian environmental management issues. All articles are peer reviewed by an international group of experts. Articles accepted for publication are those which the peer reviewers find to be of high professional standards and with a focus within the principal aims of the Journal. Specific information for prospective authors is provided at the back of this issue.

In keeping with the goal of furthering communication on Asian environmental issues, *AJEM* welcomes comments on the articles published by the Journal. We will include responsible critiques and comments along with any rejoinders by authors.

Finally, *AJEM* welcomes announcements of conferences and meetings as well as description of institutional initiatives. Appropriate submission in these areas will be published as space permits.

Bill Barron
Editor
*Asian Journal of Environmental Management*

INVITED COMMENTARY

# China's Environmental Policy

*Qu Geping*

## ABSTRACT

China's environmental policies must be formulated according to its condition and situation, and these have necessitated the development of its own approaches to environmental management. At present environmental management within China involves three major systems: 'keeping prevention as the main policy', 'whoever causes pollution should control it' and 'consolidating environmental management'. This paper describes these and related policies and how they are being implemented.

Since the early 1980s, China has implemented these policies systematically and has achieved steady improvement and remarkable results, particularly in reducing the level of additional pollution for each unit of additional output. In the future China will further develop its environmental policies and readjust its economic strategies so as to lessen impacts on the environment from continuing economic development.

***Key words:*** *environmental control, economic development, environmental policy, China*

## INTRODUCTION

Sound development depends not only on sound economic and social systems and policies, but also on constantly improved systems and policies for environmental protection. China started its world-acknowledged reform and opening up process in the end of the 1970s. In the social process of reforming the traditional economic structure (which previously had a high degree of centralization) and exploring for a new economic structure through combining planning with the market, the Chinese government gradually changed its traditional practices. These older practices stressed the importance of major breakthroughs and put undue emphasis on output and value of production.

The newer practices reaffirm the economic guiding principle of 'laying stress on results, improvement of quality, coordinated development and steady growth'. Experiences in reform and development in the 1980s showed that changing the development strategy is an extremely arduous process. However, after a decade or so of effort, significant progress has been made. The deepening of reform and continued change of development strategy have become an irreversible trend of the 1990s.

## DEVELOPMENT AND ENVIRONMENT

Environmental protection is a motive force for change of traditional development strategy, as well

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as one of its end results. In the past decade or so one of the prominent indications of change in the traditional strategy of industrialization has been the integration of development of the economy and society with environmental protection. This requires formulation of environmental strategies and policies and their implementation in accordance with the realities of the development level of China.

In the early 1980s the Chinese government began to become aware of environmental issues and started to formulate its strategy for environmental protection. There were three options which could have been pursued. First, China might have decided to temporarily put aside environmental protection and attempt to control pollution only when the country reached a higher level of economic development and when greater economic and technical strength would become available, that is, following the road of 'pollution first and clean-up later' which had been taken by advanced countries. A second possible option would be to follow the model of high investment and high technology for environmental control. This is being done now by the developed countries. A third possibility would be to explore a new path which requires less investment with better results in accordance with the conditions and economic strength of the country.

As for the first option, pollution control expenses can be saved and more funds would be available for economic construction in a short period of time. However, both our own experience and lessons of the advanced countries proved that this road should not be taken. Rough estimates suggested that if this option was followed by a populous country like China with its extensive basic industry, the country would have to pay huge economic and social costs, and its future generations would suffer a severe 'environmental deficit'. The short-term visible results would soon disappear and economic development would be disrupted. In view of present and future survival and development, we cannot do that.

The second option has proved to be very effective in the developed countries. However, in China the level of economic development is still very low. If we blindly copy the experience of the developed countries and put in a lot of funds in environmental protection, it will not only affect fund accumulation for economic development and employment but it may also fail to provide *sustainable* economic support for environmental protection. In the longer term this may not favour environmental protection.

After many years of exploration, we have become more and more aware that it will not do for such a populous country like China, which has a low level of industrialization, to follow the road taken by others. Only when we take measures corresponding to our own conditions can we effectively reduce the environmental pressure brought about by rapid population growth and economic development. Therefore, we must find a model that is both environmentally and economically acceptable. How does China realize such a third option? There is no ready answer to this question. Before we describe the present activities in China to develop this third option, we should first review the nature of the major problems.

## Major Problem Areas

Many years of practice and exploration have enabled us to gradually identify and define a number of crucial environmental problems in China. Among the major problem areas are the following: the need to cope with the environmental effects of rapid economic growth, the generally low efficiency in resource use, irrational industrial siting, and unsatisfactory management of enterprises. These are described in turn below.

China is at a stage of speedy development of industrialization and urbanization, and it must keep a fairly high rate of economic growth for a long time to come. Calculated in comparable prices, its average annual growth rate of GNP had been 9.6% during the ten years from 1980 to 1990, far exceeding the world's average growth rate of 2.8%. In that decade, the number of cities had been more than doubled, with urban population growing from 190 million to 570 million. The volume of pollution discharge had also gone up by a big margin. In addition to existing environmental pollution, the pollution caused by industries and cities would escalate if necessary preventive measures are not taken.

As the general level of technology for existing industries (including township industries) is still backward and the efficiency in the use of energy resources is not high, the per unit energy and material consumption of products in China is much higher than those of the developed countries. Thus, large amounts of useful resources become waste and are discharged into the environment. In particular, the average heat efficiency of combustion equipment in

China is very low because of the structure of the energy supply and use system and the limited technology available. This creates a further problem for environmental management and policies. For example, the thermal efficiency of electric power plants in developed countries is usually between about 35% and 40%, while industrial boilers have efficiencies of about 80%. In contrast, in China power plant thermal efficiencies are often below 30% and those for industrial boilers often only about 60%.

The industrial layout in China is often irrational with many inherited problems. From the late 1950s to the middle of the 1970s, overall urban planning and rational industrial layout were neglected. Many industries were built in residential, cultural, educational areas or in areas of vital water resources and even tourist spots. Consequently, the impacts of industrial and urban pollution became worse.

Unsatisfactory management of enterprises in general, and unsatisfactory management of the environmental impacts in particular, were very common. This resulted in a serious waste of resources and unnecessary environmental pollution. Analysis of sample investigations of industry in the first half of the 1980s showed that about half of the pollution was due to unsatisfactory management.

## MAJOR POLICY APPROACHES

When one finds the root cause of the problem one may then begin to undertake actions to correct it. Over the past ten years of practice we have formulated a three-point policy system for environmental protection:

(i) combining prevention with control while keeping prevention as the main policy,
(ii) whoever causes the pollution should control the pollution, and
(iii) consolidating environmental management.

The core of the system is the consolidation of environmental management. That is, we rely on planning, laws and regulations, supervision, and appropriate investment in pollution control to protect the environment while we also try to coordinate economic construction with environmental protection. Thus, we have opened up a road to environmental protection with Chinese characteristics. Let us review each of these three points a little more fully.

### Prevention and Control

First, what do we mean by combining prevention with control while keeping prevention as the main policy? From the perspective of economic or administrative studies, the best way to solve environmental problems is to take preventive measures for new sources of pollution, while reducing as much as possible existing pollution damage to the environment. This policy approach was formulated in light of the on-going large-scale economic construction going on in the whole country, whereby the control of new pollution damage takes on special importance. At the same time, in the past four decades of development, considerable environmental pollution had already been generated and this requires positive actions to lessen the damage from it.

Major specific measures include putting environmental protection into the medium and long term or annual plans of development of the state, the localities and various economic and social sectors. As part of this, the system of environmental impact assessment (EIA) has been introduced for development projects. In addition, a system has been introduced which simultaneously incorporates provision of environmental protection with each stage of project development: project design, construction activities, and operation. A special point must be made that departments of environmental protection have achieved substantial results in controlling new sources of pollution through the practice of carrying out an EIA and the system of requiring the simultaneous incorporation of environmental protection in the project steps of design, construction, and operation.

In recent years, 100% of the large and medium-sized construction projects have practised the system of EIA. In coastal areas, to help environmental management of construction projects to catch up with the economic construction, regional environmental assessment was carried out. The close coordination between industrial and mining enterprises with the various concerned departments as well as the strict enforcement of law by departments of environmental protection, nearly 100% of the large and medium-sized construction projects have implemented the system referred to above for incorporating environmental protection simultaneously with the stages of design, construction and operation of projects.

In the past decade our GNP has more than doubled but the volume of pollution has not increased proportionately. The discharge volumes of both waste water and the residue per 10 000 yuan* of industrial output were reduced. The rate of purification of industrial waste gas was also raised. These achievements have a lot to do with the introduction of the two systems of EIA and requiring pollution control facilities.

## The Polluter's Responsibility

The second broad policy approach we should consider further is that of 'whoever causes the pollution should control it'. This is, of course, the application of the principle of responsibility by the polluter in China. At present, there is still often inadequate environmental awareness in industrial and mining enterprises. This often results in an attitude that the responsibility for controlling pollution can be left to the government and society. In this regard, we have enforced the policy of polluter responsibility by legal means so that the polluter must take the responsibility and cover the cost of pollution control. With this policy we can not only push dischargers of pollution to actively control their pollution and raise funds for controlling its effects, but also help enterprises to further strengthen management capability and technological innovation.

Under this policy there are three major measures. The first is to combine prevention and control of industrial pollution with technical renovation. As mentioned above, the consumption of materials and energy in China is unnecessarily high. Hence, the subsequent discharge volume of waste is great and pollution is more serious due to the backwardness of industrial technology in the country. So we are faced with the heavy and imperative task of implementing technological innovation for our industry. The state stipulates that pollution control must be an important objective in technical renovation and also that no less than 7% of the total expenses should be for pollution prevention and control. As a result of the vigorous participation and conscientious supervision of the departments of environmental protection, this system is being practised throughout the country.

The second measure under the polluter responsibility policy is to implement a system of control within a time period for a number of industrial and mining enterprises which cause pollution due to historical factors. Tasks for control are categorized in accordance with the seriousness of the pollution and the supporting economic capability of the enterprises. In the past ten years, the state on two occasions ordered 417 projects to control their pollution within a specified deadline. The local authorities for their part have also made orders for such projects on a number of occasions. For the period of 1978 to 1989 alone, 120 000 projects have been completed in controlling pollution within a specific deadline, producing good environmental results. Expenses for such projects are mainly accumulated by the enterprises and local governments and a small amount of subsidy is given by the central government.

The third measure under the polluter responsibility policy is the system of charging for the discharge of pollutants. We make use of the law of value and economic policies and make units which discharge pollutants pay environmental damage compensation fees. Such a system has already been implemented generally in areas of waste water, waste gas, residue, noise and radioactive waste. Over 2 billion yuan is collected annually, with the fees collected going into a special fund in the localities to ensure the success of projects for pollution control. In recent years, to meet the needs of urban development, a series of measures for unified control conducive to environmental protection have been promoted with funds coming from the government, the polluting units themselves and the beneficiary units. Among these are central heating, increased use of gas for civil use, construction of waste water treatment plants, and the setting up of handling grounds for harmful residues. These have brought new vitality to the policy of 'whoever causes the pollution will control it'.

## Strengthening Environmental Management

The third major policy approach is that of strengthening environmental management capability. As mentioned above, in a situation in which not much money is available for environmental protection, we should rely on strengthening environmental management; through management we can address at least

*1 yuan = US$0.17 (March 1993)*

that subset of environmental problems which require relatively little or no money. It has become a practical and positive policy, and one in which we must persist for a long time.

The main measures under this policy approach of up-grading environmental management are several. The initial step is to promulgate laws and decrees and to formulate standards. Up to the present China has promulgated four laws for environmental protection and eight laws relating to resources, together with over 20 administrative regulations on environmental protection and 231 standards for environmental quality. Together, these provide a legal system for environmental management. Environmental law enforcement also has been further strengthened.

Administrative organs for the environment have been set up in the governments at the central, provincial, municipal and county levels, involving over 70 000 people. At the same time, more than 2000 environmental monitoring stations have been established, reflecting environmental conditions in different localities. In addition, large and medium-sized enterprises have also set up their own administrative organs for the environment with a total staff of over 200 000. Following on the laws and regulations, the administrative departments have performed strict management of the environment and thus enabled the implementation of environmental planning systems and standards.

### Additional Approaches

In recent years, two more new systems have been introduced to further promote environmental protection. One of these is a system of responsibility for environmental targets, based on the important role played by leading members of government in different localities. This system stipulates environmental targets these persons must achieve during their term of office. Reports on the progress in this regard, as part of the assessment of their overall achievement, should be made each year. Prominent results have been achieved since the introduction of this system three years ago.

The second new system is that of assessing the overall control of the urban environment. Cities are a key link in environmental protection in China, since they are where population and industries are gathered and hence pollution tends to be more serious. To assess environmental protection in the cities, target values for a fixed number of environmental quality parameters have been specified. An assessment will be carried out every year. The results will be made public and taken as a criterion for assessing the administrative achievements of municipal leaders. The state will assess 32 cities and the provincial governments will assess cities within their own provinces. At present, 230 cities are subject to such an assessment. About half of the cities in the whole country (including almost all the important cities) are covered. With the introduction of this system, a lot more attention has been given to the environment and, as a result, environmental conditions have markedly improved.

## CONCLUSION

In the past ten years, China's Gross National Product (GNP) has increased 1.3 times but environmental protection has not had a corresponding increase. It presently accounts for only about 0.7% of GNP expenditure. However, even with this limited funding environmental quality has basically remained stable despite the substantial expansion of the economy. This has been largely due to the strengthening of environmental management.

The change of development strategy towards one of a sustainable path is a long-term process. Environmental protection will also be a long-term task as this development strategy continues to evolve. Although we have made some efforts toward increased environmental protection, there are still a lot of problems. For example, urban environmental pollution is still serious, forest cover remains low, some large areas are subject to soil erosion, and desertification continues. The situation is serious. We must therefore further speed up the process of the change of development strategy and increase our input in environmental protection. We need to continue to strengthen environmental management and educate and mobilize the people of the whole country to protect our homeland.

# Oranges in the Apple Cart: Gathering Environmental Data in Asia

*Jamie Allen*

## ABSTRACT

Data on the environment, anywhere in the world, rarely are of the quality desired for management decisions. Such problems are more acute in Asia both because the needs are greater (due to the rapid pace of development) and formal attention to the environment is still a relatively new activity.

This paper reviews the environmental data situation in 11 settings in Asia. Although some places stand out for having made relatively strong efforts toward developing an adequate database (for example, Malaysia and Hong Kong), in general, the environmental information available in the region is incomplete, not nearly as current as one would like, and often lacking in needed context. Reasons for this appear to go beyond a shortage of resources to also include attitudes towards the role of environmental data and the extent to which governments are prepared to make it public. There is a need for up-graded systems for the collection and publication of environmental data in the region. Organizations such as multilateral funding bodies and universities could play a needed role in developing such systems and assisting in their implementation.

***Key words:*** *Asia, data, development, environment, monitoring, pollution.*

## INTRODUCTION

The availability of accurate and reasonably up-to-date data is critical for the establishment of a successful environmental management regime. In Asia, an additional imperative is the region's rapid pace of economic growth, which demands mitigation measures be put in place early to avoid exorbitant costs later and excessive damage to the diverse terrestrial and aquatic ecosystems. Indeed, because of very rapid economic growth, the structural changes its economies are undergoing, and the constant pressure of population, Asia tends to be at the cutting edge of the development/environment trade-off, making a good environmental data base perhaps even more important than it is elsewhere.

Drawing on findings from a business-oriented review of environmental issues and policy responses in Asia (Economist Intelligence Unit, EIU, 1992), this paper presents an overview of the environmental data situation in 11 Asian economies.[1] During the first three months of 1992, visits averaging about one week each were made to the capital cities of China, India, Indonesia, Japan, Malaysia, the Philippines, South Korea, Taiwan, and Thailand, as well as to Singapore. Hong Kong, the writer's home base, was also included in the research effort.

Given the long lag between the period of major economic expansion and moves toward serious environmental protection which occurred in the older industrialized economies of the world, it is not surprising that most Asian governments as yet

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possess neither strong environmental protection agencies nor an adequate environmental data base. Data problems exist with respect to both quantity and quality: in some countries certain types of data do not appear to exist, while in most places the body of data available is incomplete, sometimes inconsistent and often too dated to be of effective use for planning purposes.[2] Trying to make country comparisons is akin to 'comparing apples and oranges', a popular cliche in the environmental management business. Nonetheless, in several cases the environmental data appears to be relatively good despite the formidable nature of the task. One interesting finding is that the quality and quantity of environmental data do not appear to be closely related to national income levels.

## OVERVIEW OF MONITORING AGENCIES

Table 1 lists the principal governmental agencies responsible for collecting and analyzing data on environmental quality parameters. As one might expect, such responsibilities vary widely among the different economies. Some agencies listed in Table 1 report directly to higher ministries, but others are more independent. In the People's Republic of China (PRC), for example, the National Environmental Protection Agency (NEPA) is responsible to the State Council, the highest executive arm of the Chinese government, while the Environment Agency in Japan is not responsible to any ministry, and instead is an independent agency under the Prime Minister's Office.[3] Typically, these main bodies contain departments which carry out the gathering of environmental data. In India, for example, the Central Pollution Control Board in Delhi and pollution control boards in each state do this, while the Ministry of Environment (MOE) in South Korea has 'management bureaus' covering waste, air, and water pollution. In Singapore, the Pollution Control Department is the main sub-division of the Ministry of Environment (ENV) which monitors environmental conditions.

### Type of Data Collected

Most governments do not give their central environment agency total responsibility for all

**Table 1**
**Principal Environmental Agencies**

| *Country/Economy* | *Agency Name* | *Abbreviation or Other Name* |
|---|---|---|
| People's Republic of China | National Environmental Protection Agency | NEPA |
| Hong Kong | Environmental Protection Department | EPD |
| India | Ministry of Environment and Forests<br>Central Pollution Control Board | MEF<br>CPCB |
| Indonesia | Ministry of State for Population and Environment | KLH |
| Japan | Environment Agency | EA |
| Malaysia | Department of Environment | DOE |
| Philippines | Department of Environment and Natural Resources | DENR |
| Singapore | Ministry of Environment | ENV |
| South Korea | Ministry of Environment | MOE |
| Taiwan | Environmental Protection Administration | EPA |
| Thailand | Environmental Policy and Planning Office (formally the Office of the National Environment Board) | |

aspects of the environment, so the range of data each collects is often limited. Typically, the environmental agency has at least some control over basic municipal and industrial pollution and must therefore monitor air and water quality, municipal/industrial waste arisings and noise as part of its on-going activities. As discussed below, the degree of detail in the data varies widely, however, as does the question of whether exotic hazardous wastes are monitored.

One major difference among the agencies listed in Table 1 lies in the level of control they possess over nature conservation problems in contrast to pollution problems. For example, the Ministry of Environment and Forests (MEF) in India has responsibility to protect forests, rivers, wetlands and wildlife in addition to its pollution work. Hence, it publishes information on each of these broad areas (MEF 1991 p. 5). The Environmental Protection Department (EPD) in Hong Kong, on the other hand, bears no responsibility for the conservation of natural habitats, a fact reflected in the absence of flora and fauna issues from its annual report (EPD 1991).

A second difference is the extent of control each major agency has over pollution. In Hong Kong, responsibility is shared among a number of departments, while in Singapore the Ministry of the Environment (ENV) has departments covering pollution control, sewerage, drainage, environmental health (including refuse collection and litter control), hawkers, food control, vector control (disease-bearing pests), and so on (ENV 1990 pp. 2 and 3). Nevertheless, the EPD in Hong Kong remains the lead agency for the environment. In Japan, the powers of the Environment Agency are more circumscribed. It plays a predominantly policy and planning role, with limited powers of enforcement. The agency has bureaus covering planning and co-ordination, nature conservation, air quality and water quality, and a few research and training institutes. While the air and water quality bureaus enforce laws in these areas, noticeably lacking are powers to control municipal and industrial waste (EA 1991a Appendix 3). In Japan, other ministries are active in the area of environment as well.[4] Table 2 attempts to list all the major agencies with responsibilities in the two major areas of environmental management: pollution control and the conservation of nature.

Other factors which limit the quality as well as the quantity of environmental data collected by each agency include: inadequate funding and staff; and the institutional changes and development many are undergoing. Because responsibility for environmental management is spread across many departments in each government, it is difficult to calculate with confidence the total financial and human resources allocated to this problem. What is clear, however, is that each environment agency tends to complain about not having enough money and staff to carry out its responsibilities effectively.

That many of these agencies are still relatively young and in the process of developing also means that their monitoring systems and capabilities tend to be in a similar state. NEPA was established in China in 1987, although prior to that it was a lower-level bureau (the Environment Protection Bureau). There has been some talk that it may be turned into a ministry, although it is not certain if or when this will happen (NEPA 1992 personal communication). Japan's Environment Agency has been pushing to become a ministry, but the move is opposed by other powerful ministries, particularly the Ministry of International Trade and Industry (MITI).

## PUBLIC SECTOR DATA

Although government environmental data is only one of several types of relevant information about a country's ecological problems, it is normally viewed by professionals, academics, officials and journalists as the most authoritative, consistent and detailed. While there are other sources of data — an issue dealt with in more detail below — official data is often the first port of call for researchers. This section deals with the availability of such data in English, its accessibility and its limitations.[5]

It would be ideal, of course, if each country's principal environment agency produced a single annual report, in English as well as the local language, which contained a rigorous description of all its environmental problems and activities to address these problems. Those which attempt something close to this (at least for those areas under the purview of the principal environmental agency), include Hong Kong, India, Japan, Malaysia, the Philippines and Singapore. The others — China, Indonesia, Taiwan and Thailand — do not appear to publish one discrete and easily obtainable report (EIU 1992). South Korea in 1990 produced a very brief pamphlet about the government's environmental policies, but it is difficult to put this in the same category as the reports above.

**Table 2**
**Institutional responsibility**

| *Country/Economy* | *Pollution Control Responsibilities* | *Conservation* |
|---|---|---|
| People's Republic of China | National Environmental Protection Agency<br>Several other ministries have environmental divisions, including energy, etc.<br>The Ministry of Mechanical and Electrical Engineering manufactures pollution control equipment | Other ministries with responsibility include the Ministry of Forests |
| Hong Kong | Environmental Protection Department<br>Urban/Regional Services departments (rubbish collection)<br>Royal Hong Kong Police Force<br>Drainage Services Department<br>Planning Department | Department of Agriculture and fisheries<br>Urban & Regional Services departments (open space, urban and country parks)<br>Marine Department (floating refuse) |
| India | Ministry of Environment and Forests<br>Central Pollution Control Board<br>State pollution control boards | Ministry of Environment and Forests |
| Indonesia | Bapedal (the Environmental Impact Assessment Agency) | Ministry of State for Population and Environment |
| Japan | Environment Agency<br>Ministry of Health and Welfare<br>Ministry of International Trade and Industry<br>Ministry of Construction<br>Ministry of Transport | Environment Agency<br>Ministry of Agriculture, Forestry and Fisheries |
| Malaysia | Department of Environment (Ministry of Science, Technology and Industry) | |
| Philippines | Department of Environment and Natural Resources | Department of Environment and Natural Resources |
| Singapore | Ministry of Environment | Ministry of Environment |
| South Korea | Ministry of Environment<br>Ministry of Trade and Industry<br>Ministry of Transportation | Ministry of Agriculture, Forestry and Fishery |
| Taiwan | Environmental Protection Agency (Taiwan province)<br>Municipal departments of environmental protection, Taipei and Kaohsiung<br>County environmental bureaus (under the Taiwan provincial government) | Ministry of Interior<br>Council of Agriculture |
| Thailand | Environmental Policy and Planning Office<br>Department of Industrial Works<br>Bangkok Metropolitan Administration<br>Department of Land Transport<br>The Police | Royal Forestry Department |

A major limiting factor for English-speaking researchers is that not all the publications of each agency are translated, or translated in a reasonably timely fashion. The Taiwan Environmental Protection Administration (EPA), for example, appears to have many publications which are not available in English (EPA 1992 personal communication; EPA 1991 pp. 28 and 38). Likewise, Indonesia's Bapedal, the country's pollution control agency, does not appear to have any readily available overview report published in English on a periodic basis (Bapedal 1992 personal communication). Hence, the next section focuses only on the reports of those agencies which produce annual, relatively comprehensive environmental reports in English.[6]

## Annual Reports and Yearbooks

There is great variation in the detail of the data contained in the publications of the seven agencies. The annual report of the Hong Kong Environmental Protection Department (EPD), the 187-page *Environment Hong Kong 1991*, is in the opinion of the author, the most useful and comprehensive — at least from a pollution point of view — of all the reports published in English in Asia. It covers water, waste, air and noise pollution in great detail, listing under each of these categories the department's environmental objectives, the current state of the environment, legislative and enforcement efforts, infrastructure programmes and other mitigation policies, and what is being done in the area of planning against pollution. Although the report appears to be in part a public relations exercise (and this aspect seems to be growing), it also paints a fairly bleak picture of the territory's environmental degradation. It also includes information about objectives which are not being met (although this sometimes requires a close reading to glean). What it does not do — and perhaps one could not expect it to — is explain why policies have not succeeded or targets not met. For this one must read the local newspapers or interview officials.

The next most detailed report is that produced by Malaysia: *Environmental Quality Report 1989*.[7] The roughly 200-page annual report examines each type of pollution in detail — including problems of specific importance to Malaysia, such as organic waste from palm oil processing — and covers continuing problems as well as successes in reducing pollutant levels or their impacts. Unfortunately, the report is not as well presented as Hong Kong's: there are fewer graphs, charts and tables, and the chapters are not organized according to separate pollution/conservation issues, making specific information sometimes harder to find. Another problem is that the report is slower in coming out. For example, in early 1992 this writer had access to Hong Kong data for 1990 but only the 1989 data for Malaysia.

Probably the next most informative annual report comes from India: the 107-page *Annual Report 1990-91*. Although significantly less detailed than the above two, it seeks to cover a range of environmental problems in a balanced way. It is also broader than those of Hong Kong and Malaysia in that it includes information about conservation issues, such as forests and wildlife. Its major limitation is that it has very little objective scientific data about pollution or conservation. There is, for example, a map showing areas of critical industrial pollution and a list of the industries producing these wastes. But there is no data describing what are the actual levels of air and water pollution.

The *1990 Annual Report* of the Philippines' Department of Environment and Natural Resources (DENR) reflects the name of that country's environment agency in being heavily weighted towards natural resource/ecological issues such as forest and land management, wildlife and 'ecosystems research and development'. Only one short section, and several graphs in another part of the report, are devoted to pollution (DENR 1990 pp. 13-15, 24 and 26). Furthermore, at least in DENR's *1990 Annual Report*, most of the information is a description of DENR's initiatives, rather than an objective document about the state of the environment in the Philippines.

Singapore's report, the 58-page *Annual Report 1990*, is quite balanced in terms of coverage, but is highly selective in the data it provides on each type of pollution. There is very little said, for example, about hazardous waste beyond the efforts of ENV to control its import and distribution (ENV 1990 p. 32). Yet given that the island city produces about 42 000 tones of hazardous waste each year (ENV personal communication 1992), the ministry is considering investment in a centralized chemical waste treatment facility (EIU 1992 pp. 262 and 272). In contrast to the Hong Kong and Malaysian reports, the omissions in the Singapore report raise suspicions that the agency is choosing to present data which puts Singapore in a relatively favourable light.

The reports from Japan follow a similar approach as Singapore's in describing the various environmental management activities of the government, while lacking detailed data on the state of the environment in that country. One is a 24-page pamphlet called *Environmental Protection Policy in Japan, 1991* and the other is a 29-page executive summary called *Quality of the Environment in Japan 1991*, the annual report that the Environment Agency submits to the Japanese parliament.

One is tempted to speculate about the reason for differences in the quality of the major periodic publication of each of these principal environmental agencies. Although each environment agency makes similar complaints about inadequate resources, clearly something more is involved, given the wide disparity of development levels among the various countries and economies. The lack of thorough periodic English-language reports in countries such as Japan and Korea appears to be a matter of priority rather than resources.

A more important factor determining how thorough a report should be is probably the attitude towards information in each country. While the reports from Hong Kong, Malaysia and to a lesser extent, India, each exhibit an element of scientific objectivity, those from Japan, the Philippines and Singapore seem to this writer to have something like the selectivity of company reports and advertising brochures.[8] This is reflected in the fact that they do not take each environmental problem and analyze it in detail in their annual reports. Instead, one receives a pastiche of each problem (for example, EA 1991a, pp. 13-14; DENR 1990 p. 13).

### Other Reports, Pamphlets

In addition to their main annual report, many environment agencies publish numerous smaller pamphlets and reports on individual subjects. Some of these are periodic and some ad hoc. In certain instances, the annual report will provide a list of these, as in the case of Hong Kong, Malaysia and India. Among the other reports from Malaysia is *Berita EIA*, a newsletter devoted to the environmental impact assessment work of the DOE. The Indian report lists numerous studies available from other government organizations and related institutions, such as the Central Pollution Control Board (CPCB) and the Environmental Information System (ENVIS) network (established by the Ministry of Environment and Forests).[9] In the other economies considered in this paper, a researcher would need to ask each environment agency for a list of additional publications. It is also important to remember that other government departments and ministries with responsibility for environmental management also publish their own reports. In Japan, for example, the Ministry of Health and Welfare is the main source of information on municipal waste, while the MITI and associated bodies have data on industrial pollution, energy conservation and so on.

### UNCED Reports

All countries which attended the UNCED conference in Rio de Janeiro in June 1992 were required to submit national reports.[10] Each was organized into four or five main categories: the state of the natural environment; the effect of economic development on the environment; government policy responses; environmental education and public awareness; international co-operation and political position on the 1992 UNCED conference. The lengths of these reports vary between 70 and 150 pages. Although, as discussed below, the usefulness and objectivity of the reports vary greatly, they do provide an easily accessible snapshot of environmental conditions.

## OTHER DATA SOURCES

An important source of additional information is the multilateral development institutions, such as the World Bank, the Asian Development Bank (ADB), the Organization for Economic Cooperation and Development (OECD), and the Economic and Social Commission for Asia and the Pacific (ESCAP). The World Bank's 1992 World Development Report is subtitled *Development and the Environment*. The World Bank and private-sector lending arm — the International Finance Corporation (IFC) — also produce ad hoc reports too numerous to mention here. The best advice one can give is obtain a copy of their publications index. The ADB also produces a range of newsletters and reports. One particularly useful ad hoc report is *Economic Policies for Sustainable Development*, produced in 1990 as the ADB's main input into the first Asia-Pacific ministerial-level conference on environment and development, held in Bangkok in October 1990. The report has concise annexes written by academics

covering the state of the environment in several countries: Indonesia, Korea, Malaysia, Nepal, Pakistan, Philippines and Sri Lanka.

OECD produces an annual compendium called 'OECD Environmental Data' which compares pollution, energy, industrial and environmental management policies of its members. Although Japan is the only Asian country in this group, the report is nonetheless an interesting benchmark. Meanwhile, ESCAP, a United Nations agency, produced a report called *State of the Environment in Asia and the Pacific 1990*. An initial draft of this report was produced for the 1990 ministerial conference in Bangkok; it was later revised and improved for the UNCED conference.

The main difficulty with these reports is that they tend to be very general and one does not know how the data were compiled. They probably serve best as general background information which need to be cross-checked where possible with national sources of information.

Bilateral economic assistance institutions, such as Danida (the Danish international aid agency) and the US Agency for International Development (USAID), are often excellent sources of environmental data for Asia. Danida produced a very good overview report on Thailand in late 1991 as part of an 'environment project identification mission' (Danida 1991). It also wrote an equally useful report on India in 1989 (in fact, the majority of this was written for Danida by the Center for Science and Environment, an environmental research and information NGO in New Delhi) (Danida 1989). In 1991 USAID published excellent reports on India and the Philippines (USAID 1991a and 1991b). The one on India is mainly a survey of market opportunities, while the one on the Philippines is designed to recommend specific urban and industrial sectors requiring development assistance.

In Indonesia, the Canadian International Development Agency (CIDA) and the Ministry of State for Population and Environment are jointly implementing the Environmental Management Development in Indonesia (EMDI) program. Part of this is the development of environmental information systems (see Dalhousie, undated). Lastly, researchers should not overlook United States embassies as a source of general information, particularly their commercial sections, while the American Chamber of Commerce in some major Asian cities is usually well informed on environmental issues that affect business.

Certain countries have independent or quasi-independent research institutions which publish data on environment and development issues. An outstanding example is the Thailand Development Research Institute (TDRI). TDRI's 1990 year-end conference, which was called 'Industrializing Thailand and Its Impact on the Environment', produced 11 major papers and reports on natural resources, mineral resource and industrialization issues. TDRI continues to be a focal point for environmental data in Thailand. Although the overall data availability remains far from satisfactory, the number and diversity of information sources is often extensive.[11]

## A CASE STUDY: INDICATIONS OF AIR QUALITY

A useful way to illustrate the differences in the published environmental data of, and about, each country/economy is to take one form of pollution — emissions affecting air quality for example — and examine the degree of detail these are accorded in the various reports mentioned above.[12]

In *Environment Hong Kong 1991* for example, air quality (like the other main forms of pollution) is given a separate chapter of more than 20 pages and organized under the following headings: policy and objectives, introduction, control, monitoring, investigations and special studies, and planning. There is specific information on, among other things: air pollution standards; regulations; the number and nature of stationary premises which emit pollutants; the number of prosecutions for violations of standards; a description of controls implemented against industrial facilities, motor vehicles, asbestos and ozone-depleting substances; and the level of major air pollutants — nitrogen dioxide ($NO_2$), sulphur dioxide ($SO_2$), ozone ($O_3$), total suspended particulates (TSP) and respirable suspended particulates (RSP) — at each monitoring station around the territory. Bar graphs show the degree to which air quality objectives are met for each pollutant at each station. However, one potentially serious drawback is that the report does not address the problem of the adequacy of the air quality monitoring system in Hong Kong.[13]

The Malaysian annual report is structured thematically — the main types of pollution are dealt with together under headings such as 'monitoring',

'state of the environment' and 'pollution abatement and control'. It devotes fewer pages to air quality than does the Hong Kong report. The information covered includes: the number of air monitoring stations; measured levels of major air pollutants (such as $NO_2$, $SO_2$, TSP, and lead); sources of pollution; and enforcement efforts. Unfortunately, RSP is not measured (or at least not reported). In Malaysia, the International Finance Corporation's environmental technology market report contained a brief summary of the main sources of air pollution, the major air pollutants measured, such as lead and dust, and some information on acid rain (IFC, draft Malaysia report p. 2/2 and C/1). However, the volume of data provided was less than that in the DOE's annual report.

The Indian report covers pollution and conservation issues, and limits pollution data to only one of its 11 chapters. Information on air pollution is, therefore, extremely limited. There is little more than a broad description of monitoring and control efforts (MEF 1991 pp. 41-3 and pp. 45-6). Here, the reports of the Central Pollution Control Board were critical for building a factual picture of air quality. The Confederation of Indian Industry and the Directorate General of Technical Development, Ministry of Industry jointly published in September 1991 a pamphlet called *Status Report on Air Pollution Control Equipment Industry*. This is a concise description of air quality problems, the major industrial sources of pollution, and air quality standards. While the report contains less data than the Central Pollution Control Board reports, the fact that it is under one cover makes the information somewhat easier to access. Lastly, the USAID document on India contained some objective data on air quality and pollution sources (USAID 1991b pp. 10-15).

The coverage of air quality in the two main Japanese reports (EA 1991a and EA 1991b) is meagre. The first devotes three pages to the topic, with graphs designed to show how air pollution in Japan is significantly lower than that in North America and Europe (comparisons are made on 'per unit of GDP' and base-year basis). No information is given for actual levels of pollution. The second report is more forthcoming, even though it does not accord a great deal more space. Broad nationwide averages are given for $NO_2$, $SO_2$, smog (photochemical oxidants) and particulate matter. The problem of rising $NO_2$ levels from motor vehicles in large cities is also mentioned briefly (EA 1991b pp. 5-6 and p. 20). Since none of the other national reports give broad national 'annual averages' for specific air pollutants — an exercise of dubious use in any case — it is impossible to compare most of the Japanese figures with other countries.

In Japan, a group associated with the Environment Agency called the Study Group for Global Environment and Economics produced in 1991 an interesting report of three of the country's worst pollution disasters — Yokkaichi (air pollution), Minamata (mercury poisoning) and Jinzu River (cadmium poisoning) (EA 1991c). The Yokkaichi chapter contains selected data on the trend of that city's $SO_2$, the particular pollutant of concern from 1969 to 1989. Like the Environment Agency's annual reports, this data is averaged out on an annual basis. The data in these reports suggests that environmental monitoring in Japan is significantly more objective and detailed than the Environment Agency's annual reports would lead one to conclude — at least where pollution hot spots are concerned. Also of importance is the fact that the tables and graphs in this chapter come from documents such as *Environmental Protection in Yokkaichi City 1990* and *Quality of the Environment in Mie (Prefecture) 1990*. Therefore, individual cities and prefectures would appear to produce their own environmental data. Whether or not these documents have been translated into English is a question this writer is unable to answer.

The report from the Philippines notes the number of vehicles apprehended in the 1990 'Anti-Smoke Belching Campaign' — 50 243 — and proudly states this is 50% more than in 1989. It gives figures for the number of air sampling stations in the country and the number of firms inspected. What is lacking is any information on the actual level of air pollution in the country or in Manila (DENR 1990 p. 13).

Additional information in some places, such as in Singapore, does not add a great deal to this writer's stock of environmental data obtained from the major annual environmental publication. Singapore's UNCED report makes the same bland statements as its annual report about specific air pollutants falling by 'so many percent' as a result of control measures and that in 1990, 'overall air pollution levels remained low, within the USEPA primary air quality standards and the WHO long-term goals' (Singapore 1992 p. 20). (The Singapore report leaves unstated what USEPA *primary* standards mean: they are the standards judged *necessary* to protect public health.)

In conclusion, environmental data for air quality — and environmental data in general — is not presented evenly or roughly comparably from one country to the next. Furthermore, at least for air quality, annual reports are not necessarily the best sources of factual information and it would appear that much more data is collected than published by central environment agencies. Better data can sometimes be found if one has the time and curiosity to follow up on leads — such as the 'sources' given for graphs and tables — but often these will not have been translated into English.

## DATA CONSISTENCY, ACCURACY AND USEFULNESS

Once sources of information have been identified and collected, the most difficult challenge is judging the accuracy and comparability of that data. Official information is often inconsistent with other sources of data, such as newspapers, academic journals and consultant reports, or common sense. An example of this can be found in the Thailand report to UNCED. The report makes the apparently extraordinary statement:

> Measurements of air quality taken in 1989 near major streets in Bangkok and compared with the NAAQ (national ambient air quality) standards showed that, in most cases, concentrations of the pollutants measured (CO, lead and SPM) did not exceed the standard. However, the range of concentrations was quite wide and indicated that occasional breaches of the standards do occur, particularly in the case of suspended particulate matter. (Thailand 1992 p. 28)

While this statement purports to show that air quality in Bangkok is reasonably good, it only reveals how much laxer are the country's standards compared to those in other parts of Asia. It also contradicts the vast majority of newspaper reports describing the severity of air pollution in Bangkok (for example, *Asian Wall Street Journal, AWSJ,* 23 May 1991: 'Thai Environmental Problems Worsen') and the experience of virtually anyone who has been there. Indeed, the *AWSJ* article cited claims:

> Children in Bangkok have among the world's highest levels of lead in their blood, largely attributable to air pollution. (*Asian Wall Street Journal* 23 May 1991)

Because Asia's economies are changing so rapidly, timely information is vital to record accurately what is happening. Yet reasonably current data is often difficult to find. As one might expect, during this writer's research in the first part of 1992 there were no countries for which official 1991 data was available in easily accessible form (that is, in a printed report). *Environment Hong Kong 1992* (covering 1991), for example, was not published until May 1992, while the latest Malaysian annual report available in early 1992 was published in September 1990 and presented information on 1989 conditions. The India report stopped at the end of the first quarter in 1991. The Japanese reports, although published in 1991, had little data after 1989.

One must be careful about information presented without proper context. A common feature in reports from Singapore and Japan, and occasionally in Hong Kong, is to state that pollution levels are 'within acceptable' limits, without a description of what 'acceptable' means. Another non-contextual technique used is to describe the relative contribution of different sources of pollution at inland lakes and enclosed harbours, but without any information given for the absolute levels of pollution. In the Japanese report, for example, one learns that in 1988 household sewage accounted for 68% of the pollution in Tokyo Bay, while industry made up 22% and other sources 10%. One does not learn what physical quantities are involved (EA 1991b p. 6). The Japanese Environment Agency also publishes charts showing 'annual average' levels of different air pollutants ($NO_2$, $SO_2$ and suspended particulate matter) for the *entire* country (EA 1991b p. 5), without accompanying data setting down which parts of the country have the worst air pollution or how the annual average levels compare with daily levels.[14]

Another example of non-contextual information is found in China's UNCED report. Under the subheading, 'Ecological Engineering of Forests Begins to Pay Off', there is the concluding sentences:

> In the past 40 years, with the sustained and unswerving efforts of the government and people of China, 10 billion trees have been planted in the nationwide campaign to plant trees, and the area of preserved newly planted forests has reached 38.3 million hectares, thereby raising the nation's forest coverage from the previous 8.6% to 12.98%. Tangible results have also been achieved in preventing soil erosion, breaking the wind, fixing sanddunes and mitigating the disasters of floods and droughts. (China 1991 p. 24)

Although other parts of this report describe the grave problems the countryside faces from soil

erosion, salinization and desertification, the above section on afforestation contains no comparative information on *deforestation* over the past 40 years, or on the survival rates for the afforestation plantings and is therefore of questionable usefulness as an indicator of *net* gains. Further, net gains or losses in different regions are not compared. In short, readers should perhaps not pay too much attention to general official statements about environmental quality, but should instead concentrate on the actual figures (which also must be read carefully, as noted below).

One cannot make sense of environmental data unless something is known about the monitoring methodology. Where, how and when one measures pollution will have a marked influence on the results obtained. In Thailand's UNCED report, the comments on air quality in Bangkok only state that measurements 'taken in 1989 *near* major streets' did not exceed the standard in most cases (emphasis added; Thailand 1992 p. 28). The Hong Kong report, which gives more information about the 'how' of monitoring than other places, no more than hints at the limitations of the territory's system: sites are selected which are as far as possible not directly influenced by local emission sources. Satisfactory air quality, as measured at an ambient monitoring station, does not necessarily mean that air quality is satisfactory at every location, as local pollution hot spots may still exist (*Hong Kong 1991* p. 108). (Also see Note 13.)

Making comparisons between the data of different countries is, for all the reasons above, extremely difficult. The data may relate to different years. One cannot be sure how it is gathered and interpreted. The lack of objective data for certain types of pollution means that some countries have to be left out of the comparison, which weakens the exercise. Differences in degree of generality and context among various national sets of data — say, between annual averages of air pollution from one country, and city specific daily readings from another — could make the exercise futile.

## RESEARCH SUGGESTIONS

Every researcher of environmental data (in Asia as elsewhere) faces the frustrating task of digging through a deep layer of political (and sometimes nationalistic) and unscientific surface soil to find the true gems beneath. The pragmatic approach is to shed overly high expectations and find as many official and non-official sources of information as possible. In addition to building reliable contacts in different government departments, researchers would be well advised to get to know consultants, local academics, environmental journalists (a small, but growing group), chambers of commerce and embassies.

Environment officials are sometimes willing to talk about the limitations of their environmental data, especially if they think that publicity will assist them in winning additional funding for monitoring and other projects. Since the environment is a relatively new part of government policy, many of these officials are quite candid about the problems they face in being taken seriously by other government departments. In this writer's experience, they tend to be less closed than the average bureaucrat.

Although consultants are often unable to express their opinions publicly (because they rely on government contracts to stay in business), many are more than willing to talk off-the-record about government policy and data.

Academics and journalists are usually very open. The strength of academics is their ability to put an issue in context and dissect it rigorously. Their main weakness is a frequent reliance on published data which tends to be rather old. Where they have access to current data (for example, such as they collect themselves) this tends to be highly focused. A journalist, on the other hand, will often have more detailed knowledge of the most recent information and policies of governments. Most, however, lack scientific training and may therefore miss some of the subtleties which academics would grasp.

The strength of chambers of commerce and embassies, particularly those representing American business and government, is that they often have committees or officers with responsibility to track environmental issues, regulations and business opportunities. Some produce internal reports which can be a useful source for verifying government figures.

## CONCLUSION

The state of environmental data in Asia is similar to the state of the environment itself — poor. However, one may also predict with some confidence that the body of data collected by each government should

increase and improve in response to the growing pressure to manage development and environment. Nonetheless, given the varying attitudes towards information in different countries and level of economic growth, it seems unlikely that this development will be relatively consistent across Asia. It is also questionable whether the improved data will be good enough, both for the purposes of disinterested analysis and the comparison of environmental conditions in different countries.

One solution might be for a university research institute or a multilateral institution to encourage the development of uniform (or at least consistent) monitoring systems and comparable data sets. The study could begin by reviewing the strengths and weaknesses of the systems operating in Asia and later set down guidelines for government agencies to follow. A complementary task, and one that is necessary if one country's oranges are ever to be compared to those of another, would be to examine on an on-going basis the extent to which existing data can be compared. Ideally, this work would lead to the publication of a regular and reliable compendium of environmental data for Asia. At present there are few independent and reliable non-official sources the researcher can tap for broad-based information about the state of the environment. Even many of the additional institutional sources listed above are linked to, or rely on, governments.

While the ADB may or may not be best suited to funding independent data analysis, it could certainly play a very useful role in sponsoring the translation into English — and possibly other languages — of publications produced by environment agencies.

If governments in Asia hope to learn from the mistakes of those in the industrial world and put environmental management systems in place during the developmental process, a crucial function that must be improved is the collection and publication of accurate data. Publication is important because many groups in society, in addition to the government, have a stake in what is happening to the environment. Good public policy requires an informed public as well as officials with adequate resourcing.

## NOTES

1 One purpose of the research effort reported in EIU (1992) was to outline for various national and international business audiences the major environmental problems in each economy, the policy responses of the governments, and to provide available information on the attitudes of the general public, and the business community in each area toward environmental issues. The information sought in each economy included basic data on pollution levels and the status of environmental protection policies, as well as information on economic priorities and judgements of environmentalists, politicians, business leaders and the academic community regarding the state of the environment and what was being done about it. The research also sought to put these responses into an international context: how is Asia being influenced by, and how is the region influencing, environmental developments elsewhere.

2 Because of Asia's often extraordinarily rapid pace of development, even normal lead times for data publication (for example, one to two years) would mean that the nature or scale of important environmental problems could be rather different from that presented when the data are finally published. Unfortunately, due to budget problems and other reasons, in much of Asia environmental data is even less current than one would normally hope for.

3 To complete the listing: in Indonesia Bapedal reports to the Ministry of State for Population and Environment; the Environmental Protection Department (EPD) in Hong Kong reports to the Planning, Environment and Lands Branch of the Hong Kong government; the Department of Environment (DOE) in Malaysia is organized under the Ministry of Science, Technology and Industry; and in Thailand the Environmental Policy and Planning Office reports to the Ministry of Science, Technology and Environment. In contrast, in India, South Korea and Singapore, the principal environment agency itself has ministerial rank.

4 The Ministry of Health and Welfare, for example, has the power to manage municipal waste, dispose of industrial waste once it has reached a disposal site (mostly by private waste collection companies) and takes an active role in recycling. The Ministry of International Trade and Industry (MITI) encourages manufacturers to minimize the volume of wastes they produce and, in recent years, has begun to take an interest in the recycling of these more difficult wastes. Both ministries promulgated recycling laws in 1991 (Plastic Waste Management Institute 1991 pp. 170-89). MITI is also encouraging greater energy efficiency within Japanese industry (Energy Conservation Center, Japan 1990 p. 26), an issue the ministry has been concerned about for economic reasons since the first oil shock in 1973 (*Tokyo Business Today* 1992 p. 63). However, MITI's plans are not as strong as those adopted by the Japanese cabinet on 23 October 23 1990 that aimed at stabilizing carbon dioxide emissions at 1990 levels by the year 2000 (Japan Economic Institute 1990 pp. 9-10).

5 Clearly, data availability in English may not be the most useful for national purposes. However, considering that English is the de facto international language in Asia, the availability of English language data is an important step for the dissemination of information on management efforts from one part of Asia to others not sharing the same national language.
6 All is not lost, for the four which do not — each, with the exception of Taiwan, produced national reports for the 1992 United Nations Conference on Environment and Development in Brazil. Both China and Thailand had theirs ready by early 1992, and were therefore available for this writer's research efforts. Indonesia's report was not ready by the first week of March 1992, when this writer visited that country, and there was some doubt as to whether it would be made publicly available before the UNCED conference (Ministry for Population and Natural Resources, personal communication 1992). Nonetheless, it is important to remember that the UNCED reports were special one-off exercises and so are not representative of the on-going data publication activities.
7 It is perhaps especially interesting that Malaysia has a relatively good environmental data publication system, considering the reputation the Malaysian prime minister, Dr Mahathir Mohamad, has in some quarters of the international press as being 'anti-environmentalism'.
8 Although this is not necessarily true for all their official publications as noted in the 'Case Study: Indications of Air Quality' section of this paper.
9 The main reports from the CPCB which this writer made use of included: *Ambient Air Quality Status of Some Cities/Towns in India* (1990); *Assessment of Vehicular Pollution In Metropolitan Cities* (major cities, such as Bombay, Delhi and Calcutta, were each given a separate 15 to 25 page report in this 1988-89 series); *Water Quality Statistics of India 1988 and 1989*; and *Status of Water Supply and Wastewater Collection, Treatment and Disposal in Class I Cities —1988.*
10 Taiwan did not participate in UNCED and Hong Kong participation was only as part of Britain's activities (a separate Hong Kong report was not produced).
11 Other non-public sector data sources this writer found especially useful include: **US-Asean Council for Business & Technology**. This Washington-based organization produced a 37-page report in 1991 called *Asean Environmental Markets: Opportunities for US Equipment and Service Companies*. A shorter follow-up was written in 1992. **Engineering/environmental consultants**, such as Arthur D. Little (Taiwan) and Dames & Moore (Jakarta, Kuala Lumpur, Tokyo and Sydney). **Non-governmental organizations (NGOs)**, such as the International Institute for Energy Conservation (IIEC) — their Bangkok office; Project for Ecological Recovery, Bangkok; the World Wide Fund for Nature, Hong Kong; Walhi (Friends of the Earth, Indonesia); the Consumer Association of Penang/Sahabat Alam Malaysia (Friends of the Earth); the Environmental Protection Society Malaysia; the Center for Science and Environment in New Delhi; and the Nature Society, Singapore. **Merchant banks** such as Credit Suisse in Tokyo, for example, published a 30-page report in September 1991 entitled, *Japan's Environmental Protection Industry: Emerging Green Opportunities*. It gives a good overview of the Japanese environmental goods and services market. And, **Conference proceedings**, such as People's Forum, Bangkok 1991; Pollution in the Urban and Metropolitan Environment (Polmet), Hong Kong 1991; the International Council on Social Welfare 1991 Asia and Pacific Regional Conference (on environmental protection and social development, role of non-government organizations); and Changing Course Towards Sustainable Development — An Indian Industry Perspective, organized mainly by the Confederation of Indian Industry, New Delhi, 1991.
12 None of these places had published an UNCED report by early 1992 when the data used in this paper were being collected.
13 For example, with one exception monitoring is at rooftop levels while the major health issues lie probably at ground level, particularly where there is heavy pedestrian use of streets with congested traffic or idling diesel buses. In other words the rooftop measures may be useful indicators of average air quality over a general area, but the major health concerns lie with particular hot spots of ground-level concentrations of pollutants, more than with the averages.
14 Such breakdowns are given in the Hong Kong report, which admittedly covers a much smaller geographical area.

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# Sustainable Forest Management and Development: A Southeast Asian Perspective

*S.T. Mok*

## ABSTRACT

Countries in Southeast Asia have basically sound forestry policies and subscribe to the concept of sustained yield forest management. Nevertheless, substantial areas of land have been deforested by shifting cultivation or degraded by inappropriate management and harvesting practices. Major areas of concern include: eurocentric forestry, inadequate technical and managerial capabilities, inappropriate technologies, deficiencies in information, constraints of human and financial resources, and increasing pressure on forest resources.

Among the important steps needed are: conservation forestry based on a tropical forestry culture and supported by centres of excellence for forest economics and policy analysis; integrated studies in forest management, development, harvesting and reforestation operations; upgrading capabilities for formulating sound policies and strategies and effective implementation of programmes and activities.

***Key Words:*** *Southeast Asia, tropical forestry, forest development, sustainable development*

## INTRODUCTION

Southeast Asia comprises the southeastern tip of continental Asia and thousands of islands in the Eastern Archipelago which stretches to the north of Australia.[1] The region can be divided into Continental Southeast Asia comprising Cambodia, Laos, Myanmar, Thailand and Vietnam, and Insular Southeast Asia comprising Brunei, Indonesia, Malaysia, the Philippines and Singapore (ADB 1987). Thailand and the insular countries are members of the Association of South East Asian Nations (ASEAN) and have achieved significant socio-economic progress, while the rest of the countries are beginning to be associated with it. As shown in Table 1, the region had a population of 444 million in 1989 which is expected to increase to 519 million by the year 2000 (ADB 1987).

The countries of Southeast Asia are endowed with rich natural resources including agriculture, and energy.[2] Its vast forest areas constitute one of the last remaining major reserves of tropical timber in the world. The Southeast Asian economies are also among the fastest growing in the world and are expected to play a major role in developing the Pacific Rim into the economic powerhouse of the twenty-first century. This paper examines the issues and makes recommendations with regard to the managment of these forest resources in the region's development and in light of the world's environmental concerns.

## FOREST RESOURCES

Until recently, Southeast Asia was largely covered by tropical forests comprising mainly rain (seasonal)

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**Table 1**
**Land Area and Population in Southeast Asia**

| *Country* | *Land Area* (x1000 ha) | *Population* (million) | *Forest/cap.* (ha) |
|---|---|---|---|
| Brunei | 576 | 0 3 | 1.6 |
| Cambodia | 17 652 | 6 8 | 1.6 |
| Indonesia | 191 866 | 184.6 | 0.6 |
| Laos | 23 080 | 3.9 | 3.2 |
| Malaysia | 32 981 | 17.4 | 1.2 |
| Myanmar | 65 774 | 40.8 | 0.8 |
| Philippines | 29 817 | 64.9 | 0.1 |
| Singapore | 57 | 2.7 | – |
| Thailand | 51 177 | 55.6 | 0.2 |
| Vietnam | 32 536 | 66.8 | 0.1 |

Source: Collins et al. 1991

forests in the Eastern Archipelago and smaller areas of monsoon (seasonal) forests along the northern and southern margins. Within the rain and monsoon forests are various formations dependent upon local conditions of soil, topography, climate and ground water (Collins et al. 1991; Tho 1991). The most common and commercially important tropical forests are the tropical lowland evergreen rain forest, tropical semi-evergreen rain forest, mangrove forest and peat swamp forest. The dipterocarp forests of Southeast Asia are the largest source of tropical hardwoods in international trade.

The tropical rain forests of Southeast Asia are widely acknowledged as one of the most species-rich and complex terrestrial ecosystems in the world (Soepadmo 1992).[3] The rain forests of Southeast Asia constitute one of the major centres of origin and distribution of more than 6000 species of plants with economic potential. The forest's mammals and birds play a crucial role as pollinators and dispensers of seeds in the rain forests. They are also an important source of protein and the basis of a flourishing local and international trade.[4] The forests of Southeast Asia are rich in wild relatives of domesticated animals such as pig, cattle, deer and antelope (Collins et al. 1991).

The Southeast Asian forests have satisfied the peoples' basic needs of food, fuel, shelter and medicine since time immemorial and contributed significantly to socio-economic development in recent years. In spite of the long history of forest utilization, Southeast Asia is still relatively well-covered with forest resources. Five of the countries have more than 50% of their land area under forests. Most of the cleared forests have been replanted with perennial tree crops of forest origin such as rubber and oil palm. The remaining forest cover was recently estimated at 216 million hectares, or 48.6% of the total land area (Collins et al. 1991). About 190 million hectares are rain forests and 26 million hectares are monsoon forests which represent 42.8% and 5.8% of the total land area respectively. Of the remaining forest area, about 31 million hectares are existing conservation areas while 32 million hectares are proposals which together account for 14.2% of the total land area. The extent of forests and conservation areas in Southeast Asia are given in Tables 2 and 3 respectively.

## FOREST MANAGEMENT

The importance of rational and sustainable forest management and development has long been recognized in the Southeast Asian countries. Because of low population densities, the indigenous communities in these countries have been able to live in harmony with the forests and they have often managed them deliberately to sustain yields of many products (Poore and Sayer 1987). The beneficial influence of the forests in ameliorating local climatic conditions and maintaining environmental stability and quality is well-known to the farmers and rural population. The retention of natural forests for soil and water conservation and the planting of trees as shelterbelts and for slope stabilization are traditional practices in many of these countries. Hence, extensive areas of forests have been reserved for the conservation of wildlife and biological diversity, protection and management of the environment.

**Table 2**
**Extent of Forests in Southeast Asia**

| *Country* | *Rain Forest* (x1000 ha) | *Monsoon Forest* (x1000 ha) | *% Land Area* |
|---|---|---|---|
| Brunei | 469 | – | 81.4 |
| Cambodia | 6 550 | 4 775 | 64.2 |
| Indonesia | 114 840 | 3 074 | 61.5 |
| Laos | 9 879 | 2 581 | 54.0 |
| Malaysia | 20 045 | – | 60.8 |
| Myanmar | 22 339 | 8 846 | 47.4 |
| Philippines | 5 074 | 1 528 | 22.1 |
| Thailand | 7 540 | 3 150 | 20.9 |
| Vietnam | 3 717 | 1 951 | 17.4 |

Source Collins et al. 1991

**Table 3**
**Extent of Conservation Areas in Southeast Asia**

| *Country* | *Rain Forest* (x1000 ha) | *Monsoon Forest* (x1000 ha) | *% Land Area* |
|---|---|---|---|
| Brunei | 108 | 10 | 20.5 |
| Cambodia | 2 035 | 468 | 14.2 |
| Indonesia | 19 806 | 21 846 | 21.7 |
| Laos | – | 4 732 | 20.5 |
| Malaysia | 1 675 | 1 524 | 9.6 |
| Myanmar | 708 | 1 969 | 4.1 |
| Philippines | 566 | 68 | 2.1 |
| Thailand | 5 138 | 1 390 | 12.8 |
| Vietnam | 1 095 | 20 | 3.4 |

Source: Collins et al 1991

production of all forms of wood and non-wood forest products, and enhancement of the peoples' quality of life.

The national forestry services, policies, legislation and principles of the Southeast Asian countries are among the oldest and soundest in the world. The forestry policy of Sarawak (Malaysia), for instance, has been acknowledged by the International Tropical Timber Organization to have admirable features while Peninsular Malaysia's Selective Management System (SMS) has been singled out by the International Institute for Environment and Development as the most encouraging and complete theoretical system for operational forest management (Mok 1992a).

Unfortunately, logging of tropical forests was accelerated enormously by the European powers and systems for managing the forests evolved in parallel with increasing demands for tropical timber in Europe (Poore and Sayer 1987; 1991). The ensuing eurocentric forestry imbued with European ideals, philosophies, principles and practices based on the timber-oriented concept of sustained yield proved to be inappropriate and ineffective in achieving sustainable forest management and development or in slowing down the rapid decline of tropical forests. Instead, it led to pessimistic and unrealistic perceptions that the tropical rain forest is a non-renewable resource (Gomez-Pompa et al. 1972) and that the area of tropical moist forests which is demonstrably under management for sustainable timber production amounted to less than one million hectare out of an estimated total of 828 million hectares of productive forests remaining in 1985 (Poore et al. 1989).

Although the Southeast Asian countries subscribe to the concept and principles of sustained yield and most of them have technically sound forestry policies, legislation and institutions, their forestry strategies, programmes and practices are

often unrealistic or impractical. Furthermore, inter-sectoral coordination essential for sustainable forest management and development is often lacking or ineffective.

Many of the countries are constrained by bureaucratic and conservation institutions with incompatible eurocentric concepts and ideals, inadequate managerial expertise and skills, inappropriate technologies and operating systems, inadequate or unreliable information and insufficient human and financial resources (Mok 1991a). Consequently, the increased efforts in socio-economic development in most of these countries have invariably contributed to an acceleration of forest degradation and deforestation. The situation is exacerbated by the increasing demand of rapidly growing populations for more food and employment which is often satisfied by the conversion of forests to commercial agricultural crops and the development of wood-based industries. The resultant escalating rates of forest degradation and deforestation inevitably led to a loss of biological diversity and adverse environmental impacts locally and possibly globally.

## ISSUES AND CONCERNS

The rate and impact of tropical forest degradation and deforestation have become increasingly evident in recent years due to rapid improvement of technological capabilities such as remote sensing and geographic information system for detecting, monitoring and documenting changes in forest cover. However, there is no consensus in defining the term forest or in quantifying the extent and impact of tropical forest degradation and deforestation. The generic term deforestation is used so ambiguously that it is virtually meaningless as a description of land-use change (Hamilton and Pierce 1987). As much of the forests in Southeast Asia have been converted to perennial tree crops which are no different from the monocultural stands of trees in temperate forests, it might be prudent to consider the expression natural forest depletion rather than deforestation (Tho 1991).

The causes of tropical forest degradation, depletion and deforestation are many and varied (Collins et al. 1991; Mok 1991b; Tho 1991). The underlying natural causes are mainly fires and monsoonal storms. Human causes include poverty, inequitable land distribution, low agricultural productivity, poor land use policies, inappropriate development programmes and technologies, weak institutions and rapid population growth. The main activities include fuelwood cutting, shifting cultivation, commercial logging, conversion to annual cropping, grazing and perennial food and industrial crops. The construction of dams, settlements, highways and infrastructures can also be major causes of deforestation. The Tropical Forestry Action Plan (Anon. 1987) estimated that nearly half the forests cleared in the tropics each year are used for shifting cultivation by landless farmers.

The outstanding forestry issues in the Asia-Pacific region are centred around the depletion of the natural forests which is causing environmental problems and loss of biological diversity of an unprecedented nature and scale and affecting the future supply of fuel and industrial wood (Rao 1990; Tho 1991). The Southeast Asian countries, which dominate world trade in tropical hardwood products and are crucially dependent on such trade for export earnings and socio-economic development, are beginning to feel threatened about future supplies of raw materials for their industries. As a consequence, the following seem to have emerged as the priority forestry development concerns in the Asia-Pacific region (Rao 1990):

- managing the remaining natural forest areas in a sustainable way;
- involving local communities in the protection and management of natural forest resources;
- identifying critical watersheds and undertaking programmes of conservation;
- finding appropriate solutions to minimize forest degradation by shifting cultivators;
- establishing networks of protected areas to conserve flora and fauna;
- strengthening conservation, collection and storage of germ plasm and tree improvement to ensure productivity gains in reforestation programmes;
- reducing the wastage of wood through improved logging and utilization;
- utilization of non-wood products and plantation-grown wood; and
- promoting community forestry and agroforestry.

Effective conservation and sustainable management and development of tropical forests require comprehensive and pragmatic policies,

strategies and programmes based on adequate information particularly in respect of inter-linkages. The key issues that emerged from a review of national forest policies of Asia-Pacific countries (Anon. 1992) include the following:

- how government, population, economic and land tenure policies impact on forest resources and sustainable land use;
- how to assist the more than 20 million migrants and tribals already living in state forest lands to adopt sustainable farming systems;
- reclamation of degraded Southeast Asian forest lands;
- alternative tenurial approaches to conservation and management of forest lands;
- accelerated industrialization policies;
- improved understanding of how government forest revenue collection and concession license policies influence tropical forest management;
- shifting the emphasis from industrial to non-timber forest products;
- improved understanding of farm forestry policy interventions;
- prevailing uncertainties (and confusion) about the sustainability and economic viability of natural forest management; and
- the impact of global climate change on forest resources.

The growth in tropical timber trade, especially in South Sea logs and lumber, led to the signing of the International Tropical Timber Agreement and the establishment of the International Tropical Timber Organization (ITTO). The high rates of deforestation and forest utilization in Southeast Asia inevitably attracted the attention of the environmentalists and conservationists. The issues reached the top of the global political agenda and featured prominently at the United Nations Conference on Environment and Development (UNCED) and the Non-Governmental Organizations' (NGO) Global Forum. The United Nations Food and Agriculture Organization launched the Tropical Forestry Action Plan and ITTO adopted the Year 2000 Target as well as 'ITTO Guidelines for the Sustainable Management of Natural Tropical Forests' (ITTO 1990) and 'Criteria for the Measurement of Sustainable Tropical Forest Management' (ITTO 1992).

UNCED reached the following agreements which impinge on forests and forestry:

- Rio Declaration on Environment and Development;
- Framework Convention on Climate Change;
- Convention on Biological Diversity;
- Non-legally binding authoritative statement of principles for a global consensus on the management, conservation and sustainable development of all types of forests; and
- Agenda 21

## SUSTAINABLE DEVELOPMENT

Based on the issues and concerns identified, Rao (1990) proposed a strategy for forestry development in Southeast Asia which requires the countries to carefully reassess their forestry and land use policies to ensure sustainable timber removals in future by bringing unplanned deforestation under control; rehabilitating some 50 million hectares of previously logged forests; rigorously implementing sustainable systems of forest management; and undertaking compensatory reforestation schemes. The ADB (1987) proposed that countries with abundant forest resources, such as Indonesia, Laos, Malaysia and Myanmar, focus on further development of industry; plantation for future supplies of wood for industrial and domestic requirements; rehabilitation of water catchments; conservation of forest ecosystems; strengthening institutions; and involvement of local populations. Countries with significant forest resources, such as Cambodia, the Philippines, Thailand and Vietnam, should expand plantations; improve watershed conditions and management; develop agroforestry and minor forest industries; and involve local populations in forest activities.

Although support and commitment for sustainable tropical forest management and development have been increasing, there is no consensus in defining it. The traditional concept of sustained yield has been rejected as being too narrow in spite of the fact that it is not necessarily restrictive but can embrace all the relevant objectives of management. The ITTO has adopted the following working definition of sustainable forest management (ITTO 1992) which is based on a simpler proposal by Mok and Poore (1991):

> Sustainable forest management is the process of managing permanent forest land to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow

of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment.

The Southeast Asian countries have the potential and the capacity for sustainable management and development of their tropical forest resources. In order to do so effectively, however, the eurocentric forestry culture must be replaced by a tropical forestry culture which is compatible with local political, social, cultural, environmental, ecological and economic conditions. A centre of excellence should be established to conduct comprehensive and in-depth forest economics and policy studies to evolve and propagate such a culture and to upgrade human resources necessary for formulating and implementing socio-culturally, ecologically, environmentally and economically sustainable tropical forestry policies, strategies and programmes.

While sound forestry policies, strategies and programmes are essential for sustainable development of tropical forests, the imperatives for sustainable forest management must include realistic objectives of management which are politically, socially and culturally acceptable and forestry practices which are technically feasible and economically viable. A conservation forestry approach based on integrated forest resources assessment and management, clear and realistic objectives, and pragmatic forest management and development regimes and options offers the best prospects for sustainability. The strategic principles of conservation forestry should be as follows (Mok 1977):

- manage and utilize the forest resources for maximum benefits based on the inherent capability of the forest and its optimal use;
- manage the utilization of the forest resources based on comprehensive land use and forest management plans;
- determine the potential yield on the basis of systematic and in-depth appraisal of the forest resource base, its growth potential, and other relevant factors;
- regulate log flows based on a careful balance of supply and demand as well as maximum utilization prospects and constraints;
- harvest the forest resources conservationally by selective felling and retention of adequate natural regeneration, consistent with safe and economic harvesting, to ensure sustainability of the forest resource base; and
- apply optimal forest management regimes or options developed on the basis of information generated by systematic resource appraisal and integrated studies in forest management and operations.

The effective implementation of conservation forestry requires careful pre-felling and post-felling assessments of the forest resources, the determination of optimal management and development regimes and options, the preparation of sound management and operational guidelines, and the application of appropriate technologies to ensure that the prescribed forest practices are socio-culturally, ecologically environmentally and economically sustainable Centres of excellence should be established to conduct integrated studies of forest conservation, management harvesting and reforestation to develop models and standards, appropriate technologies and techniques, as well as timely and reliable information necessary for the formulation of sound forestry policies and strategies, the implementation of appropriate forestry practices, and the evaluation of the effects and impacts of different forest management regimes, harvesting systems, and silvicultural treatments on socio-cultural, ecological, environmental, economic and other intrinsic forest values.

The practice of conservation forestry requires substantial investments in human and financial resources for research, development and reforestation operations as well as for the maintenance of infrastructural facilities and the provision of logistic support. The need to increase investments in forestry to reduce deforestation and to enhance sustainable forest management and development to save the tropical forests has been recognized. Various proposals have been put forward, including debt relief, nature-for-debt-swap, levy or surcharge on imported tropical timber, but none of them has been effective. A recent partnership between a Malaysian forest products company and power stations in Holland and the United States to offset carbon dioxide products by improved management and conservation of tropical forests may prove to be more successful (Mok 1992b). It is likely that more financial resources will be forthcoming, especially for the implementation of Agenda 21, when the proposed Commission for Sustainable Development is established.

## CONCLUSION

The tropical forests of Southeast Asia are naturally resilient and easily renewable as the region is blessed with ideal conditions for plant growth and possesses the requisite expertise for the establishment and management of industrial tree crops. The region's dipterocarp forests, which produce the bulk of the commercial tropical timbers, are uniquely suited to selective management and development based on the conservation forestry approach. Consequently, conservation and sustainable management and development of the tropical forests are inherently possible but will only be practically feasible, socially equitable, environmentally sound and economically viable if there is:

- no over-use, misuse or abuse of the forest and land resources base;
- political and professional will and commitment to ensure rational land use and sustainable forest management and development;
- a tropical forestry culture which is compatible with local political, social, cultural, biological, ecological, environmental and economic conditions;
- technical and managerial competence, supervisory and operational skills, appropriate, cost-effective and environmentally friendly technologies, timely and reliable information, and adequate human and financial resources to optimise management decisions and actions;
- inter-sectoral and inter-disciplinary collaboration to achieve rational and integrated land use and natural resources management and development; and
- international co-operation to promote conditions which are conducive to, and will facilitate, the practice of sound land use and sustainable conservation, management and development of the tropical forests.

Sustainable conservation, management and development of the tropical forests of Southeast Asia can be achieved by practising conservation forestry based on a tropical forestry culture which has the following strategic goals:

- conservation and sustainable management and development of the natural forests;
- afforestation and reforestation of deforested land and degraded forests;
- research and development to optimise forest land use, biodiversity conservation, harvesting, re-forestation, and environmental management; and
- education and extension to promote awareness in the multiple values of tropical forests and to transfer appropriate technologies and skills.

## NOTES

1 The region is located astride the Equator between latitudes 29°N and longitudes 92°E and 141°E. It covers a total land area of 445 million hectares which vary from coastal swamps in the humid tropics to snow-capped peaks up to 5729 m in northern Myanmar. The largely equatorial climate is dominated by the southwest and northeast monsoons from June to October and November to February respectively which bring average annual rainfalls of up to 5000 mm.

2 The ASEAN countries produce about 95% of the world's output of abaca, 85% of its natural rubber, 83% of its palm oil along with substantial quantities of cocoa, tin, copra, copper, sugar, coffee, timber and various tropical fruits (Anon. 1989). The region has substantial sources of energy as well as large seas rich in seafood.

3 The natural forests harbour more than 40 000 species of vascular plants of which 37 000 species distributed in 266 families and 3075 genera are flowering plants and 87 species in five families and 12 genera are conifers.

4 The diversity of vertebrate animals in Southeast Asian rain forests is high but the number of species is much less than that of plant species. Borneo has over 200 mammal species, 350 bird species, 200 reptile species and 80 amphibian species (Payne 1992).

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# Observations on the Role of Non-Governmental Organizations in the Rio Conferences of June 1992

*Gordon T.L. Ng*

## ABSTRACT

The June 1992 United Nations Conference on the Environment and Development (UNCED) openly recognized the importance of non-governmental organizations (NGOs). The NGOs' Global Forum ran parallel to the official UNCED meetings and in many respects significantly extended both the range of issues and the scope of participation for global discussions on the environment. However, the diversity and loose organization of the international community of NGOs may keep its influence relatively weak.

This paper describes the June 1992 Rio de Janeiro conferences from the perspective of a local Hong Kong NGO participating in the Global Forum. Drawing on this and other experiences, recommendations are made to increase the effectiveness of the activities of the NGO community and its influence on official international organizations and national governments in promoting environmental protection and sustainable development.

***Keywords:*** *UNCED, Earth Summit, Global Forum, NGO, Hong Kong*

## INTRODUCTION

The international environmental gathering in Rio de Janeiro, Brazil in June 1992 actually involved two conferences. The official meeting was the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit. This was the first attempt by the United Nations to address environmental problems within the context of current economic and social development. It was also the first attempt to coordinate the international governmental efforts on environmental protection with those of the international community of non-governmental organizations (NGOs). In this regard, a second meeting in Rio — known as the Global Forum — ran parallel to the Earth Summit and was organized by and for NGOs.

Over the past several decades, NGOs have taken an expanding role in environmental protection. Their functions now range from that of mobilizing community resources and energies to influencing government on major policies. Some NGOs have even become independent funding sources for environmental activities and some have become prominent research institutions in the field. It is also important to recognize that certain NGOs have members in many parts of the world, while many others are locally (or at most nationally) based. However, even the local independent NGOs often are active in issues affecting the regional and global commons as well as in more localized concerns.

The Rio conference demonstrated for the first time at an international level the respect NGOs have gained in the two increasingly important areas of

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international dialogue — environment and development. How did this situation come to be? Whose interests did the NGOs represent? What were their primary concerns? Answers to such questions would be valuable in understanding the dynamics and outcomes of the Rio conference. This paper addresses these and other matters from the perspective of the Hong Kong Conservancy Association — one of the local (as distinct from international) participating NGOs.

As context for what follows, it should be stressed that activities such as the Rio conference represent only one aspect of the work of NGOs in the environmental field.[1] In addition, the NGO community represented at Rio — while large and diverse — was only a subset, and not a fully representative one, of the NGOs active in environmental matters throughout the world.[2] Finally, as noted above, this paper presents matters at Rio as seen through the eyes of one local NGO.[3] Despite these limitations, the perspective presented here illustrates the constraints and strengths of a local NGO participating in global events. Apart from the author's own observations, the extensive newspaper articles, organization reports, leaflets, booklets, and other documents collected before, during and after the Earth Summit and Global Forum have provided useful information for writing this article.

## NGOs AS A VEHICLE FOR WIDER COMMUNITY PARTICIPATION

The importance of NGOs is increasingly being recognised in recent years. Redclift (1992) asserted that greater local involvement in environmental decisions through NGOs is one important element in achieving sustainable development. The rural poor and women in developing countries often have been deprived of opportunities to participate in the decision-making process and NGOs can provide a vehicle for such representation. In its annual report the World Bank (1992) used an example of an afforestation programme in Haiti to illustrate the point that a participatory approach involving NGOs was more successful than a top-down approach. The World Resources Institute (1992) also recognized the ability of NGOs to mobilize collective action from the local community. Local NGOs may provide services, training and education to the communities, being more effective and accountable than the official counterparts.

In Agenda 21, one of the documents adopted at the Earth Summit, the independence of NGOs was recognized as an important element in enhancing their credibility and in enabling them to play a responsible and constructive role in society. In particular, Chapter 27 reads,

> Non-governmental organizations possess well-established and diverse experience, expertise and capacity in fields which will be of particular importance to the implementation and review of environmentally sound and socially responsible sustainable development, as envisaged throughout Agenda 21. The Community of non-governmental organizations, therefore, offers a global network that should be tapped, enabled and strengthened in support of efforts to achieve these common goals

### Whose Interests?

The significance of NGOs' participation in the Rio conference may best be assessed according to the types of NGOs involved and the interests they represent. NGOs could seek accreditation from UNCED or register under the Global Forum, or both The latest date for UNCED accreditation was 3 April 1992 when the fourth Preparatory Committee Meeting (PREPCOM) ended. In contrast, representatives could register for the Global Forum during the conference period itself. Eventually, there were 1428 NGOs with 1955 representatives from just over 100 countries accredited by UNCED.[4] For the Global Forum, there were 27 000 registrants (including 9000 members of the press) representing over 11 000 organizations and institutions from more than 171 countries and economies.

Since data on the individual registrants to the Global Forum is not available, the database of NGOs accredited to the UNCED provides the data for analysis in this section. These UNCED accredited NGOs probably represent those with better pre-Summit planning and scheduled action programmes.[5]

NGOs in developed regions such as North America, Australasia and Europe predominated in the official conference. The three regions have about 20% of the world's total population, but as shown in Table 1, account for roughly 60% of the total number of accredited NGOs and representatives at the official conference.

The larger number of accredited NGOs from the developed regions reflects several factors. In part it reflects their better planning and organization capability. Also, the high cost of travelling to and

**Table 1**
**Number of NGOs accredited by UNCED by regions**

| *Regions* | *Number of NGOs* | *Number of representatives* |
|---|---|---|
| Latin America | 228 (16%) | 344 (18%) |
| Asia | 233 (16%) | 279 (14%) |
| Africa | 126 (9%) | 158 (8%) |
| Europe (including former USSR) | 415 (29%) | 640 (33%) |
| Australasia | 36* (3%) | 45 (2%) |
| North America (USA and Canada) | 380 (27%) | 489 (25%) |
| Total | 1418* (100%) | 1955 (100%) |

* In the database, there are missing data for 10 of the accredited NGOs.
Source. UNCED database. (Please refer to Note 4 )

staying at Rio may also have deterred NGOs in developing regions from seeking accreditation. It is also possible that fewer NGOs in developing countries were interested in the Rio conference as some might regard the Rio conference as representing unacceptably high opportunity costs on the use of very scare financial resources.

The USA has the largest number of accredited NGOs (22%), followed by India (7%) and Switzerland (6%). Of the ten countries with the largest number of accredited NGOs, only two are developing countries (India and Brazil). The USA also accounted for most NGO representatives (20%), followed by Switzerland (8%), Brazil (7%) and Japan (5%). It is understandable that Brazil ranked third in the number of NGO representatives. Its proximity reduced travel cost drastically for the representatives. Other inhibiting factors for many developing countries may be language barrier and customs requirement.

One abnormality may be India which has 103 accredited NGOs, just second to USA. This is related to the flourishing of NGOs in India and to the cultural characteristics of India (WRI 1992). However, only 82 representatives were sent, an average of less than one representative for each NGO. Many accredited Indian NGOs did not send a representative, or a single individual often represented several NGOs.

The implications of over-representation of NGOs from developed regions could be significant. Would there be a predominance of ideas from developed countries with insufficient regard to the needs of the community from developing countries? Many NGOs from the north emphasized the importance of conservation of wild animals and protection of the rainforest to an extent that NGOs in the south may fear that the poverty issue may be played down in lobbying the official delegations making Earth Summit decisions.

Although the conference focused on environmental and development themes, accredited NGOs concerned primarily with these specific themes accounted for only about half of the total as shown in Table 2. Other sectors covered include research institutions, women, youth/students/children, professional associations, indigenous peoples, legal interests, business and industry, churches, parliamentarians/local authorities, and trade unions. While these groups are not wholly devoted to environmental protection, they incorporate environmental problems as one of their concerns.

It should be noted that some groups such as those from business and industry tend to represent commercial and industrial interests (for example, trade associations for the asbestos industry) which some in the NGO community regarded as being obstacles to adequate environmental protection. In a number of cases such organizations were suspected of lobbying UNCED to water down the agreements and to reduce environmental regulations on behalf of specific polluting industries.

Accredited NGOs from developed and developing regions showed some difference in the sectors they represent. More accredited NGOs from developed regions included research institutes, information clearinghouses, media organizations, and business and industry associations. In contrast, NGOs from developing regions have distinctly more representation by organizations dealing with women and indigenous groups.

In terms of their primary concerns, accredited NGOs from developing countries have distinctly

**Table 2**
**Sectors covered by accredited NGOs**

| *Sectors covered by accredited NGOs* | *Developed region (%)* | *Developing region (%)* | *Total (%)* |
|---|---|---|---|
| Environment/development groups | 21.4 | 26.6 | 24.5 |
| Information clearing house/media organization/public awareness | 9.4 | 6.1 | 14.6 |
| Research institutions | 12.9 | 11 9 | 10.2 |
| Conservation groups | 7.1 | 7.8 | 7.6 |
| Women | 8.0 | 14.0 | 7.0 |
| Youth/students/children | 6.6 | 7.8 | 6.3 |
| Professional associations | 5.4 | 4.8 | 5.6 |
| Indigenous people | 4.2 | 7.8 | 4.8 |
| Legal interests | 3.5 | 2.0 | 3.8 |
| Business and industry | 6.4 | 3.1 | 3.5 |
| Churches | 4.7 | 2 0 | 2.6 |
| Parliamentarians/local authorities | 1.9 | 1.0 | 1.6 |
| Trade unions | 0.5 | 1.4 | 1.0 |
| Others | 8.0 | 3.4 | 6.8 |

* Developed regions include Europe, Canada, USA, Australia and New Zealand while developing regions include Asia, Africa, and Latin America
Source UNCED database. (Please refer to Note 4 )

marked differences from their counterparts from developed regions. They have more interest with respect to land resources, agriculture and rural development and desertification problem, reflecting the rural nature of environmental and development problems in their respective countries. On the other hand, NGOs from developed regions regard education, training and public awareness, the relations between the international economy and the environment, financial resources and issues related to the atmosphere and energy as their primary concerns.

## NGOs AND THE EARTH SUMMIT

The participation of the NGO community which culminated in the June 1992 meeting started in the four Preparatory Committee (PREPCOM) meetings held in Nairobi (August 1990), Geneva (March and August 1991) and New York (March 1992). NGOs were given the right to present their viewpoints in the PREPCOM meetings but could attend the Earth Summit only as observers. Some large NGOs, such as World Wide Fund for Nature, were able to secure representation in the official delegations so that they could voice their opinions directly. Twelve NGOs were selected to present the views of the NGO communities in the plenary sessions of the official conference. However, the presentation may not necessarily represent the bulk of NGOs at Rio. For example, the presentation by the International Chamber of Commerce was criticized as being unrepresentative (*Terra Viva*, The independent daily of the Earth Summit, 12 June 1992, p.4).

NGOs have different feelings on the Earth Summit. For example, in a press briefing on 10 June 1992, Greenpeace International stated its position that 'UNCED is rubber stamping, marginalizing, manipulating and ignoring (NGOs)'. Yet Greenpeace recognized that the Conference 'brought a useful . . . measure of where the world stands' (International Press Centre Press Release No. 212 'Greenpeace calls UNCED failure' 10 June 1992). Indigenous people accused the Summit of denying their access to RioCentro, where the official conference was held (*Earth Summit Times*, 5 June 1992, p.10). Youth organizations claimed they were not adequately represented in the decision-making process of the Earth Summit since they claimed to represent half of the world's population (International Press Centre Press Release no. 27 'Youth Lambast Business Involvement at Earth Summit', 2 June 1992).

Many NGOs were aware that high hopes for UNCED were probably unrealistic. Most accepted that environmental problems could not be solved in a fortnight, but looked at the Rio conference as the possible starting point for new initiatives. Some

groups such as the World Wide Fund for Nature took a pragmatic view and affirmed the positive contribution of UNCED towards building a skeleton plan for future action.

## THE GLOBAL FORUM

As noted above, the Global Forum was the NGO conference which ran parallel with the official Earth Summit. One international newspaper described it as a 'Counter-Summit', a kind of world's fair of environmental and social justice groups (*International Herald Tribune*, 6-7 June 1992, p.5). Officially the Global Forum was to provide 'an opportunity for all sectors to express their independent views at the time of the Earth Summit' (Global Forum 1992). A series of simultaneous events were organized including 330 exhibitions, 350 separate meetings on a wide range of topics and special events. In contrast to the Earth Summit meeting which was held 25 km from the city centre, the global Forum took place near the city centre with scattered meeting places in 53 auditoria, mostly within easy reach by Metro-subway or public buses. There were 650 exhibition booths, 16 pavilions for different types of functions, 35 tents in which meetings could be held simultaneously, and other facilities including a post office, fax centres, kiosk, etc.

### Types of Meetings

According to the official schedule of the Global Forum, a total of 761 meetings were planned, most of which were open. Less than 10% of the meetings arranged were restricted to those invited. The Forum was intended for massive public participation. Originally, according to the official schedule, meetings open to the public were planned to accommodate an average of 448 people per meeting. Meetings by invitation had a much smaller planned capacity, 156 people per meeting. Yet casual observation suggests that relatively few meetings were full, mostly with less than one-quarter attendance and many ended much earlier than scheduled, and some were not held at all.

It was observed that meetings in the early part of the Forum were better attended than those on the last few days of the Forum. It may be that many NGO representatives left Rio from 10 June or earlier. The increasingly hot weather and the poor ventilation within the tents temporarily set up for the meetings might have discouraged participants from staying longer. Another possible reason may be the removal of sound and interpretation equipment by the contractor because the organizer did not pay the outstanding bill on 9 June 1992, further handicapping the lengthy meetings in the Global Forum.

The financial problem of the Global Forum reflected the type of difficulties that many NGOs often encounter. Thus, it was particularly unsettling when some groups such as the Youth Panel criticized the Global Forum for taking money from polluters. On 8 June 1992, a local newspaper produced for the Earth Summit ran its headline 'Global Forum Crisis: Last-minute Rescue Effort Launched' and reported that the organizer was US$2.1 million short of its budgeted US$11.8 million (*Terra Viva*, 8 June 1992, p.1).

Unlike the official UNCED, the meetings at the Global Forum were often poorly organized and lacked coordination. For example, the International Council for Adult Education organized four whole-day and two half-day meetings on environmental education while the British Ecological Society held a three-day seminar on the same topic. Use of resources on redundant meetings, which the NGOs probably could not afford, could have been reduced through better coordination.

Language barriers were also a problem. The Forum only provided simultaneous interpretation for meeting organizers who could afford to pay for the facility. Some speakers spoke solely Spanish or Portuguese while many others could understand only English or French. There was often no single common language among the NGOs or facilities for adequate translation.

Despite such problems, the Global Forum provided a meeting place for people who would normally not be able to participate in an official international meeting. In addition to the different sectors of society represented, the Global Forum also included those who would ordinarily be excluded for political reasons. For example, the British colony of Hong Kong, which formerly participated separately in international meetings, is now routinely absent (or subsumed with the UK delegation) due to objections from China as Hong Kong moves closer to reverting to China's rule in 1997. The participation of the Hong Kong Conservancy Association at the Global Forum provided at least some opportunity

for the particular concerns and viewpoints of those living in Hong Kong to be separately expressed at Rio. On a much more controversial point, the Central Tibetan Administration of the Dalai Lama was able to distribute and present a report on the deterioration of the Tibetan environment under Chinese rule, even though this document was not accepted by UNCED because the United Nations does not recognize Tibet as a country.[7] Hence, to a certain extent, one success of the Global Forum was to allow independent views to be expressed.

### Other events

Apart from the serious discussions in the many meetings described above, the variety of events occurring at the Global Forum gave it a more relaxed environment. One may describe it more as something of a carnival and public exhibition to raise public awareness on environmental protection. Actor Roger Moore was invited to the opening ceremony, while a replica of the Viking ship *Gaia* and a balloon which was called the 'Drop of Hope' added to the festive atmosphere. On the lawn within the Flamengo Park, religious groups practised meditation and spiritual healing. Singing and dancing performance under the 'Tree of Life' attracted those recuperating from long meetings. At night, the park was still crowded with people for social gatherings.

The 650 exhibition stalls occupied by 330 NGOs did not fall short of spectators and customers (some were selling souvenirs and books). Apart from the 27 000 registrants from NGOs, there were about 400 000 local people, mainly children, who visited the Forum during its 14 days. Even if the Forum had not achieved its role as a focal point for NGOs to exchange their views and discuss environmental issues, it probably performed reasonably well as an educator delivering messages and information on environment and development from around the world.

Several demonstrations and marches also marked the Global Forum. An Ecological Walk organized on 7 June in Copacabana Beach was turned into a parade of NGOs with banners. Eventually the parade attracted wide media coverage as thousands of people joined in. However, two days later a protest organized at RioCentro was attended by less than 100 NGO representatives and was stopped by the security guards. Not all the demonstrations were pro-environment: a group of local people protested in front of the Hotel Gloria, the headquarters of the Global Forum, with banners stating 'We want jobs, not the forest'.

## INTERNATIONAL FORUM FOR NGOs AND SOCIAL MOVEMENTS

The International Forum for NGOs and Social Movements was a more centralized body established during the PREPCOM IV when the NGOs proposed to draft their own treaties as they were disappointed with the Agenda 21 and the Earth Charter which was reduced to the Rio Declaration on Environment and Development. While the Global Forum was a loose agglomeration of numerous meetings, exhibitions and events, the International Forum was intended to be a more co-ordinated effort with international networking based on regions on all issues.

While the official delegations were negotiating on the details of the forty chapters in Agenda 21, the NGOs drafted a set of *Alternate Treaties*. Most of these treaties reflected either the belief that the official meeting had neglected certain issues or that the NGOs were not satisfied with what were included in the Agenda. Yet, like the Global Forum, the treaty-making process of the International Forum was often confused and unsystematic, especially when compared with Agenda 21. It is not surprising as the Agenda was the result of four PREPCOMs and backed by a strong UNCED Secretariat, while most of the alternate treaties were drafted and discussed only in the fourth PREPCOM, if not right at the Rio Conference itself, by the much more loosely organized NGO community.

At the beginning, it was announced that 33 treaties would be produced. By the end of the Forum, only 27 treaties were submitted for signing up by the NGOs (International Press Centre Press release no. 253 'Alternative Treaties to be signed on Saturday'). In a recent report by the Centre for Our Common Future (1992), 46 treaties emerged. While Agenda 21 has a relatively uniform style and format, the alternate treaties are not well-structured and have different formats and style, depending on the people or organizations drafting the treaty.

The strength of the secretariat initiating the treaty had a significant influence on the success of the treaty making process. For example, the International Council on Adult Education initiated the Treaty on

Education for Sustainable Societies and Global Responsibility and provided strong secretarial support. The treaty was circulated within its own network in late April 1992 and comments were made by many organizations before the Rio conference. Eventually, at Rio, the meetings were basically to proofread the treaty with minor amendments on the wording rather the framework of the treaty.

Due to the limitation of on-going information exchanges, little is known at the international and regional levels about the follow-up work of the alternate treaties. For example, although the Hong Kong Conservancy Association is a signatory NGO, it has not been informed of the latest development and implementation, if any, on the treaties.

In contrast, some treaties, such as the one on education, have strong support from the International Council on Adult Education, which has established a network on which the follow-up work could be pursued so as to have a better chance of implementation. One regional branch, the Asian South Pacific Bureau of Adult Education, for example, held sub-regional meetings in September-November 1992, and plans for implementing the treaty were made at the regional level in early December 1992.

## THE ACTIVITIES OF THE HONG KONG CONSERVANCY ASSOCIATION AT RIO

Although the environmental NGO community in Hong Kong is relatively active and diverse, only the Hong Kong Conservancy Association decided to send a delegation to the Rio conference. For various reasons, the other and sometimes better financed environmental NGOs in Hong Kong such as the Friends of the Earth and the World Wide Fund for Nature Hong Kong did not send delegates to Rio.

The Conservancy Association prepared for the Earth Summit one year before the Rio conference when the association sent a representative to the third PREPCOM in Geneva in August 1991. During 1991, the Conservancy Association sent proposals to companies for sponsorship to Rio, but in vain, as most companies in Hong Kong were not then aware of the Earth Summit and its potential for publicity. The Conservancy Association decided that, if necessary, it would fund participation at the Rio conference itself, even though this would mean a drain on very scarce resources.

Fortunately, there was growing publicity during early 1992 about the Rio conference, including support for the participation of local NGOs at Rio voiced by the Hong Kong government. A second round of fund raising was launched and a total of roughly US$ 8 000 was secured by the association. More generally, through the active publicity and promotion for the Rio conference from the Hong Kong Environmental Campaign Committee — a governor-appointed committee to promote environmental awareness in the community — a total of about US$13 000 was eventually secured for organizing programmes related to the Earth Summit within Hong Kong, including a signature campaign, the publication of a report, the Tree of Life programme, and a seminar to be held after the Earth Summit. It should be noted that all sponsorships were for organizing programmes in Hong Kong, rather than sending delegates to the Earth Summit. The association's delegates at Rio paid their own expenses, supplemented with a modest subsidy from the association.

### Pre-Summit Programmes

In January 1992, when the association committed a budget for the Earth Summit related programmes, the Executive Committee of the association also resolved to produce a document as its contribution at the Earth Summit. The document was intended to provide suggestions which were most relevant to Hong Kong in its international obligation to environmental protection. Due to limited resources and time, the document was limited to a brief nine-point recommendation called 'Hong Kong Environment Charter for Sustainable Development'. The first draft of the document was circulated among the local environmental groups and Environmental Campaign Committee for comments and was endorsed formally on Earth Day by all environmental groups in Hong Kong in April 1992.

The association intended to arouse public awareness on sustainable development by explaining what it means and asking people to sign for their support. Eventually, 34 000 people signed for their support, including 14 legislative councillors, the governor and the director of the government's Environmental Protection Department. In addition, a booklet called the *Hong Kong Environment Profile* was produced to explain the state of the environment and the environmental movement in Hong Kong.

Copies of this booklet were carried by the delegates to Rio and distributed to other delegates.

## During the Earth Summit

In Rio the Hong Kong Conservancy Association organized an ad hoc meeting among NGOs from the People's Republic of China (PRC), Taiwan and Hong Kong on 4 June 1992. The intent was to foster communication among NGOs in each of these economies, eliminating as far as possible the political element while focusing on environmental protection. It should be noted that the representatives of NGOs from Mainland China were also Chinese officials — the attending PRC's NGOs are established partly at the initiative of the government. The Taiwanese NGOs present varied from academic bodies to community organizations. As noted above, Hong Kong NGOs were represented by the Conservancy Association only.[8] This meeting had a limited purpose and in fact served primarily to allow the NGOs from each place to get to know one other and to share experiences.

The Conservancy Association also arranged meetings with the official PRC and United Kingdom representatives to the Earth Summit on two occasions. These meetings proved interesting, but the environment — like much else in Hong Kong in the run-up to 1997 — could sometimes be politicised. For example, the question of the sewage treatment strategy for Hong Kong was evaluated by the PRC largely in terms of its financial impact on the people of Hong Kong. One should recognize that there is an increasing need for PRC input especially when the British Hong Kong government seeks to undertake infrastructure projects which affect the territory after 1997.

The political sensitivities reminded the association's delegates that it is naive to overlook the political and other aspects of apparently straightforward environmental issues. Despite these limitations, the meetings did at least lay the foundation for future discussions between Hong Kong environmental groups and the PRC.

## Other Activities

With eight members in the team, the Conservancy Association's delegation divided itself for different meetings and programmes. Members gathered every night for a brief report, followed by the discussion of press releases and the following day's work. With so many meetings taking place simultaneously and with little pre-meeting information, it was difficult for the group to decide which meetings were worth attending. With insufficient preparation and pre-meeting contact, the delegates acted more as observers than as participants. Yet, the team did achieve its purpose of learning from other NGOs and getting to know more about how they operate. While the piles of booklets and leaflets collected from the meetings and exhibition booths proved useful, probably much more important were the ideas expressed by the various NGOs and the personal contacts with their representatives. As a networking exercise, Rio was a major success from the Conservancy Association's perspective.

## Post-Summit Programmes

Since the Earth Summit, the Hong Kong Conservancy Association has continued with its lobbying and education work in Hong Kong and participation in further networking with NGOs within and outside the region. On returning to Hong Kong the association organized meetings with government officials, legislative councillors and the governor to discuss how Hong Kong should follow up the resolutions adopted in the Earth Summit. A press conference was held in late June 1992 and a petition was put forward in early December 1992 to put pressure on the government to ratify the Conventions on Climate Change and Biodiversity and to adopt Agenda 21.

One outcome of this lobbying was the initiation of a debate in the Legislative Council on 2 December in which councillors requested a review of environmental priorities in the government, the setting of a conservation policy in the direction of sustainable development and the adoption of the two conventions resolved at the Earth Summit.

In its education work, the association published *The Earth Summit: Implications for Hong Kong* and *Green Alert: Earth Summit Special* (Conservancy Association 1992a and b). The two publications were intended to report on the Earth Summit and its relation to Hong Kong. A forum was held in early July 1992 to discuss the impact of the Earth Summit among business leaders, the government and environmental groups in Hong Kong. In addition, in the Conservancy Association's talks organized for schools, community organizations and other groups,

the Earth Summit is typically mentioned so as to remind the audience of the international obligation Hong Kong should observe.

In its networking role, the association chaired the meeting for the East-Asian Sub-Region environmental education network in November 1992 which planned for the implementation of one of the alternate treaties on Education for Sustainable Societies and Global Responsibility. An information centre was set up in Macau to facilitate the exchange of environmental information and a conference will be organized in Korea in 1994 for sharing experience on the implementation of the treaty at local levels.

## CONCLUSION

The importance of the NGO community in environmental matters has been strongly affirmed at the Rio conference. However, its potential influence is restricted by the financial resources available and could be further weakened because its constituents are often loosely organized and poorly coordinated. A strong networking system could possibly link up NGOs to build a more concerted force to pressure for change on the part of international organizations and national governments. However, this would be very costly and its success far from certain.

On another point, rich NGOs from the developed countries could surely help their poor friends in the developing countries. Before this could even become a reasonable prospect, there would be the need to first agree on a consensus of concerns and priorities.

The concept of sustainable development has proved to be a useful vision for reviving a local environmental NGO, such as the Conservancy Association. Would it be possible that the concept could link the gap between NGOs from developed and developing countries? Obviously, we may need to explore further how the concept of sustainable development could be applied in different regions, which is another area for further research.

## ACKNOWLEDGEMENTS

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## NOTES

1 Readers interested in a more comprehensive review of NGOs' achievements on the environment may refer to Bratton (1990), The World Resources Institute (1992), Twose (1987), Fox (1987), Herbert-Copley (1987), Landim (1987), and Fernandez (1987).

2 It should also be noted that the NGOs attending the Rio conference are probably not representative of environmentally concerned NGOs as a whole. For example, attendees were necessarily limited for the most part to those which could afford the costs of international travel. In addition, member-based NGOs with limited supporting staff would find even greater difficulty because their representatives would need to use their own holidays for attending conferences. Many local NGOs — particularly rural ones — may not have representatives who can speak English, Portuguese, Spanish or French, the main languages of the conference.

3 The perspective of a local environmental group in Hong Kong predominates in this article. However, it is hoped that these specific experiences will allow NGOs in other areas to understand and learn from our experience.

4 UNCED Secretariat created a database with information on the name, address, contact person, sector and interests on the Earth Summit for all accredited NGOs. This information on computer disk is available to interested organizations on request. (Please write to UNCED Secretariat, 160 Route de Florissant, P.O. Box 80, CH-1231 Conches, Switzerland.) The Secretariat also published a directory containing brief information of the accredited NGOs and distributed it during the official conference.

5 These figures were given in a letter from W.H. Lindner, one of the two coordinators of Global Forum, to all registrants of Global Forum dated 2 November 1992. Unfortunately, the organizers of Global Forum have not published a directory or made available a database of registrants of Global Forum.

6 Although clearly not fully representative, the 1400 accredited NGOs is perhaps not as small and non-representational a sub-set as might first seem. The 11 000 organizations registered under the Global Forum included not only NGOs but the press (possibly over 7000 as most media organizations sent only one reporter), academic institutions, and companies. In addition, small, local NGOs from Brazil and surrounding countries may also account for a relatively large number of the total for the Global Forum.

7 The Chinese NGO delegation stated in their meeting on 5 June 1992 that the peaceful environment of Tibet has been maintained, with development going on harmoniously.

8 Age difference among the representatives from the three areas were also observable. Chinese representatives were much more senior, Taiwan's are younger and Hong Kong's are between the two. This is perhaps to be expected as Chinese representatives that are sent out of Mainland China are generally of higher rank and seniority. Taiwanese NGOs in Rio had both young and old members but only the younger ones went to the meeting.

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# Environmental Management Implications of Aquatic Species Introductions: A Case Study of Fish Introductions Into the Sepik-Ramu Basin, Papua New Guinea

*David Coates*

## ABSTRACT

Introductions of aquatic species should be subject to prior evaluation, irrespective of the intended purpose or whether the species involved are 'exotic' or not. In the case study area, rapid population growth poses a significant threat to the sustainability of traditional systems. A rational development option is to stock (introduce) further species of fish. Potential risks and benefits to the environment of this option are outlined. The potential benefits mainly involve the establishment of sustainable capture fisheries. Improved practical methods for predicting the ecological interactions of alien and native biota are required also. Potential environmental impacts of introductions are considered in relation to those arising from alternative options for improving food supply and socio-economic conditions.

***Key words:*** *biodiversity, conservation, hunting, fishing, food production, sustainable development*

## INTRODUCTION

Species introductions into aquatic systems have long been commonplace. Welcomme (1988) lists 1354 international introductions of 237 inland animal species into 140 countries worldwide. The actual number of introductions of aquatic species is likely much higher if plants, introductions within countries, into marine environments and those not reported are considered. Interestingly, less than 11% of inland introductions worldwide have been undertaken with the purpose of establishing wild or feral food resources; 12.6% of introductions have been for sport fisheries, 8.6% for ornamental purposes, 5.4% for control of nuisance biota, 9.2% were 'accidental' and 20.6% for unknown reasons, while aquaculture accounts for by far the largest number at 32.6% (Welcomme 1988). Within Asia, about 25 species of fish alone have been introduced beyond their native range (De Silva 1989a).

Controversy has surrounded aquatic species introductions in recent times. Introductions undertaken on purpose directly into the wild seem to attract the most criticism while, in general, the majority occur without comment. This is illogical since introducing a species for aquaculture is similar to introducing it into the wild — in all but exceptional cases it will escape.

Neither should concern be limited to the effects of exotic on native species.[1] The effects of native species on native species, for example, stocking or escapes from aquaculture, can impact natural biodiversity of wild strains of the same species (and all artificially reared biota are modified strains). The

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effects of exotic species on other exotic species where the resident exotic species has significant socio-economic or ecological importance, for example, can be equally problematic. Hence, discussion should centre on introductions as such, irrespective of whether 'exotic' species are involved or the purpose.

Species introductions can obviously have both desirable and undesirable effects. The main areas of concern are potential or real reductions in biodiversity in the recipient region, including degradation of natural habitats, and undesirable socio-economic impacts. Conversely, there are numerous examples of the real contribution that introductions can make to improved socio-economic or environmental conditions. These subjects have received much attention in the literature. The status of exotic aquatic organisms in Asia, for example, was reviewed in a recent symposium edited by De Silva (1989b).

What have rarely, if ever, been documented are the potential advantages of species introductions in terms of promoting the sustainability of food production and limiting the loss of biodiversity. For example, the inadvertent introduction of the noxious aquatic weed *Salvinia molesta* in the Sepik River (Fig. 1) can be cited as a 'bad' introduction. The weed resulted in significant socio-economic hardships and threatened the sustainability of food production and biodiversity (Coates 1987a). However, following the successful purposeful introduction of a second exotic aquatic species (a weevil, *Cyrtobagous salvineae*, for biological control) these problems and threats have been eliminated (Room & Thomas 1985). Consequently, the often held view that all introductions into natural ecosystems are 'bad' by threatening sustainability and biodiversity clearly does not hold.

This paper discusses aspects of the issues of species introductions with particular reference to

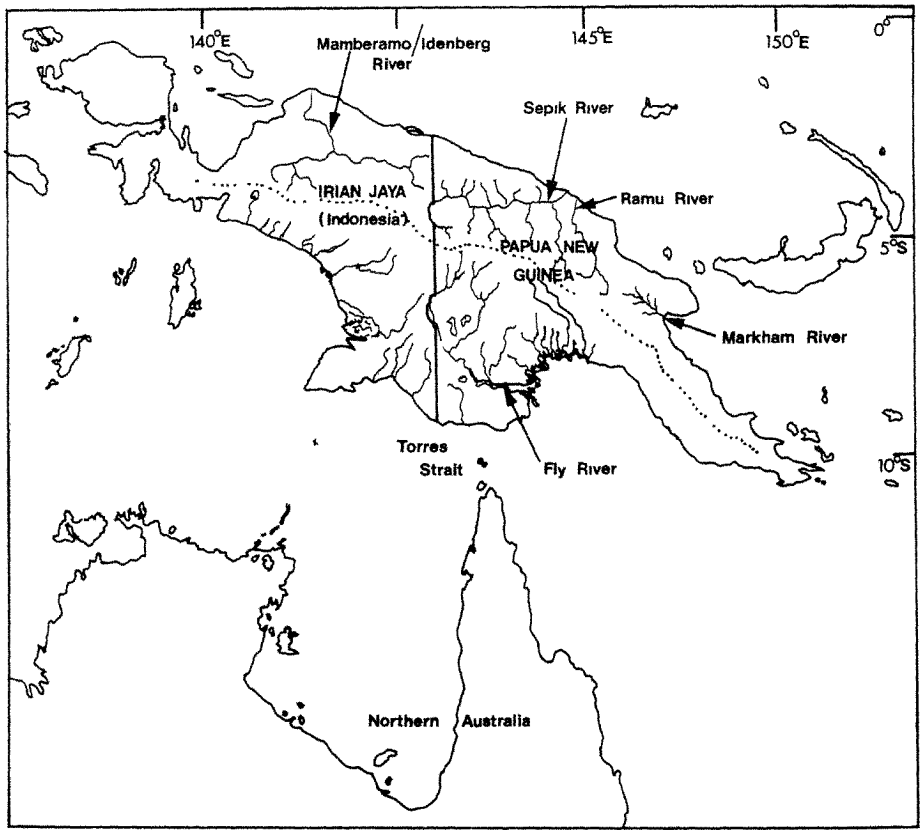


**Fig. 1** Sketch map of New Guinea. The Sepik and Ramu Rivers, in northern Papua New Guinea, interconnect in lowlands forming what is referred to as the Sepik-Ramu basin.

exotic fish introductions into the Sepik and Ramu River basin in northern Papua New Guinea (Fig. 1). In view of the abundance of literature outlining the potential negative effects of introductions, the paper is orientated towards an outline of the potential environmental advantages in the Sepik-Ramu.

To openly discuss species introductions can be fraught with frustration. This may partially explain the notable absence of documentation for most introductions that have occurred. However, the conclusion here is that, if introductions occur, they should do so under a consensus of scientific opinion, following established codes of practice. The Sepik-Ramu situation has been subject to public scrutiny in this fashion and the question of the desirability of fish introductions into the Sepik-Ramu is dealt with elsewhere (Coates 1992). The purpose here is to outline some of the complexities of the more general problems when considering plausible introductions fully, giving due regard to both their environmental risks and benefits.

## THE NEED FOR INCREASED FOOD SUPPLY

The mainland of the independent state of Papua New Guinea comprises the eastern half of New Guinea, the world's largest tropical and highest island (Fig. 1). The region has been inhabited by people interacting with their local environment for many thousands of years (Bulmer 1982). The people are renowned for their diversity of lifestyles based predominantly on subsistence gardening, hunting and fishing. This situation still exists in most regions, especially in the Sepik-Ramu basin (Lutkehaus et al. 1990).

Development began in a significant manner within approximately the last half century. It is assumed that people traditionally lived in a sustainable fashion whereby populations were subject to natural controls. However, the human cost of this, far-from-idyllic, 'sustainable' lifestyle in parts of the Sepik-Ramu basin, for example, include average longevities of less than 43 years and child mortality rates in excess of 40% (Coates and Mys 1989). Few people would argue against appropriate development, although there is debate over the form this should take. Whatever rational direction such development takes, the result is, and will be, a rapid increase in population numbers. The 1980 population of just under 3 million people in Papua New Guinea is projected to increase to at least about 6.5 million by the year 2015, even assuming that realistic population control measures are effective (Brogan 1985). And, there is no reason to assume that the population will stabilize at this level.

Hence, the sustainability of traditional food production systems is already jeopardized; rapid environmental perturbations are certain to occur. Even at current population levels, traditional food production systems are under stress (Kesavan 1983). Therefore, sustainable development programmes, including fisheries, must be aimed at meeting the needs of a two- or three-fold increase in human population in the near future.

Further, even at present levels of population severe malnutrition exists. In parts of the Sepik-Ramu basin, over 60% of children below five years of age are classified below 80% of targeted weight for age, protein shortages being a major problem (Coates and Mys 1989). Adequate food supply in the Sepik-Ramu basin may, therefore, require an increase in the order of 200% to 300% over the next two decades just to maintain present nutrition levels, while a 400% or more increase in quality protein supply may be necessary to actually improve diets over the same period.

## THE RATIONALE FOR STOCKING FISH INTO THE SEPIK-RAMU BASIN

New Guinea has a wide range of climatic zones (largely altitudinal determined). It is situated near the equator, borders both the Pacific and Indian Oceans, and lies on the crossroads of Southeast Asia and Australia. Consequently, terrestrial and marine biodiversity is generally regarded as very high (for example, Paijmans 1976; Maragos 1991; Miller and Holloway 1991). The present extent of pristine rainforest and coral reef is impressive. However, New Guinea is east of 'Wallace's Line' and the freshwater fish fauna, with few exceptions, is composed of freshwater representatives of marine families and diadromous species (Allen and Coates 1990). None of the freshwater species that support significant inland fisheries in the majority of Asia occur naturally here (for example, cyprinids are absent). A similar contrast in zoogeography between Asia (west of Wallace's Line) and New Guinea occurs with the native mammalian fauna which is based almost entirely on marsupials (Flannery 1990).

Coates (in press) has outlined the problems with freshwater fisheries in the Sepik-Ramu basin:

(1) the marine origins of the ichthyofauna result in a species assemblage ill-adapted to fully exploit the potential production of rivers and lakes;
(2) the lack of an estuary has resulted in the absence from the Sepik-Ramu of several fish taxa (for example, the barramundi, *Lates calcarifer*) that support more productive fisheries in the south of the island (Fig. 1); and
(3) the extremely young age (less than 6000 years) of Sepik-Ramu lowland freshwater habitats has resulted in low speciation in the limited number of families of fish able to colonize such habitats.

The result is that fish species diversity and fisheries production are very humble in Sepik-Ramu lowlands, even by Australasian standards (Coates in press). Yields from Sepik-Ramu floodplains are less than 10% of the world average and over half of current yield is accounted for by feral exotic tilapia (*Oreochromis mossambicus*), originally brought to Papua New Guinea for aquaculture (Coates 1985, 1987b).

The basin is also poor in fish species adapted to rhithronic sections of rivers (Coates in press). Fish biomass and fish species diversity in tributary streams are very low by world standards resulting in negligible fish stocks in areas at altitudes higher than about 400 m above sea level (Van Zwieten 1990); while the basin extends to over 4500 m.

### The Proposed Stocking of the Sepik-Ramu Basin

In 1983, a management plan for fisheries development based on stocking the Sepik-Ramu basin (that is, introducing species) was proposed (Coates 1987b). Fish introductions to Papua New Guinea was not a new concept. West and Glucksman (1976) list 29 fish species brought to the country for a number of purposes by the Australian administration prior to independence in 1975. The later Sepik-Ramu proposals were, however, based on a rationalization of existing introduction methodologies and extensive pre-stocking evaluation of the benefits and risks of further introductions. From the outset, an international code of practice regarding the introduction of aquatic species (Turner 1988) was followed. This was possibly the first full implementation of this code of practice despite its existence, in various forms, for over 20 years (Coates 1992).

In 1990, an independent group of specialists from seven different countries unanimously endorsed a proposal to stock the Sepik-Ramu basin with fish species to be further evaluated under code procedures (Coates 1992). Based on such independent scientific advice, the Papua New Guinea government undertook further extensive internal evaluations before exercising its statutory right over the stocking of species. This process involves consultations among at least five government departments.

The socio-economic justifications for stocking the Sepik-Ramu with appropriate fish species are self-evident (Coates 1987b, 1990). Detailed scientific explanations as to the low yields presently achieved and the potential for improvements via fish introductions have also been presented (Coates in press). It is conservatively estimated that potential fisheries yield in the Sepik-Ramu basin can be increased tenfold from the present level of about 6000 tonnes per year to about 60,000 tonnes per year, assuming that improved stocks are properly utilised in the long-term (Coates 1990). In addition, the increase in protein supply would occur in some of the poorest regions of the country where alternative developments and improvements in socioeconomic conditions are limited. The discussion which follows focuses on the environmental aspects *per se* of fish introductions into the Sepik-Ramu However, it will be noted in the following discussion that a strong relationship exists between socio-economic and environmental considerations.

## ENVIRONMENTAL CONSIDERATIONS OF FISH INTRODUCTIONS INTO THE SEPIK-RAMU

### Risks

The risks of introduced fishes may include hybridization with native species, habitat and water quality alterations, competition for space and food, predation, and the introduction of exotic parasites and diseases (Courtenay and Stauffer 1984; Moyle et al. 1986). In the present case there are possible detrimental effects on the existing Sepik-Ramu fishery, as well as the risks associated with whole or partial failure of the introduction itself.

Safeguards can be implemented to minimize these risks. Coates (in press) notes that, in theory, the diversity of existing fish species in the Sepik-Ramu could be maintained following appropriate introductions, although noting the difficulty of achieving this in practice. Predatory species can be avoided and introductions can be based on species having habits compatible with those of the existing fauna.

Potential hybridization can be avoided by introducing fish species incapable of interbreeding with resident species. Potential for the introduction of parasites and pathogens can be minimized by suitable quarantine procedures (Coates 1992). Although shifts in the ecological balance of the system following introductions might be expected, there is no reason to conclude that species extinctions are inevitable and data on species previously introduced support this view (Coates in press).

Potential detrimental effects on the existing fishery might also have environmental consequences. However, due to the poor production presently achieved there is less concern in this respect. In addition, the majority of the basin (at higher altitudes) presently does not support a significant fishery at all. It was noted, however, that a major concern over future fish introductions is safeguarding existing stocks of exotic species, especially those of tilapia (Coates 1992).

The ichthyofauna of the Sepik-Ramu basin is well studied in comparison to most other faunal groups in New Guinea (Allen and Coates 1990), partly because its low diversity makes its study easier. Of the 70 fish species recorded from the Sepik-Ramu basin only 11 are endemic, and there are no endemic genera or families (Allen 1991). The majority of fish species are diadromous and, hence, usually much more widely distributed. Therefore, the worst case scenario following introductions (which hopefully can be avoided) would result in the loss to the world of 11 fish species plus a possible smaller number of species yet to be recorded. Most of these cannot be readily distinguished from closely related species with wider distributions. The loss of any of the non-endemic fishes from the basin might reduce regional diversity depending upon the degree of genetic mixing with nearby populations (which is likely high for most of the diadromous species). Nevertheless, the approach taken to stocking the Sepik-Ramu has always placed a high premium on attempting to safeguard the existing biodiversity (Coates 1992).

The effects of fish introductions on the biodiversity of biota other than fish (for example, bacteria, protozoa, aquatic invertebrates, etc.) in the Sepik-Ramu is potentially of more consequence. Unfortunately, remarkably limited knowledge precludes any detailed discussion of this aspect of introductions into the Sepik-Ramu or any other natural aquatic system (Coates in press). Although this is an important point, it is noted that similar considerations apply to potential disturbances of all other ecosystems (terrestrial, marine, etc.) arising through alternative developments mentioned later. It is of course impossible to be certain of the outcome of introductions, irrespective of the depth of any analyses, and, therefore, risks will always remain (Coates 1992).

## Benefits

The environmental benefits of fish introductions into the Sepik-Ramu mainly stem from the ultimate establishment of sustainable fisheries. It is argued later that the greatest support for this approach to development is the consideration of the environmental implications of alternatives to fish introductions into the Sepik-Ramu.

There are serious concerns that the Sepik-Ramu fishery is not sustainable even at the present low levels of exploitation, and therefore would be unable to sustain any increased production to meet projected demand (Coates in press). Examples of over-fishing already exist in certain areas. In lowlands, attempts at commercial exploitation of existing stocks has resulted in reductions in the species composition and the size of key species (Coates 1990). At higher altitudes, villagers frequently report that their limited fish stocks have already been decimated.

While it might be assumed that fishing pressure alone is unlikely to cause the extinction of species (FAO 1991), a reduction in stocks due to over-exploitation is likely associated with reductions in intra-species genetic variability, itself an important component of biodiversity. Additionally, fish species endemic to the Sepik-Ramu, as elsewhere in New Guinea, can have remarkably restricted distributions (Allen 1991). Extreme fishing pressure can, therefore, potentially cause extinctions especially in view of the widespread traditional use of derris poisons (*Derris* spp, rotenone) by fishing communities. There is little doubt that the provision of improved, and sustainable, fishery resources through stocking can

realistically reduce such fishing pressure on sensitive native species (Coates 1990).

Some native fish species are important for customary purposes and used in traditional ceremonies. Their conservation is an important aspect of the maintenance of cultural diversity and traditions amongst the local people. A number of these species are already under threat, irrespective of introductions (for example, Coates 1988).

Well-planned fish introductions can help sustain such traditional resources, especially if introduced fish predominantly live in different environments and are caught with different gears (Coates 1990). Part of the management rationale for the Sepik-Ramu is to provide exotic species for food and commercial exploitation, reducing pressure on native stocks and sustaining them for long-term use in traditional ways.

Improving fish stocks in the Sepik-Ramu also has the advantage of promoting better management of freshwater habitats by local people. In Papua New Guinea most land and water resources are owned by individuals or clans, and traditional resource management systems are widespread (for example, Haines 1982). At present, freshwater habitats in many areas of the Sepik-Ramu provide little direct benefit to the local population. Improving their value will improve their management. A similar concept exists with the conservation of stocks of crocodiles (*Crocodylus porosus* and *C. novaeguineae*) in the Sepik-Ramu whereby advances made have been based on villagers receiving recompense through exploiting the resource (Burgin 1982).

## ALTERNATIVES TO FISH INTRODUCTIONS

### Fisheries Options for Protein Supply

Satisfying demand for low cost fish by supplying inland areas from the coast is generally an unworkable solution at present in Papua New Guinea. The inland population of Papua New Guinea outnumbers that in coastal regions by a factor of about 9 to 1 (Coates and Mys 1989). Prevailing socio-economic conditions make it difficult for commercial coastal fisheries to supply fish efficiently to coastal regions, let alone cover the greatly increased costs of transport to inland areas. Further, more than half of the people in the Sepik-Ramu live further than 10 km from any road (Coates unpublished). Satisfying demand inland by supply from the coast also fails to promote self-reliance amongst the Sepik-Ramu people.

Finally but most importantly, the majority of the population in the Sepik-Ramu have insufficient income to buy fish from coastal areas. With per capita incomes as low as US$30 per year in many regions (Heywood et al. 1986) it is difficult to see how people could be expected to purchase fish at economic prices from their local shop, assuming that such shops exist! If such an approach were possible, it would also be necessary to consider the environmental effect of the greatly increased catches that would be required from marine habitats (which also have a far greater amount of biodiversity to conserve). Aquaculture in Papua New Guinea has a particularly unimpressive record due mainly to sociological factors, including the lack of a tradition of animal husbandry (Coates 1989).

After considering all the above factors, Coates (1990) concluded that the only rational alternative to introductions for the Sepik-Ramu fishery was to do nothing. This results in two problems. First, the appropriate authorities must accept that the people are being denied a feasible, cost-effective and significant benefit. Second, and more importantly, one must then consider the environmental implications of alternative non-fisheries options for development

### Non-Fishery Options for Protein Supply

In many respects, fish can be viewed as simply being an animal protein commodity. The problem being addressed in the Sepik-Ramu, therefore, is not strictly the poor fisheries production, but how to satisfy demand for animal protein and improve cash-earning opportunities based on this activity. Alternative sources of animal protein come from imports, local agricultural produce, and hunting and gathering wild or feral species.

The option of supplying demand from imported food has obvious drawbacks. Apart from being unpopular, because it fails to promote self-reliance, it also has environmental implications. First, it is expensive in terms of foreign exchange (even assuming that the target population in the Sepik-Ramu could afford imported food) and reduces government financial resources available to be spent on alternative activities, such as environmental protection. Second, and most important, it does not solve the environmental issue but moves it to the region of origin of the imported produce. Papua New

Guinea already imports massive amounts of low cost animal protein on a per capita basis; the major commodity being tinned fish with substantial amounts of lamb off-cuts another major item.[2]

Improvements in subsistence agriculture through the promotion of domestic animals has met with limited success in Papua New Guinea (Kesavan 1983) for similar reasons as for the failure of aquaculture.

The intensification of agriculture utilizing more modern techniques, as opposed to the traditional slash and burn subsistence systems, has the potential to greatly increase local protein supply. This approach also assumes that the key people needing assistance can afford to purchase such produce (not everybody can be an intensive farmer). Intensified agriculture, however, requires large increases in the use of suitable land, in most areas requiring the felling of primary rainforest. Cattle production, for example, at an optimistic yield of 50 kg per hectare under Papua New Guinea conditions would require 11 000 $km^2$ of land to replace the potential protein production predicted from stocking the Sepik-Ramu with fish, even assuming cattle ranching was successful. This area is in excess of an entire and substantially wide range of current rain forest habitat within the Sepik-Ramu. In addition, felling such a vast area of forest would increase soil erosion and reduce nutrient inputs into streams, to the detriment of aquatic systems. The question of the sustainability of such intensive agriculture is also relevant.

In consideration of the alternatives to fish introductions into the Sepik-Ramu it was noted that the greatest difficulty exists in obtaining accurate assessments of the impact of agricultural development in both socio-economic and environmental terms (Coates 1992). Of course, in reality it is not simply a choice of fish or agricultural produce. Both will play their role in development. The point is that the arguments against agricultural production, in terms of its potential environmental effects, may be stronger than those against fish introductions.

It is unlikely that traditional food production systems based on hunting and gathering are sustainable given at least a doubling of the population size and requirements for a per capita increase in quality protein consumption. The strongest argument for the environmental benefits of fish introductions is that they will substantially increase protein resources within the region and, hence, potentially reduce the ultimate pressure upon alternative natural resources.

Rather than potentially interfere with biodiversity in the Sepik-Ramu, either by fish species introductions or alternative improvements of the subsistence protein base, it could be argued that alternative developments could improve socio-economic conditions. Such developments may, for example, take the form of increased income from mining or timber royalties, improved cash-crop production (such as tea and coffee) or improved formal employment. None of these are real options for preserving biodiversity since all have potential environmental impacts. Mining, for example, has potentially significant impacts upon aquatic biota (Eagle et al. 1986), the potential effects of unsustainable logging are obvious and cash cropping concerns similar environmental impacts to the intensification of animal protein production. These alternatives also do not increase protein supply, only the ability to purchase it. Therefore, none solve or even assist the fundamental problem. In addition, per capita economic growth is declining in Papua New Guinea at present, and may do so over the next 25 years, since population growth is outstripping increases in gross national product (Brogan 1985).

## CONCLUSIONS AND RECOMMENDATIONS

It would be naive to think that fish introductions into the Sepik-Ramu alone will necessarily ensure that wildlife will be preserved because hunting pressure and the need for agricultural intensification will be eliminated or even significantly reduced. Neither will fish introductions alone solve the problems with malnutrition, since other factors, such as education, are relevant (Coates 1990). It is not a simple choice between development options and the alternatives mentioned. All have their potential environmental impacts, which are often difficult to compare quantitatively. Ultimately, the issue is whether options are taken in good faith, with ample consideration of both socio-economic needs and environmental impacts. With respect to fish introductions into the Sepik-Ramu the conclusion here is that this has been the case. Real attempts to minimize potential risks to natural biodiversity have been made, which are in any event likely less than impacting terrestrial or marine biodiversity in Papua New Guinea, and the potential socio-economic and related environmental benefits clearly justify stocking.

The fisheries development strategy is also appropriate in sociological terms. It focuses on existing cultural activities (fishing as part of hunting), giving people improved conditions while requiring no drastic changes in their lifestyles; they simply catch more fish for the same, or less, effort.

It would be incorrect to extrapolate from this paper that all fish introductions have environmental advantages. In some respects the Sepik-Ramu case is unusual because of the low biodiversity of the native ichthyofauna at risk and the extent of potential socio-economic improvements. Considerations of aquatic species introductions in other situations will vary greatly according to circumstances, but are unlikely to be simple. However, the fact remains that the evaluations of introductions of many aquatic species worldwide were, and still are, less than ideal. The production of low-cost food for the rural poor is probably the most justifiable reason for introductions. Evaluations should, arguably, be more strict for introductions undertaken for sport, ornament or the production of luxury food items. The important question of the actual need for an introduction, involving the consideration of alternatives, is often overlooked entirely (Redding-Coates and Coates, 1981; Coates 1992).

Global projections of population increase, and hence food production requirements, mirror those for Papua New Guinea. In consideration of the environment and sustainability in fisheries, FAO (1991) concluded that fisheries are, in fact, generally not the culprit but rather the victim of environmental degradation. Worldwide, the habitats of many wild inland fishery resources are being severely damaged by intensive agriculture, river control and urban development. For example, the effects of environmental degradation other than the introduction of exotic fish species is probably mainly responsible for disturbing or eliminating native aquatic biota in two regions of Australia (Cadwallader 1979; Arthington et al. 1983).

Although FAO (1991) noted the real and persistent dangers of species introductions, it was also highlighted that stocking has significantly increased production from inland fisheries. For such reasons, and requirements for aquaculture, deliberate aquatic species transfers are likely to increase. Fisheries management has always been essentially based on the concept of sustainability (FAO 1991). That species introductions and sustainability are not necessarily mutually exclusive is illustrated by considerations of fish introductions into the Sepik-Ramu. However, to ensure compatibility, sound management strategies are required in these respects.

Views on species introductions vary from those that are under-cautious to those promoting total restriction. Both approaches can result in undesirable environmental consequences; in the latter case because alternatives may be more damaging. Total restrictions may also promote illicit introductions Here, the code of practice can be of considerable help. The best approach is to take the middle ground whereby the potential benefits and risks of introductions are compared and decisions are made in the light of existing knowledge and under a reasonable consensus of scientific opinion. In other words, by following a code of practice. Throughout, alternatives, including the impacts of not introducing the species, need also to be considered.

To wrap up this discussion one might simply ask: is there a need to rush with fish introductions into the Sepik-Ramu, with an alternative suggestion to wait until general socio-economic conditions improve and people become better off in other respects? Unfortunately, socio-economic conditions are simply not improving fast enough. Even if they were, where would the food come from? Neither is it necessarily unduly patient for the Papua New Guinea Government to wait 10 years from fish introductions being suggested to being implemented as a rational development strategy for the Sepik-Ramu (Coates 1992).

What are the consequences of making a mistake? Through the procedures adopted one can retort by asking for a quantification of the term 'mistake' and that the option of not introducing may result in a greater potential negative impact. By following a code of practice one can also ensure that actions are at least responsible and that the best attempt to tackle a problem was made under a consensus of scientific advice. If fish introductions into the Sepik-Ramu do not have the anticipated impacts, it will be the result of the inadequacies of the science that supports the conclusions drawn, not a lack of caution on behalf of those involved.

Despite the considerable literature on aquatic species introductions there has been limited utilitarian outcome. A notable exception is the code of practice regarding aquatic species transfers (Turner 1988). The improvement and wider adoption of such codes has already been advocated (Coates 1992). There is

certainly a need for increased practical assistance from the scientific community, particularly through improving the understanding of the inter-relationships between alien and native biota. There is also a need for a wider understanding and appreciation of the environmental consequences of all human actions.

Finally, one must applaud the responsible approach to fish introductions taken by the Papua New Guinea government. The extent to which evaluations have been supported reflects a genuine desire for sustainable and appropriate development, in the face of limited facilities, seemingly insurmountable obstacles and, occasionally, ambiguous criticism.

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## NOTES

1 A broad definition of 'exotic' is used here to mean any species introduced from outside its natural range irrespective of political boundaries.

2 To indicate the scale of the issues in question: the potential increase in fish production from the Sepik-Ramu basin through fish introductions, i.e., about 55,000 t $yr^{-1}$, is in the region of twice the current level of national imports of tinned fish.

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# Three Recycling Industries in Hong Kong: Market Structures, Vulnerabilities and Environmental Benefits

*Evita So Yeung and James N. Ness*

## ABSTRACT

Current private sector (non-subsidized) recycling practices in Hong Kong with respect to waste paper, aluminium cans and plastics were investigated through telephone interviews and personal visits to firms operating in the recovery businesses and recycling plants. The waste recovery and recycling activities in Hong Kong in these selected areas are relatively extensive but the full potential of recycling is not being realized. The major economical, attitudinal, technical and other constraints to further recovery and recycling are identified and discussed.

***Key Words:*** *recycling, private sector, conservation, Hong Kong*

## INTRODUCTION

Rising standards of living and the associated increased consumption of consumer goods lead to increasing levels of wastes in society. While the production of goods results in the production of wastes and other emissions detrimental to the environment, the impact of the product at the end of its functional life must also be of concern to producers, end users and governments; producers because increasingly they are being confronted with the realization that product design can have a significant impact on disposal or recovery of the material in the product, end users because they must deal with the immediate problem of disposal of a product at the end of its life, and governments because they need to deal with the pollution and environmental consequences that result from this disposal. There are a number of options available for dealing with the problems of increasing quantities of waste. These options include waste reduction, product reuse, recovery and recycling of the material, energy extraction and landfill. In this paper we address the recycling option.

Recycling can make a significant contribution to the solutions for many environmental problems. With recycling, wastes are regarded as raw materials which can be reprocessed into the same or alternative products. This reuse of the material reduces the demands on natural resources, the demand for landfill space, and the extent of litter.

Recycling involves a number of distinct steps common to most materials being recycled. These steps consist of collection, separation, processing and reuse. The details of these steps, however, are specific for the different materials so that the recycling of waste requires treatment suitable for each individual type of waste. In this paper we consider the recycling activities for three types of materials in Hong Kong: aluminium, paper and plastics.

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## METHODOLOGY

Because of the diversity of materials that may be recycled and the many options that are possible, the scope of this study was limited to waste recovery by extraction from the various waste streams in Hong Kong. The possibilities of energy recovery by incineration or conversion recovery by chemical or biological processes were excluded from the study. The three materials chosen for the study were paper, aluminium (as aluminium cans) and plastics. Paper waste is the second largest constituent of urban refuse (EPD 1989). Aluminium is an attractive recyclable material with aluminium cans being relatively plentiful and attracting a high price per tonne. The plastics industry is a significant industry in the manufacturing sector of Hong Kong's economy. Also, plastic bags, packaging and other plastic objects are a common and very visible component in litter and household refuse.

Data were obtained from the following sources:

- published data, reports, documents;
- government publications and government officers;
- telephone contact and personal visits to firms and individuals working in the recovery business and recycling plants; and
- telephone survey of the public

The field data were collected from June to September 1991. Further details are given in Yeung (1992).

## OVERVIEW OF INDUSTRY STRUCTURE

In Hong Kong the recycling activity is export oriented. It is largely confined to the collection and separation, and the recyclable material is then exported for further processing. Nevertheless, there is some local processing and use of recycled products of paper and plastics.

### Participants

The salvage industry in Hong Kong has in general three strata in terms of participants: the scavengers, small salvage dealers and the secondary material processors (Figure 1).

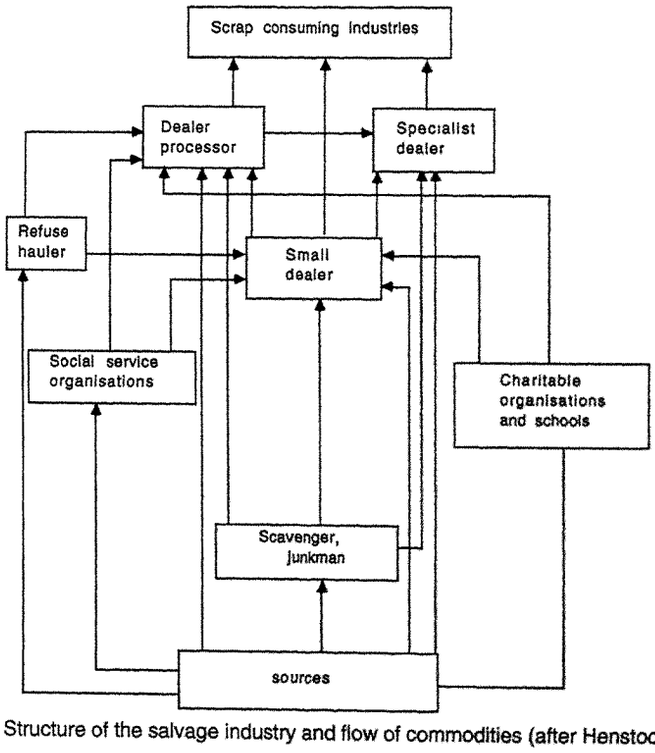


**Fig. 1** Structure of the salvage industry and flow of commodities (after Henstock 1983)

The scavengers include the refuse collectors (who remove the paper and other valuable materials such as aluminium cans from the collected wastes), and the so-called 'rag-pickers'. The latter are mostly elderly people who 'sift through' the litter bins and refuse collection points near markets, shops, supermarkets or on the beaches. From observation, the types of materials recovered by them are mainly carton boxes, aluminium cans and pieces of plastic film. The scavengers are independent operators, not associated with any company; they support themselves, wholly or partially, by selling the recovered waste materials to small salvage dealers.

The small salvage dealers are the next tier. In addition to getting waste paper from scavengers, some of the small salvage dealers also obtain waste paper from industrial sources, mainly printing works and paper products factories. They usually work on a contract basis using their own labour and transport. Some dealers collect from the factories daily. Others operate on a toll basis and will collect from the factories only when sufficient waste paper has been accumulated; this will economize on the collection costs. The implementation of door-to-door collection depends on the size of the business and its location relative to the sources. Small-scale dealers employing one or two labourers and located near the market depend solely on the scavengers for their waste paper. However, door-to-door collection is not practised for aluminium cans and plastics. The small salvage operators carry out simple processing such as baling of the collected and separated waste paper, aluminium cans and plastic film.

The last stratum, the secondary material processors, include the recycling operators and the salvage exporting companies who have extensive connections with the overseas processing industries. They are responsible for the export of the collected, sorted and baled materials.

With the increased awareness of environmental protection among the public, the social service and voluntary organizations also play a supplementary role in the recycling industry structure. For example, schools, community centres and environmental groups have organized collection programmes for old newspapers, other paper wastes and aluminium cans.

## Market

Most of the baled waste paper is sold to the exporting companies who in turn sell and deliver them to the processors in other countries, usually in Southeast Asia. A minority of small salvage dealers sell the baled waste paper directly to the local paper manufacturing factories. It is estimated that about 90% of the waste paper collected in Hong Kong is exported. The export statistics for waste paper and paperboard are set out in Figure 2.

There are four factories in Hong Kong that process 100% recycled paper. The principal products from these factories are paperboard, industrial packing and corrugated paperboard.

Unlike waste paper, all the collected aluminium cans from the small salvage dealers will be exported through the salvage exporting companies since there

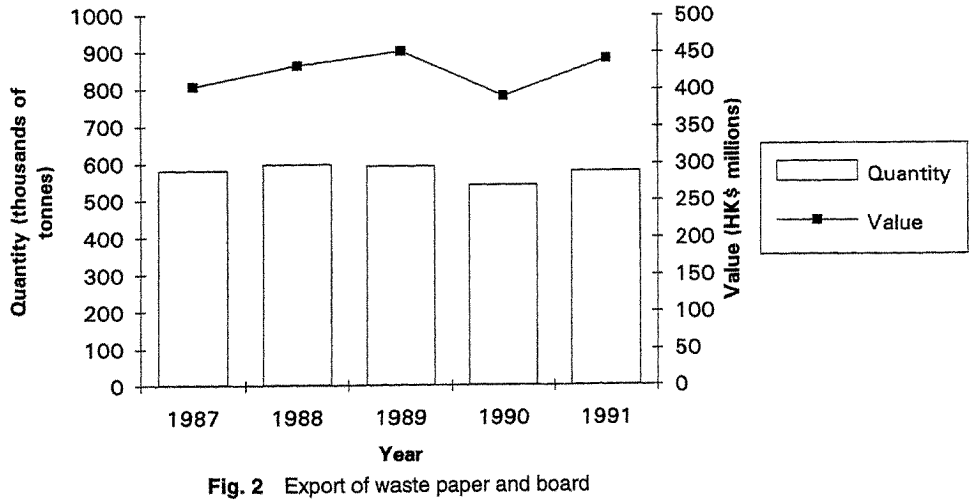


**Fig. 2** Export of waste paper and board

is no company producing aluminium cans in Hong Kong. The export statistics for aluminium scrap (see Figure 3) include in-plant scrap, engine components, consumer durables and miscellaneous aluminium products.

The export statistics for plastic waste and scrap are given in Figure 4. However, compared with the situation for paper and aluminium, the operators in Hong Kong's plastic recycling industry play a more significant role. There are at least 100 recycling firms engaged in the processing of plastic waste (Lai 1990). They buy the plastic waste from scrap dealers or collect the rejects and cuttings from the local manufacturers of plastic products. Some of the firms also buy the post-industrial scrap from other countries such as Japan and the United States. The scale of operation for individual firms is small, often being less than 100 tonnes per month. The end product is the recycled plastic pellets which are sold either to local firms in the plastics conversion industry or overseas as part of the raw material for manufacturing plastic wares or packaging materials such as plastic bags.

The use of post-industrial plastics waste is significant as this is the cleanest and therefore most valuable of the plastics wastes. Other sources of plastics waste such as post-commercial and post-consumer waste are less valuable as they are

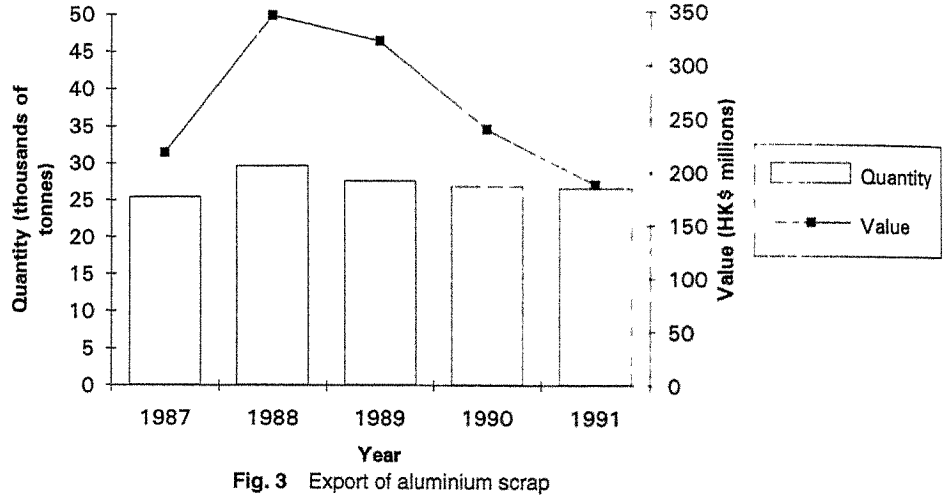


**Fig. 3** Export of aluminium scrap

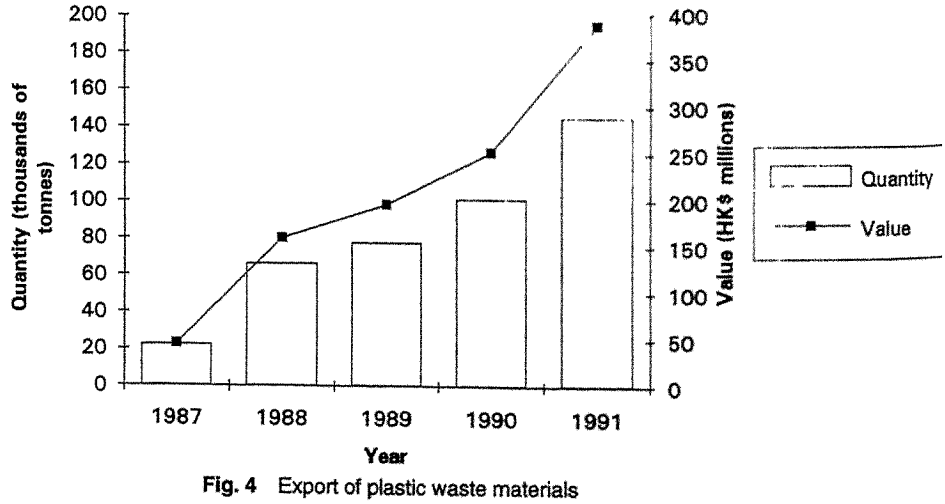


**Fig. 4** Export of plastic waste materials

contaminated by other materials or are a mixture of different types of plastics. This makes them less attractive for recycling as it involves additional costs for collecting, sorting and cleaning.

China is the largest market for plastics waste and waste paper, while Japan is a major purchaser of aluminium scrap (Hong Kong Trade Statistics, 1987–1991).

## Environmental Benefits

Wastes pose a variety of environmental problems. To minimize the impact of wastes on the environment, resources must be used in the treatment, containment and storage of wastes. Recycling is part of the solution to the problem of solid wastes as recycling is an effective means for reducing consumption of raw materials, reducing energy consumption and minimizing the quantity of solid waste going to landfills. The environmental benefits that can be obtained from the recycling of the three materials considered here are discussed below.

## Savings in Scarce Raw Materials (Including Energy)

For non-renewable resources that are in relatively short supply, recycling provides a means of extending the availability of the material. For example, the world's reserves of bauxite have been estimated to be $1.06 \times 10^9$ tonnes. At the current rate of consumption, these reserves will last for about 100 years (Bridgwater and Mumford 1979). Recycling of aluminium can effectively extend the life of the bauxite reserves. The recycling of plastics in significant quantities would reduce the demand for virgin polymers and thus the consumption of petroleum and natural gas, the ultimate raw materials for plastics.

For renewable resources the balance between consumption and replacement is important. If the resource is not being renewed at a rate high enough to replace consumption, then ultimately the renewable resource will not be renewable. For resources that have a long production cycle as in the growth of trees, the recycling of the product reduces pressure on the resource and can allow the resource to regenerate. Recycling is also beneficial where a temporary scarcity exists or is anticipated. Thus the recycling of waste paper reduces the need to harvest timber reserves. From one tonne of waste paper, 850 kg of waste paper pulp can be produced. This quantity of pulp corresponds to about twenty 8 m high standing trees with a bottom diameter of 14 cm (Clean Japan Center 1989).

The recycling processes consume energy, but for many materials the energy used in the recycling process is much less than that needed to obtain the material from its natural resource. The recycling of reclaimed aluminium cans immediately obviates the mining and processing of bauxite, and the recovery of aluminium from the alumina. The energy saving for aluminium recycling can be up to 97% due to the high electricity consumption in extracting aluminium from bauxite. It has been estimated that a saving of 23% to 74% of the energy consumption can be achieved in recycling paper compared with producing paper from trees (Letcher and Sheil 1986).

## Impact of Recovery on Environmental Pollution

The processing of both reclaimed and virgin materials can have adverse environmental impacts as all conversion processes produce waste and other emissions. Hence it is the net reduction that is important when comparing recycling of materials with the processing of virgin materials.

As an example of the environmental benefits that may be obtained by recycling, the remelting of one tonne of aluminium can reduce emission of air-polluting aluminium fluoride by 35 kg compared with extraction from alumina. Producing recycled paper creates up to 74% less air pollution and 35% less water pollution than producing paper from virgin fibres (Table 1).

**Table 1**
**Environmental benefits derived from substituting secondary materials for virgin resources**

| *Environmental benefits* | *Aluminium* | *Paper* |
|---|---|---|
| Reduction of: | | |
| Energy use | 90 – 97% | 23 – 74% |
| Air pollution | 95% | 74% |
| Water pollution | 97% | 35% |
| Water use | – | 58% |

Source: Letcher, R.C. and M.T. Sheil. 1986. Source Separation and Citizen Recycling. In *The Solid Waste Handbook*, ed. Robinson, W.D. New York: John Wiley & Sons.

### Cleaner Environment With Proper Collection of Waste

Careless discarding of wastes to which the end user or manufacturer attaches no value can result in the problems of litter and destruction of natural beauty of the environment. By valuing wastes as a resource the problems of litter can be reduced as there is then an incentive to collect rather than discard the materials.

### Reduced Pressure on Landfills

The removal of solid wastes from the waste stream reduces the volume of material that has to be disposed of in landfills. This is important in a society such as Hong Kong where land is a comparatively scarce resource and therefore expensive. The amounts of paper and plastics in the urban refuse stream of Hong Kong have been estimated at 18% to 22%, and 16%, respectively, on a mass basis (Walker 1990). On a volume basis the plastics waste would occupy a much higher percentage of the landfill space. The removal of paper and plastics from the waste stream would represent a very significant savings in landfill usage and transportation cost to the landfill sites.

Some of the environmental benefits noted above apply on a global rather than local scale. For example, since Hong Kong does not mine or process bauxite the energy savings and reduced emissions associated with the reprocessing of aluminium would not apply locally. Nevertheless, the contribution to the reduced consumption of world reserves is beneficial from a global perspective.

## FINANCIAL ISSUES IN PRIVATE SECTOR RECYCLING

There has been a long history of recycling/recovery activities in Hong Kong. The recovery of ferrous metals and steel has long been practised. Glass recycling was once an active business but is now declining. The survival of any sort of recycling industry depends very much on its financial viability The costs of recovery and revenue for firms in the three recycling industries will be presented. These cost figures were based on data collected by interviewing firms and case studies during the period of the investigation. Further details are given in Yeung (1992). In particular the analysis concentrated on the waste paper and aluminium cans recycling as the small salvage dealers play a prominent part in the functioning of those industries. The costs of recovery include both the initial collection and recovery from the waste stream and any further treatment needed to make the material usable in a particular way. For aluminium cans and paper this is the collected material. For plastics the end product is the reprocessed plastic in pellet form.

Table 2 shows the estimates of the cost per tonne in recovering each of the three materials — paper,

**Table 2**
**Summary of the costs of recovery**

| *Form of reclaimed material (recovery route)* | *Other materials recovered simultaneously* | *Approx. cost of recovery per tonne of waste (HK$)** | *Amount of waste lost in recovery by weight* | *Approx. cost of recovery per tonne of materials recovered (HK$)* |
|---|---|---|---|---|
| Paper feedstock for paper board etc. (misc. paper via sorting & baling) | Aluminium cans, plastic films, ferrous metals, copper | 429 – 629 | 3% | 430 – 640 |
| Aluminium cans for recycling | Paper, plastic films, ferrous metals, copper | 3000 – 5000 (0.07/ea. – 0.10/ea.) | neg. | 3000 – 5000 |
| Plastics pellets for plastic products | – | 3600 – 5600 | 10 – 15% | 4000 – 6590 |

Source: Calculations based on the cost data obtained during interviews.
*HK$1 = US$0.13

aluminium cans and plastics — from waste. The figures given are based on existing levels of costs and material prices obtained during the study. All plant and vehicles are assumed to have an operating life of 20 years and 5 years respectively. Straight line depreciation to zero salvage value over the assumed life time has been used.

It must be emphasized that the figures calculated for costs and values should be seen as being indicative only. The costs of recovery and value of the reclaimed material as a substitute for virgin material vary greatly depending on the actual situations in which the material arises and how it is to be used. For instances, the recovery of plastic waste from commercial sources is more difficult and expensive than recovery from waste from industrial sources. The value of the product is less because of the possibility of contamination with other plastics or non-plastics. The precise type of product being manufactured also makes a difference. Therefore, it is not easy to generalize about costs and values of recycling and the figures given are in the form of quite wide ranges, reflecting actual experience.

The value of the reclaimed materials (paper, aluminium cans and plastics) are listed in Table 3 and these can be compared with the corresponding costs in Table 2. Given that firms do exist and continue to operate in these recycling industries, it can be presumed that the recycling operations are profitable. Indeed, it can be seen by reference to Tables 2 and 3 that there is a net profit for the three recycling industries. In other words, they are financially viable under the stated limitations. However, the profit margin is not wide and the vulnerability of all three industries to fluctuations in the price of competing materials or increase in cost factors is evident. In particular, the additional costs associated with materials that are difficult to collect or separate means that such materials will not be included in the quantities being recovered. Thus the full potential for recycling is not being realized.

**Table 3**
**Value of Reclaimed Material**

| *Material* | *Value (HK$/tonne)** |
|---|---|
| Paper | 700 – 800 |
| Aluminium cans | 3500 – 5500 |
| Plastics | 5500 – 7700 |

Source: interviews
*HK$1 = US$0.13

## BARRIERS TO INCREASED RECYCLING

An industry can continue to survive only if those who participate receive adequate rewards for their inputs. In the case of recycling, a number of independent decision makers are involved. These are: the manufacturers, the scavengers and scrap dealers, the consumers and the government. People in each group must obtain net benefits from participating in the recycling of materials.

The scavengers and scrap dealers will continue to participate in the industry if the monetary rewards for their labour are judged to be adequate. There must be a demand for the collected waste at a suitable price. However, since the recycling industry of Hong Kong is export oriented it is very much dependent on demand in the overseas markets and is therefore vulnerable to the market forces in those countries. Fluctuations in commodity prices and exchange rates add further uncertainty to the situation since both these factors affect the price of virgin materials in competition with the recycled material.

Consumers can have a considerable impact on the economics of the recycling for some materials. Separation of wastes would reduce the cost of collection and separation to the scrap dealers. But this requires some effort by and causes inconvenience to the consumer. People may participate for monetary incentives such as deposit schemes on certain products or because of environmental values. However, source separation requires the ability to identify the different materials and this is difficult with some waste materials, especially the different types of plastics.

If consumers demand products that are more easily recyclable or if consumers can return wastes such as packaging materials to the manufacturer or the point of sales, then manufacturers will respond by designing products and processing systems that make recycling more economical. These actions imply an increased environmental consciousness on the part of consumers.

For manufacturers, the decision to recycle or dispose of wastes depends on their assessment of the economics of the two options. Government regulations and landfill charges influence such costs and therefore decisions. Larger firms will also consider their public image and recycling may be of assistance in building consumer goodwill.

Governments can promote and encourage recycling activities by various actions including

legislation, incentive schemes, subsidies, promotion of technology development and transfer, and provision of information. Areas for possible government initiatives in promoting recycling were set out in the Hong Kong government's 'White Paper: Pollution in Hong Kong — A Time to Act', 1989.

Government initiative may be necessary to increase the extent of recycling in Hong Kong. Consumers and manufacturers would then follow. In a small telephone survey done in conjunction with this study, 90% of the public respondents said they would cooperate with voluntary separation of wastes if given the lead by the authorities and if the system was convenient (Yeung 1992). Examples of convenient measures include locating collection centres close to homes and providing plastic bags for plastic wastes. In a trial study of public involvement in the collection of plastic wastes at a housing estate in January 1991, 71% of the households participated. (Chong 1991). However, many small-sized waste producers (manufacturers) indicated reluctance to participate in voluntary waste separation schemes. Their prime concern was the removal of wastes from the premises rather than considering alternatives to disposal or the possibilities of recovery. One problem most manufacturers face is shortage of space; allocating valuable work space to the separation and storage of wastes is not acceptable to them.

Another difficulty for recycling is the acceptability of products made from reclaimed materials. Market penetration with products made from recycled materials is often difficult, mainly because the recycled material is seen to be of inferior quality compared to the virgin material. Markets for such products would need to be established and products that can effectively use recycled materials without any loss of functionality or performance developed. Paperboard and similar products manufactured from recycled paper are successful to a certain extent.

## Market Supply

The continued functioning of the recycling industries requires the existence of a recycling infrastructure. This is essential in the supply of materials. Manufacturers can be expected to switch to using recycled materials as inputs only if there is a reliable supply of materials of the quality suitable for the reprocessing operations. The dealers and exporters depend on obtaining adequate quantities from the industrial and trade wastes and, to a lesser extent, the other waste streams. The availability of many recycled materials is not always steady and the supply of such raw materials to the waste dealers is erratic

## Technical Difficulties

Difficulties with the use of contaminated wastes and the problems of separation and cleaning restrict the use of materials in mixed wastes. Thus a considerable proportion of recyclable materials in a society's waste streams cannot be recovered once they enter the mixed municipal wastes. For this reason most of the scrap dealers in Hong Kong tend to concentrate on the waste material from industrial and trade sources.

Sometimes the materials themselves present particular barriers to recycling. This is so in the case of plastics where there are dozens of different thermoplastics and hundreds of different grades of varying properties and formulations containing additives such as anti-oxidants, fillers, pigments, stabilizers and processing aids. There are difficulties with separating such plastics when they become mixed as in post-commercial and post-consumer wastes. There are also limitations to the processing and use of mixed thermoplastics. Although some processes capable of handling mixtures of certain types of plastics have been reported (Chemical Engineering 1990), such processes do not seem to be used in Hong Kong.

## Other Obstacles

The scrap dealers in Hong Kong face a number of other obstacles which inhibit the expansion of the recycling activities. The secondary materials industry has not traditionally used sophisticated management techniques. During the interviews it was noted that most of the small salvage dealers engaged in the collection of waste paper and aluminium cans do no business planning. Since wastes are dispersed widely, the acquisition of wastes for recycling is a costly operation and labour intensive. Small salvage dealers have difficulty attracting labour into the industry.

The high price of land in Hong Kong restricts the recycling operations for the salvage dealers and the processors. Plastics have low bulk densities, so the storage of plastic scrap requires large volumes. Some small salvage dealers revealed that they often

have to store the collected waste paper or aluminium cans on the street outside their premises. Due to shortage of space, dealers are unable to hold stocks to take the best advantage of the spot market prices for scraps.

## CONCLUSION

The waste recovery and recycling business is active in Hong Kong. However, the cycle is not complete as most of the collected material is exported and not processed locally. China is the major market for exported recycled materials.

Small scrap dealers and scavengers play a significant role in the collection of the various materials from waste. The preferred sources of waste are the industrial and trade wastes.

Reprocessing of waste paper and good quality plastic scrap is done in Hong Kong. Development of markets for appropriate products is considered necessary if further expansion of reprocessing is to occur.

The expansion of recycling activities in general is restricted by a number of factors including technical problems in the collection and separation of some types of wastes, lack of knowledge and management skills in the small scale dealers, investment costs in reprocessing machinery and general uncertainties in the economics of recycling, lack of a comprehensive recycling infrastructure and attitudinal factors of manufacturers and consumers. Government action will be needed to stimulate the expansion of recycling activities in Hong Kong.

## ACKNOWLEDGEMENTS

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Evita So Yeung is an employee of the Hong Kong Government, but the views expressed in this paper are her own and do not necessarily reflect those of the Hong Kong government.

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INSTITUTIONAL PROFILE*

# Centre of Urban Planning and Environmental Management The University of Hong Kong

## BACKGROUND

The Centre was originally established in 1980 as the Centre of Urban Studies and Urban Planning, its remit being to teach masters degree programmes in urban studies and urban planning and to act as a focal point for urban research within the University of Hong Kong. In the late 1980s, the Centre changed its title to reflect more accurately its evolving academic and professional emphases. The new Centre of Urban Planning and Environmental Management came into existence on 1 January 1991. The Centre has eight full-time teaching staff and is located in the Knowles Building on the main campus of the University on Hong Kong Island.

## ACTIVITIES

The Centre's activities are grouped under four headings: teaching, research, consultancy and training services, and academic exchanges.

### Teaching Programmes

Teaching activities relate to three taught masters degree programmes and a rapidly growing doctoral training programme. The Centre offers the only professional urban planning programme in Hong Kong. The degree is fully accredited by both the Hong Kong Institute of Planners (HKIP) and the Royal Town Planning Institute (RTPI) of the United Kingdom. This programme is offered on both a full-time and part-time basis. In 1992-93, some 90 students are registered for the M.Sc. (Urban Planning) degree. The Centre also coordinates and makes a major teaching contribution to the University's interdisciplinary M.Sc. (Environmental Management) programme, which was first offered in 1989. The objective of this programme is provide training for specialists in the environmental field in both government and the private sector. This is a part-time degree for which approximately 60 students are currently registered. In 1992, the Centre launched another part-time programme, the Master of Housing Management (M.H.M.) in collaboration with the School of Professional and Continuing Education and the Faculty of Social Science. Some 25 students registered in the first year of this new programme. The Centre's doctoral programme has grown substantially in recent years and there are now 14 registered candidates, from Hong Kong, China, Malaysia and Italy. These students are working in various areas, including the use of land information systems in urban planning, energy-environment issues in Hong Kong and China, economic aspects of environmental policy in Hong Kong, methodologies for environmental impact assessment, sustainable development, urban transport planning and housing policy in Hong Kong.

### Research

The Centre continues to function as a focal point for urban research in The University of Hong Kong but its research programme now incorporates a strong environmental management dimension as well. Major research themes of the Centre include regional development issues in China, urban transport planning in developing countries, urban planning

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methodology, environmental policy analysis in Hong Kong and Asia, and housing policy issues. The Centre publishes occasional research monographs and an internationally circulated Working Papers series.

## Consultancy and Training Services

The Centre is also increasingly active in the field of consultancy and training services. It has undertaken various consultancy commissions in Hong Kong on local area planning and various other fields. It is also providing a number of training programmes in such areas as environmental impact assessment, transport planning and the use of computer systems in urban planning. These programmes are largely intended to meet the needs of local professionals for Continuing Professional Development (CPD) activities but international training courses and seminars have also be organized. Centre staff have undertaken consultancy assignments for various international agencies and institutions including the World Bank, the Asian Development Bank, the United Nations Economic and Social Commission for Asia and the Pacific, the United Nations Development Programme, the Asian and Pacific Development Centre, USAID, and the U.S. Department of Energy.

## Academic Exchanges

Finally, the Centre functions as a focal point for academic and professional exchanges in the urban and environmental fields in the wider regional context. It is active in promoting and hosting international conferences and symposia as well as academic visitorships. The Centre has extensive contacts with similar departments and units around Asia and further afield in Europe, North America and Australasia. The Centre has an active exchange programme with academic and governmental institutions in China and is currently expanding this aspect of its work to foster greater academic interchange within the region as a whole.

## Further Information

Those wishing to obtain further information concerning the Centre, its research and consultancy activities and teaching programmes, should contact:

The Executive Officer
Centre of Urban Planning and Environmental Management
The University of Hong Kong
Pokfulam Road
Hong Kong
Tel: (852) 859-2721
Fax: (852) 559-0468

INSTITUTIONAL INITIATIVE*

# The Freshwater Imperative (FWI)

## BACKGROUND

The Freshwater Imperative (FWI) grew out of the concerns of an ad hoc group of scientists from the United States federal agencies about how to sustain freshwater systems in the changing world. The intent of this group is to foster enhanced communication, collaborative research and decision-making capabilities. The goals of the FWI are to provide a predictive understanding of inland aquatic ecosystems and resources as these relate to global environmental changes, and to devise plans for research leading to sustainable freshwater systems.

## ORGANIZATION AND OUTREACH

The FWI Coordinating Council holds regular meetings to exchange information and ideas on freshwater issues among scientists from U.S. Federal agencies, and to discuss, plan and implement projects leading to sustainable freshwater systems.

Recognizing that sustaining freshwater systems requires a global cooperative effort, the FWI group is extending its efforts to cooperate with other international unions that share its concerns and to jointly seek ways to sustain the earth's precious freshwater systems and resources.

Persons wishing to learn more about the Freshwater Initiative and interested in discussing possibilities for collaboration may contact either of the following:

Dr Penelope Firth
Chairperson
Committee on Earth & Environmental Sciences
Subcommittee on Water Resources (CEES)
National Science Foundation
1800 G St. N. W.
Washington D.C. 20550, USA
Tel: (USA) (202) 357-7353
E-Mail: pfirth@nsf.note.gov

Executive Secretary
Dr William Y. B. Chang
Division of International Programs
National Science Foundation
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# 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).

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# ASIAN

## *Journal of Environmental Management*

*Volume 1 Number 2 November 1993*

# International Editorial Board



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# ASIAN
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## Contents



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# From the Editor

This second issue of the *Asian Journal of Environmental Management* (*AJEM*) continues and extends the topical and geographical coverage begun in our inaugural issue. Like the first issue, the authors included here come from a variety of institutional settings, including academia, government, and research institutions.

Three of the papers (those by Sansanee Choowaew, W.Y.B. Chang, and J.J. Kao et al.) deal with management issues of wetlands and riverine systems in continental Southeast Asia, the People's Republic of China, and Taiwan respectively. A.T.H. Chin's paper addresses marine pollution management issues in the Malacca Straits. J.M. Nash describes efforts to monitor and limit environmental impacts on both the marine environment and adjacent urban areas stemming from reclamation work in Hong Kong, the world's largest on-going reclamation programme. Like Hong Kong, much of the region is experiencing extraordinary economic growth — typically with considerable impact on the environment. The papers by V. Setty Pendakur and L.J. Hill deal with two of the most important sources of these impacts — transport and the electric power sector respectively, with Pendakur using Bangkok and Mexico City to illustrate transport problems and options and Hill using Hainan Province, China, to identify opportunities for reducing power sector impacts on the environment.

One of the purposes of *AJEM* is to promote dialogue on environmental management issues within the region. *AJEM* encourages readers to comment on articles published by sending in Letters To The Editor or somewhat more detailed Commentaries on Previously Published Papers. This issue of *AJEM* includes a commentary by R.D. Hill on S.T. Mok's paper 'Sustainable Forest Management and Development: A Southeast Asian Perspective'.

*AJEM* is also pleased to include Institutional Profiles on the recently created Thailand Environment Institute and on The Center For Resource and Environmental Studies of the University of Hanoi. We welcome submissions of profiles from appropriate institutions within the region and from those elsewhere with a strong focus on the Asian environment.

Finally, we present a new information feature, Commercial Environmental Information Sources. Because environmental data are often expensive to collect and analyse, commercial sources can play vital roles in supplementing publications from governments and those from not-for-profit organizations. Although such descriptions do not constitute an endorsement by *AJEM*, we believe it is useful to inform our readers about the availability of such commercial information services. Included here are descriptions of environmental information services from the Environment Business Group (Bangkok, Thailand) and The Economist Intelligence Unit (Hong Kong).

Bill Barron
Editor

# 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.

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**COMMENTARY ON A PREVIOUSLY PUBLISHED PAPER**

*AJEM* invites comments on previously published papers. These may be in the form of a short (up to 500 words) **Letter to the Editor**, or à longer more detailed **Commentary on a Previously Published Paper** (up to 1500 words) such as that by R.D. Hill which follows.

# Sustainable Forest Management and Development in Southeast Asia: Contributions to a Debate

*R.D. Hill*

In the Spring 1993 issue of *AJEM* (pp. 21–8) S.T. Mok raised a number of basic policy issues which he addresses from 'a Southeast Asian perspective'. In the course of so doing a number of matters emerge which might benefit from additional comment.

In the region generally, there is, as Mr Mok notes, little consensus as to what, exactly, comprises 'forest'. Yet arguably, some consensus is essential to sustainable management. While it is true that formations within (as yet undefined) 'forest' are '. . . dependent upon local conditions of soil, topography, climate and ground water . . .' (p. 22), it is also true that they are dependent upon their previous history, especially that of human impacts. Thus, in areas of shifting cultivation, seral vegetations where there is a long fallow period (perhaps 30 years or more), are quite unlike those where fallows are so short or fires are so frequent that few woody species survive. Such differences may also exist in areas where *Imperata* or other grassy wastes are so extensive and seed-carrying animals are relatively few that regeneration of woody vegetation is a matter of decades rather than years, even if fire can be suppressed and cultivators excluded. Yet in legally-designated forests and outside them such areas abound.

Can it be argued that such areas should be protected from agricultural encroachment for the rather long periods needed for normal regeneration? Incidentally, as has been the case for more than a century, shifting cultivators have often been castigated with the same brush as having unsustainable farming systems necessitating help to assist them to adopt sustainable land use (p. 25). Yet at low population densities and with adequate regrowth on abandoned clearings, shifting cultivation is sustainable.

This is not to say that in areas of shifting cultivation where degradation of the vegetation (one hesitates to use 'forest') exists that nothing can be done except at the point of a gun. It was colonial foresters who introduced the *taungya* system to Burma and parts of northern Thailand. This involved planting teak (*Tectona grandis*) on abandoned clearings, thereby raising total production and creating modest wealth for the people (and much more for powerful logging interests). That system was and is sound and sustainable for all its colonial origins, so long as population densities do not rise or income levels fall to the point at which the need to provide food leads to overly intensive land use. Similarly, in Sarawak significant areas have been planted to rubber by shifting cultivators, apparently

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without much intervention by government officials. As the areas available for food production have diminished, so villagers have shifted to foods purchased from the proceeds of their rubber. The only fly in the ointment has been the fact that a fair proportion of the planting material was relatively low-yielding seedling rubber, government seemingly being unable to assist a spontaneously-occurring process by providing or assisting access to high-yielding clonal planting material.

With regard to rubber and other perennial tree crops, qualifications are needed to Mok's statement that these '. . . are no different from the monocultural stands of trees in temperate forests' (p. 24). For one thing a stand, say of *Pinus sylvestris*, normally contains juveniles whereas a stand of rubber or oil palm usually does not. Under tree-crops the ground cover is deliberately maintained at low levels. Where the canopy is fully closed, as in mature rubber, little soil-surface cover exists and because decomposition is rapid, the litter is thin and on steeper slopes may scarcely be found. In such circumstances the respective ecosystems are rather different, especially in respect of the mobilization of sediment by rain-drop impact and surface wash. Other things being more or less equal, sediment yields from areas under perennial tree-crops are likely to be significantly higher than from single-species stands in temperate lands as well as being higher than from undisturbed tropical forest.

Mok speaks (p. 23) of '. . . eurocentric forestry imbued with European ideals, philosophies, principles and practices based on the timber-oriented concept of sustained yield [which] proved to be inappropriate and ineffective in achieving sustainable forest management and development or in slowing down the rapid decline of tropical forests. . . .' While it is true that logging enormously accelerated under governance by the European powers (p. 23), that was an accompaniment to Southeast Asia's incorporation into the global economy. What is more to the point is that subsequently, environmentally-damaging logging methods involving heavy machinery, the widespread cutting of roads and drag-paths replaced the colonial-period methods. The colonial-period methods were highly selective in that the market demand was for a very limited range of species and based substantially upon human and animal labour. That environmental damage was not severe using those 'traditional' methods is evidenced by the fact that some such areas logged during the colonial period, have since been successfully logged again in post-colonial times, sometimes more than once.

It is true that there was and continues to be inadequate understanding of the complexities of forest ecology. (If I recall correctly, it was not until the late 1940s that the Malayan Forest Research Institute, for example, appointed a specialist forest ecologist). But such ignorance was by no means confined to tropical forests. There were, and there remain in any case, powerful political and economic interests which were and are opposed to all but the most rudimentary forms of management. Indeed, it is important to remember that the perception of the value of forests throughout the world has changed radically from that prevalent in the last century. Until relatively late in the last century in lands under European settlement or exploitation forests were typically regarded, not as an asset but as an impediment to development. This was so in the U.S., Canada, Australia and New Zealand as well as in tropical regions. The supply of forests seemed inexhaustible. It is also important to recognize that governments in these lands were basically in no position to do much more than legislate against further uncontrolled deforestation once it was realized that forests were not inexhaustible and played valuable ecological roles. In Malaya, for example, it was not until the great Pahang flood of the mid-1920s that serious attention began to be given to the possible environmental consequences of forest clearance.

Overall, it seems unnecessary to point the finger at earlier generations of foresters and administrators and retroactively to apply to them the standards of the 1990s. What is useful is to point out, as Mok does, that unplanned deforestation proceeds apace.

This leads to the question of appropriate interventions in the interests of sustainability. These in turn are embedded within a complex matrix of social, economic, moral and political issues at the macro level. For example, under certain circumstances, it may be appropriate to lock away managed forests from even limited use by local peoples. The fear is not only that extraction of anything at all would be damaging to the forest, but also that by permitting any such uses, political claims might be revived leading eventually to settlement and actual ownership. Such fears are perhaps justified, as the current situation in Northeast Thailand demonstrates. Yet, while Mok lists a series

of management needs, practical issues of implementation are not addressed in his paper. For example, how is it possible to bring unplanned deforestation under control? By using military force? But in some areas the military are the agents of deforestation. And who would pay? Can governments, as a matter of practical politics, prevent hungry people cutting forests? Should they?

Rehabilitation of logged and now abandoned land is by no means an easy task. As recently as two years ago rehabilitation by planting softwoods was, at best, economically marginal though that situation seems to have changed. But entrepreneurs contemplating such plantings face formidable challenges. Rights to use such lands may be difficult to acquire. Infrastructure scarcely exists. Competition with large, established softwood growers in North America, Scandinavia and New Zealand is likely to be fierce. One may agree that plantations for pulp and timber should be expanded, but they will only be so if the price is right. One may agree that forest practices should be socially, culturally, ecologically, environmentally and economically sustainable. But who pays? Who enforces?

In the development process the possession of forests can be conceived as 'money-in-the-bank'. It is reasonable that developing countries should draw upon that capital in order to build infrastructure or to place it in more remunerative sectors. What is important is fully to establish the costs and benefits of doing so. A basic issue is where has the capital represented by the region's forests gone and where is it going. Is it leading to sustained economic growth or is much of it merely finding its way into consumption and the pseudo-investment of real estate?

# Inventory and Management of Wetlands in the Lower Mekong Basin

*Sansanee Choowaew*

## ABSTRACT

Wetlands are significant ecosystems in the Lower Mekong Basin, and they have important physical, ecological and socio-economic functions and values. Over-exploitation, reclamation and mismanagement of these wetlands without a full understanding of their dynamic nature have triggered environmental and socioeconomic consequences. In order to achieve sustainable utilization of Lower Mekong Basin wetlands, and to maximize the benefits from them accruing to the region's inhabitants, development of a wetland inventory combined with formulation of environmentally-sound management strategies in all four riparian countries (Cambodia, Lao PDR, Thailand and Vietnam) is essential.

A programme entitled 'Inventory and Management of the Wetlands in the Lower Mekong Basin' was implemented in 1990 as one of the sub-programmes of the Environment Unit within the Technical Support Division of the Mekong Secretariat, the executing agency of the Interim Committee for Coordination of Investigations of the Lower Mekong Basin. This paper describes the coordinated efforts of the riparian countries along the Lower Mekong River to study and manage their wetland ecosystems.

***Keywords:*** *wetlands, environmental management, Lower Mekong Basin, Cambodia, Lao PDR, Thailand, Vietnam*

## INTRODUCTION

The 600 000 km² of the Lower Mekong Basin catchment area covers almost the whole of Cambodia and Lao People's Democratic Republic (PDR), one-third of Thailand, and one fifth of Vietnam. Within this area, wetlands represent a large and ecologically-sensitive natural resource with a high potential for utilization and development. Inhabitants of the basin depend to a considerable extent upon the Mekong River and its associated wetlands which serve a wide variety of physical, ecological and socio-economic functions.

Inevitably, the drive for economic development has imposed and, in the foreseeable future will continue to impose, a great variety of threats upon the Mekong wetlands and their biota. These threats have already destroyed or degraded some valuable wetlands, and have triggered long-term physical, chemical, ecological and socioeconomic changes.

The resources of the Lower Mekong Basin are shared by the four riparian countries — Cambodia, Lao PDR, Thailand and Vietnam. Consequently, conversion and/or degradation of wetlands in any part of the drainage basin in any riparian country may have adverse and wide-ranging impacts. Action

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by individual countries will be necessary, but is unlikely to be sufficient, to effect conservation and management of wetlands and their resources. Basin-wide, international coordination will be essential.

## GOALS OF THE LOWER MEKONG BASIN WETLAND MANAGEMENT PROGRAMME

In response to environmental concerns, and in order to develop sustainable wetland management methods and coordination among the riparian countries, a basin-wide programme 'Inventory and Management of the Wetlands in the Lower Mekong Basin' was formulated by the Environment Unit of the Mekong Secretariat in 1987–88. Implementation began in 1990 with financial support from the Swedish International Development Authority (SIDA). The stated objective is ' . . . to formulate ecologically-sound management plans that will permit the productive use of basin wetlands on a sustainable basis, while conserving their natural ecological and socioeconomic functions' (Mekong Secretariat 1993a).

The specific immediate objectives for the first phase of the programme (1990–92) are ' . . . to establish a wetland database, analyse trends in key parameters, define the wetland status, and propose guidelines for sustainable productive use of the basin wetlands' (Mekong Secretariat 1993a).

## PROGRAMME ACTIVITIES

To meet the stated goals, wetland teams comprised of multidisciplinary staff from governmental, institutional and local authorities were established by the Wetlands Management Programme in three of the riparian countries (Lao PDR, Thailand and Vietnam) in 1990. Initiation of the programme for Cambodian wetlands has just begun (1993). Working closely together, the three existing teams have undertaken a variety of activities which are described below.

### Delineation and preliminary classification of selected wetlands

Priority has been placed on riparian wetlands within 50 km of the main channel of the Lower Mekong River. Wetland mapping has been undertaken using aerial photography and satellite-imagery interpretation (LANDSAT MSS and SPOT) combined with 'ground-truthing'. Maps of the riparian wetlands will be produced at two scales: 1:250 000 for the Mekong corridor and 1:25 000 for selected priority study sites which will be the subject of pilot studies.

As the first step in forming an information base, the key staff of the teams responsible for wetland mapping and classification met in Vientiane during April 1993. The meeting was devoted to a review and discussion of a suitable wetland classification system to be used by all riparian countries in the Lower Mekong Basin. Criteria for classification were listed and considered in the light of possible priority weighting. Among the features regarded as being important were the presence and extent of water, land forms, substrates, tides, salinity, flooding regime, vegetation type, extent of human interference, and purpose of use. The system adopted was based on the International Union for the Conservation of Nature and Natural Resources (IUCN) wetland classification scheme (Dugan 1990) but included some minor modifications.

The five major systems forming the highest level of the classification hierarchy are Marine/Coastal, Estuarine, Riverine, Lacustrine, and Palustrine. The Marine/Coastal and Estuarine systems, each have three subsystems (Subtidal, Intertidal, and Nontidal), as does the Riverine system (River, Riverine Banks/Beaches/Bars, and Riverine Floodplain), while the Lacustrine system has two subsystems (Lake and Pond) as does the Palustrine system (Permanent and Seasonal). Subsystems are divided into classes based on vegetation type, substratum composition, flooding regime, and the extent of human interference (Mekong Secretariat [1993b] gives details).

Completion of the first phase of mapping and classification of the riparian wetlands of the Mekong corridor and of priority wetlands in that area is expected to be complete in late August 1993. The output will provide the necessary tools for map-based wetland inventory and management.

### Intensive surveys, monitoring and assessment of priority wetlands

Three wetlands, namely Nong Chanh marsh (0.12 km²) and That Luang swamp (120 km²) in Lao PDR, Huai Nam Un wetland (30 km²) in Thailand, and Tram Chim wetland (50 km²) in Vietnam (Fig. 1), have been chosen as priority (or pilot) study areas. They meet the criteria established by the teams

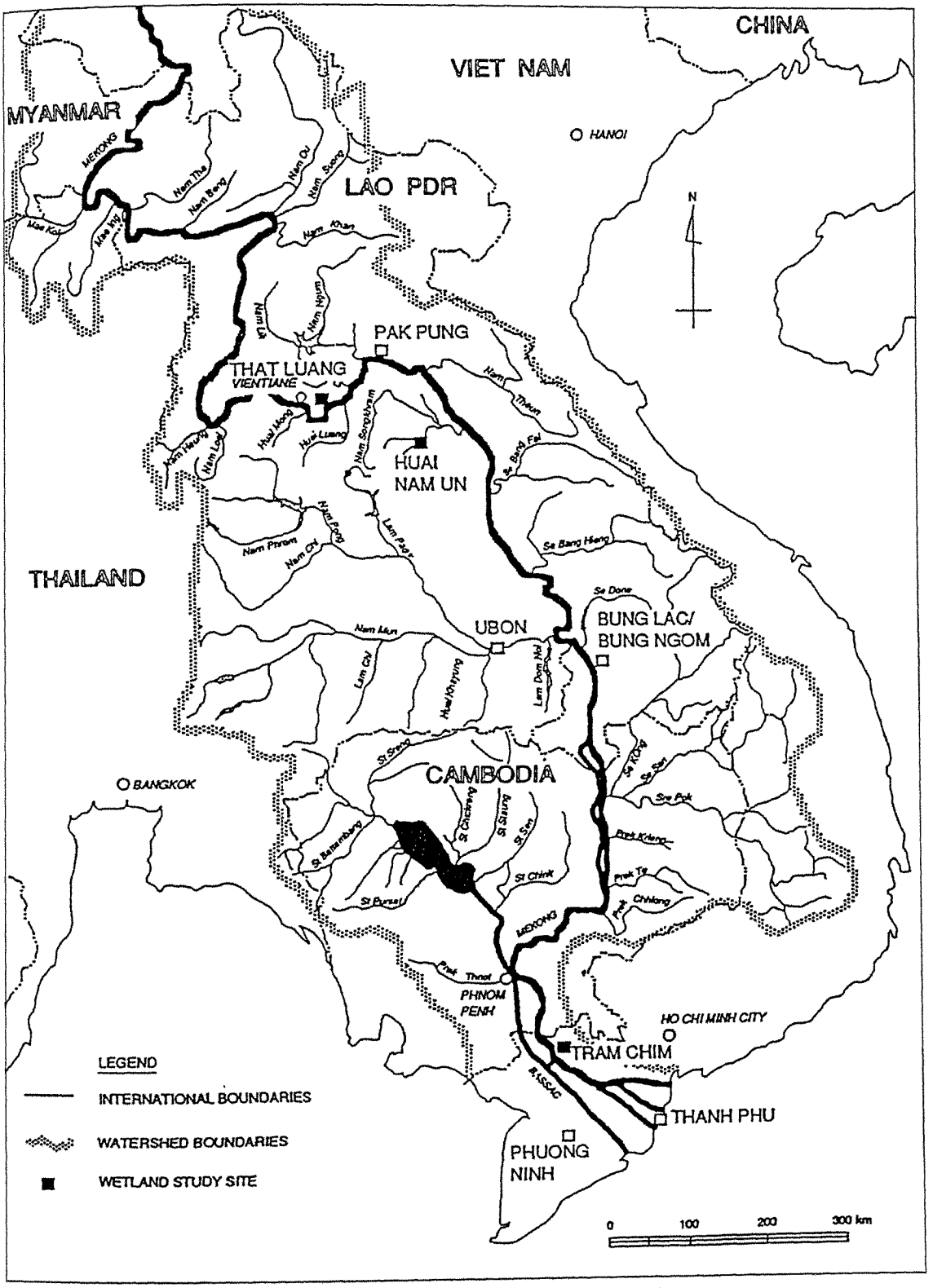


**Fig. 1** Locations of pilot study sites of wetlands in the lower Mekong basin (1990–92).
Source: Petersen 1991

responsible for wetland mapping, the Mekong Secretariat, and various wetlands consultants (Petersen and Skoglund 1990). The priority areas were selected to be used as sites where the development and verification of techniques for intensive surveys, the monitoring and assessment of wetland ecosystems, and the formulation of management plans could be demonstrated. Details of sampling stations and methodologies are given by Phithayaphone (1992), Lilitthum (1992) and Long (1992). However, factors included in the intensive surveys, monitoring and assessment of the three priority wetlands are listed below.

(i) Drainage basin (= watershed) characteristics and hydrology, especially the study of records of seasonal water flow through catchments over several years taken from hydrometeorological stations of the lower Mekong hydrologic network (Interim Committee for Coordination of Investigations of the Lower Mekong Basin 1960–89).
(ii) Water quality studies and monitoring, involving collection of water samples at monthly intervals from a total of over 20 stations in the priority wetlands. Parameters analysed include ammonia, nitrites, nitrates, phosphates, total phosphorus, dissolved oxygen, chemical oxygen demand (CODMn), biological oxygen demand (BOD), total suspended solids, pH, conductivity and alkalinity. In addition, examination of water quality records from 87 sampling stations in the Lower Mekong Basin of the Water Quality Monitoring Network Project (Environment Unit, Mekong Secretariat) has been undertaken.
(iii) Aquatic plant production involving investigation of growth rates, potential productivity and nutrient uptake of selected species (Phithayaphone et al. 1991).
(iv) Investigation of fish populations with particular reference to species diversity. Compilations of data from previous surveys have been made and compared with field observations; fish samples are also being analysed for pesticide residues.
(v) Analysis of sediments and benthic organisms, as well as zooplankton and phytoplankton.
(vi) A soil survey is ongoing, involving physical and chemical analysis of soil samples, a land-use survey and land evaluation.
(vii) Assessment of the natural vegetation and wildlife, including compilation of data available from previous surveys and additional survey work dealing with the terrestrial flora, fauna and avifauna.
(viii) Socio-economic surveys have been carried out in the vicinity of the priority wetlands with emphasis on population characteristics, wetland utilization, values of wetland products, welfare of the local people and their dependence upon wetlands, as well as attitudes to — and awareness of — wetland management for sustainable use.

## Establishment of a wetland database

Apart from information relating generally to the wetlands in the Lower Mekong Basin, major data sets for some individual sites are now available. They include data on hydrological monitoring, water-quality monitoring, socioeconomic surveys, list of birds and the terrestrial and aquatic biota, spatial data on soils, as well as land-use and wetland maps. At present, individual data sets are being managed separately by simple, low-cost and widely-used database management software (e.g., dBASE IV, LOTUS 123, FOXBASE, and PCFOCUS). Discussions on methods for structuring a wetland database in combination with a geographic information system have begun, and staff training and software development are under way.

## Training and coordination

During the past three years, wetland teams from the riparian countries have been provided with short courses and training in subjects including basic biology, limnology, wetland ecology and management, wetland mapping utilizing remote sensing and interpretation techniques, and database management. Sharing of data, field experience, resource persons, and coordination of activities at several levels have been encouraged through meetings, seminars and workshops held in rotation in each of the riparian countries. Whenever possible, support has been given to staff from these countries allowing them to participate in several international wetland conferences and study tours.

## Formulation of preliminary guidelines for wetland management

Wetland teams from each riparian country are now

analysing and evaluating all available data. Management guidelines are being developed with particular attention paid to the wetlands selected for priority study. At the end of 1993, meetings will be held in each riparian country; subsequently, the management guidelines will be conveyed to the respective governments and made available to the public. Roles, functions and management lessons demonstrated by investigation of the priority wetland study sites will help to draw attention to and raise awareness of the importance of establishing sustainable wetland management policies.

## ROLES AND IMPORTANCE OF LOWER MEKONG BASIN WETLANDS

Wetlands in the Lower Mekong Basin provide direct and indirect benefits — which may be tangible or intangible — to people living in the vicinity.

### Direct benefits

Direct benefits derived from wetland areas include those derived seasonally or throughout the year, and are listed below.

(i) Crop production: rice which is a staple food grown mainly for domestic consumption, vegetables and cash crops for domestic consumption as well as for agro-industries, and aquatic plants for domestic consumption, for animal feed, and for sale. At Nong Chanh marsh (Lao PDR), for example, 60 000 kip per month (US$1 = approximately 715 kip) can be derived from *Ipomoea* (water spinach) harvested from an area of 2250 m² (Hargeby 1991). The price of a 1.5 kg bag of *Lemna* (duckweed), a 1.5 kg bundle of *Ipomoea*, or a 2.5 kg bunch of *Eichhornia crassipes* (water hyacinth) is 100 kip, and the average daily income of vendors selling these plants around Nong Chanh marsh is 5000–8000 kip.

(ii) Livestock production: cattle and water buffalo mainly for animal labour as well as for cash, and poultry for domestic consumption as well as for sale.

(iii) Capture and culture fisheries: fishes are a major source of protein and, in the Huai Nam Un Wetland (Thailand), 61% of the total protein intake is derived from capture fisheries (Choowaew et al. 1993). In 1989, a total of 107.68 tonnes of fish was harvested from fish ponds and paddy fields on the perimeter of the Thatluang/Salakham swamp (Lao PDR) (Roger 1992). The per kg price of captured and cultured fish is around 1800–2000 kip and 1200–1500 kip respectively (Phithayaphone 1992).

(iv) Water supply: for domestic as well as industrial consumption; at Huai Nam Un wetland (Thailand), for example, more than 75% of household consumption of water is derived from shallow wells (Choowaew et al. 1993).

(v) Wetland wildlife: frogs, paddy rats, snakes, insects, molluscs and birds are a significant source of supplementary protein, and are not only consumed domestically but also sold in local markets providing an additional source of household income (Choowaew et al. 1993).

(vi) Forest resources and other wetland products: plants for food, wood for fencing, housing materials, construction and fuel; among them are edible bamboo (*Bambusa arundinacea*), as well as certain sedges (e.g. *Cyperus corymbosus*) and Dipterocarpaceae (Choowaew et al. 1993). Wetlands also provide raw materials for cottage industries involved in the production of matting and other handicrafts, and raw materials for compost and 'green coal' production (Choowaew et al. 1993).

### Indirect benefits

Indirect benefits attributable to wetlands include groundwater recharge and discharge, flood control, erosion control, sediment and toxicant retention, nutrient retention, wind breaks and protection from storms, micro-climate stabilisation, water-borne transport, and recreation (Dugan 1990).

An example of indirect benefits in terms of nutrient retention is apparent from the fact that the That Luang/Salakham swamp (Lao PDR) reduces loads of nitrogen (1.082 mg/L of nitrate at the inlet to 0.409 mg/L at the outlet) and phosphorus (0.163 mg/L of total phosphorus at the inlet to 0.094 mg/L at the outlet) in the water flowing through it (Bandavong 1991). Studies on nutrient uptake by floating water hyacinth (*Eichhornia crassipes*) at Nong Chanh marsh (Lao PDR), showed that potential uptake of nutrients by *Eichhornia* with an average biomass of 5 kg/m² was of the order of 250 kg nitrogen and 25 kg phosphorus per day for the entire 12–ha wetland (Phithayaphone et al. 1991). Water

entering Nong Sanom marsh (0.05 km$^2$), a semi-natural wetland in Sakhonnakorn Province (Thailand), had dissolved oxygen levels of less than 1 mg/L until it filtered through gravel and sand whence levels increased to 4–5 mg/L; subsequently, the same water flowed through dense *Eichhornia* beds in the marsh and, at the outlet, had dissolved oxygen values of up to 7.0 mg/L (Choowaew 1992a). These data indicate that the need to build costly waste water treatment units can be avoided if natural wetlands are conserved or if semi-natural wetlands are managed appropriately. Clearly, wetlands can play an important role in the treatment of domestic waste water from small, non-industrial communities.

Chandrachai et al. (1991) give a further example of the importance of wetlands in maintaining water quality by trapping suspended sediment and reducing sediment loads in Huai Nam Un, a branch of Songkhram River which flows into the Mekong River in northeast Thailand.

## LOWER MEKONG BASIN WETLANDS: STATUS AND THREATS

The entries for the four riparian countries of the Lower Mekong Basin in *A Directory of Asian Wetlands* (Scott and Poole 1989) are summarized in Table 1. Vietnam and Cambodia have higher proportions of their areas occupied by wetlands of international importance. However, the figures in Table 1 include only those wetlands of international importance, and do not represent the entire extent of wetlands in each country. Results from wetland mapping and classification being carried out by riparian wetland teams, when completed, will give a more complete picture. Most wetland sites, especially in Cambodia, Lao PDR and Thailand are exposed to moderate or high degrees of threat and are inadequately protected. The status of specific wetlands in the Lower Mekong Basin, and the threats that they face, are described below.

Cambodia contains two of the largest and perhaps the least known wetlands in Asia: the Great Lake/Tonlé Sap complex and the floodplain system of the Lower Mekong River. According to Scott and Poole (1989), these areas support one of the most productive fisheries in the world, and are important as spawning and rearing habitats for fish and other aquatic organisms. Siltation and decreasing fish productivity are major problems (Scott and Poole 1989; Dudgeon 1992). The wetlands surrounding the Great Lake are of major significance to many large water birds (Scott 1992). Attempts to reclaim wetlands (including swamp forest) for intensive crop production and fuel wood, combined with the proposed development of water control structures which will result in changes to the natural seasonal inundation patterns, may result in wetland loss and collapse of the floodplain fishery. Somean (1992) has discussed land-use conflicts in Cambodian wetlands. Particular conflicts occur between agriculture and fisheries, wood cutting, and wildlife hunting and trading which strongly impact wetland birds. Threatened species include the milky stork (*Mycteria cinerea*), the greater adjutant (*Leptoptilos dubius*), the lesser adjutant (*Leptoptilos javanicus*), the white-shouldered ibis (*Pseudibis davidsoni*), the giant ibis (*Thaumatibis gigantea*), the white-winged duck (*Cairina sculata*), the sarus crane (*Grus antigone*), and the spot-billed pelican (*Pelecanus philippensis*). Like Somean (1992), Scott (1992) attributes the present scarcity of many large

**Table 1**
**Extent of Wetlands in the Four Riparian Countries of the Lower Mekong Basin and Their Conservation Status***

| *Country* | *No. of sites* | *Area (million ha)* | *% area under threat protection* | *% area with some protected* | *% area completely* |
|---|---|---|---|---|---|
| Cambodia | 4 | 3.65 | 67 | <1 | <1 |
| Lao PDR | 4 | 0.22 | 67 | 0 | 0 |
| Thailand | 42 | 2.51 | 47 | 8 | 2 |
| Vietnam | 25 | 5.81 | 26 | 1 | <1 |

Source: Scott and Poole 1989
* The sites/areas given represent wetlands of international importance only, and not all of the wetlands in any given country

waterbirds in Cambodia to direct persecution by man, rather than a loss of wetland habitats alone.

Vietnam possesses one of the largest wetlands in the Lower Mekong Basin: the Mekong Delta. This wetland plays an important role in the national economy, and is of international importance as habitat for the endangered Eastern sarus crane (*Grus antigone sharpii*) and other rare water birds. Draining wetlands, alteration of the hydrological regime, a tendency towards the development of unproductive acid sulphate soils, reclamation schemes for irrigation and agriculture, deforestation, overfishing and declining fish productivity are among the problems experienced in the Mekong Delta (Scott and Poole 1989; Barzen et al. 1992; Beilfuss and Barzen 1992; Long 1992; Truong 1992; Xuan et al. 1992).

Lao PDR has fewer wetlands of international importance than Vietnam or Cambodia, but the Laotian wetlands are of considerable significance to local, regional and the national economies. Large wetland areas have been reclaimed for agriculture, aquaculture, irrigation, hydroelectric schemes and flood control, and receive waste water; all of these influences are likely to impact fisheries and wildlife (Scott and Poole 1989; Roger 1992).

When compared with the other three riparian countries, Thailand has relatively small areas of wetland within the Lower Mekong Basin. Moreover, in recent years considerable amounts of capital have been invested in northeastern Thailand in order to raise the socio-economic status of the region. In consequence, large areas of wetland have already been heavily exploited or almost completely converted to other uses (Choowaew and Hutacharoen 1992). Appreciation is nevertheless growing for the highly varied and valuable functions of Thai wetland ecosystems. Calls to conserve the remaining wetlands are now heard frequently, and attempts to construct man-made wetlands are either under trial or the subject of feasibility studies by both public and private agencies. Among them are local authorities such as the Ministry of the Interior, and industries such as the Phoenix & Pulp Co. Ltd. (*Thai-Rath* 1992, 1993; *Bangkok Post* 1993). The latter company has been a notorious polluter of the Pong River in Khon Kaen Province, northeast Thailand. Activities such as agricultural intensification, agro-industrial promotion, salt production, and fishery extension on reclaimed wetlands require proper control measures, and the few remaining natural wetlands in the Lower Mekong Basin of Thailand need proper management urgently.

## STRENGTHENING WETLAND MANAGEMENT

While attempts to develop management strategies have focused only on the priority wetlands in Vietnam, Thailand and Lao PDR (Fig. 1), with pilot studies in selected Cambodian wetlands to be initiated in late 1993, these priority wetlands do differ in a variety of features (hydrological characteristics, vegetation type, size, status, etc.). Thus it is hoped that management strategies developed for these wetlands can be applied to similar wetlands elsewhere in the Lower Mekong Basin.

The wetlands at Nong Chanh and That Luang (Vientiane, Lao PDR) comprise an interconnected marsh and swamp ecosystem located next to urban developments. They are threatened by waste water from nearby communities and small-scale industries (Phithayaphone 1992). In order to maintain their physical, chemical, ecological and socio-economic roles, the Lao PDR wetland team is studying wetland water quality in order to determine its assimilative capacity, and preparing management guidelines. This priority wetland is an example of ongoing efforts to manage a multi-functioning wetland in the Lower Mekong Basin.

The priority study area at Huai Nam Un (northeastern Thailand) is a seasonally-flooded riverine wetland facing the threat of land-use conversion. Significant parts of this wetland have been reclaimed for intensive agriculture, the production of cash crops, and as a source of supply of raw materials for agro-industries (Choowaew 1992b). Applications of fertilizer and pesticides are intensive. On average, fertilizer is applied at a rate of 180 kg per rai (1 rai = 0.0016 km$^2$) per crop, and pesticide is applied almost every week — nine times per crop. Meanwhile there is neither land-use zoning nor controls on agricultural pollution. The Thai wetland team is identifying the principal environmental changes and their potential impacts, and employing these data to prepare management guidelines. Work undertaken on this priority wetland is an example of ongoing efforts to manage unprotected riverine wetlands that are threatened by intensification of agriculture and promotion of agro-industries.

The Tram Chim swamp forest (Vietnam) is located in the Mekong Delta and is of international significance as a habitat for water birds. The wetland also contributes significantly to the local economy.

To meet the needs of both man and wildlife, the Vietnamese wetland team has proposed to the Ministry of Forestry and the central government that the area be set aside as the Tram Chim Sarus Crane Reserve. Meanwhile, with the assistance of the International Crane Foundation, a pilot plan for managing this wetland has been prepared. Zoning has been carried out, so that the wetland is divided into a core area, designated as habitat for cranes and other rare species, surrounded by a buffer area, in which some activities like grazing, *Melaleuca* (paperbark tree) reforestation and harvesting, fishery, and floating rice production may be allowed under proper management. An educational area is due to be established and will include an education centre set up to enhance public knowledge and understanding of nature (Truong 1992).

Organization of workshops in each riparian country is planned for the end of 1993. This will involve presentation of the project findings and proposed management guidelines for the selected wetlands which will serve as pilot models for managing wetlands of the same types elsewhere in the Lower Mekong Basin. The workshops will also serve to increase public awareness of wetland functions and values, and will encourage the formulation of national wetlands policies.

## TRAINING APPROACHES

Between 1990 and 1992, several training courses have been provided for staff of the riparian countries. These have taken place within the region making the most of local resource persons and using local wetlands for field demonstrations. The courses have included training in fish assessment in wetlands for Vietnamese staff, training in general biology and limnology for Laotian staff, and training in the use of remote sensing for wetland inventories and the development of environmental databases for staff from all riparian countries.

A larger-scale training course on Wetland Ecology and Management was held from 16 March to 23 April 1992 at the Faculty of Environment and Resource Studies, Mahidol University, Thailand. Designed to provide a broad introduction to wetland ecology and management to 24 staff from the riparian countries, the training curriculum focused on 13 major subjects: wetland soils; wetland hydrology; wetland water quality; statistical analysis of wetland water-quality data; wetland biology; wetland productivity; wetland sociology and economics; principles of database management systems; geographic information system applications for wetland management; wetland mapping and environmental monitoring; wetland politics, institutions and wetland management approaches; and, wetland management for mangroves. Training activities included laboratory sessions of practical work, fieldwork, and field visits to several wetland types and sites. This course was the first of its kind held in the region. Mahidol University plans to develop its regional wetland training capacity further by working with international organizations, especially the IUCN's Wetlands Programme in Southeast Asia.

## CONCLUSION

Activities during the previous three years have already yielded a great deal of data. To avoid the 'data-rich but information-poor' syndrome, the wetlands-management programme will place emphasis on wetland data evaluation and integration of findings with other environmental projects in the Lower Mekong Basin. With further joint efforts and cooperation among all four riparian countries, it is hoped that the work put into pilot studies of the priority wetlands will widen knowledge, understanding, and acceptance of the principles and concepts of sustainable management of wetlands. This, it is hoped, will lead to formulation of national policies and appropriate legislation to support conservation of wetland ecosystems in the Lower Mekong Basin. A substantial increase in national capacities to manage the wetlands of the Basin will be to the long-term benefit of the human inhabitants of the region.

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# Lake Management in China

*William Y.B. Chang*

## ABSTRACT

China has more than 2800 lakes exceeding 1 km² in area. These lakes are important for flood control, fishing and aquaculture, and the supply of drinking and irrigation water, as well as for transportation and recreation. This article presents an overview of the general features of Chinese lakes, major approaches to their management, and on-going evolution in the management concerns arising from these changes. Particular attention is paid to the effects of pollution, and to the importance of aquaculture (especially integrated lake farming) in Chinese lakes. Many of the problems associated with Chinese lakes are not unique and are shared by the inland waters of other developing countries.

The purposes of this article are to promote the exchange of information on Chinese lakes and to encourage assessment of sustainable management options for reversing the accelerating degradation of lakes.

***Keywords:*** *lake management, aquaculture, pollution, sustainability, China*

## INTRODUCTION

In China, the world's most populous country and third largest in area, lakes cover more than 80 000 km². These lakes have been exploited extensively and have become an intimate part of the people's life, playing an important role in flood control, food production, the supply of drinking and irrigation water, transportation, and recreation. In general, the smaller the lakes, the more closely they are linked to the daily life of the surrounding population and its associated activities, and the more sensitive they are to environmental changes — especially human-caused degradation.

Rapid growth of China's population over the last 40 years and accelerated industrial development since the 1980s have greatly increased the exploitation of — and concomitant pressure upon — lake environments. The pace of change has accelerated dramatically under the influence of the rapidly expanding market-based economy, and this development has markedly increased the complexity of decision-making with regard to lake management.

This paper provides an introduction to the general characteristics of Chinese lakes and their major uses, and describes current and potential management approaches to deal with the changes in lake management. In a broader context, the paper provides information useful to those concerned with the management of inland waters in developing countries in general. In particular, there is a need to formulate practical strategies to halt accelerating lake degradation, and to strengthen the sustainable use of aquatic resources.

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## Distribution, Formation and General Characteristics of Chinese Lakes

China has more than 2800 lakes with an area of over 1 km²; together they occupy approximately 80 000 km². They constitute 0.8% of China's total area and, as shown in Table 1, 28 of these lakes exceed 500 km² and together make up 39 389 km², 48.9% of the country's lake area (Academia Sinica 1981). Small lakes of 1–10 km² surface area are the most common, numbering more than 2000 and covering a total area of 9000 km², 11.3% of total lake area.

**Table 1**
**The Number and Total Area in Each Lake Size Category**

| *Lake size (km²)* | *Number* | *Total area (km²)* |
|---|---|---|
| 1–10 | 2 383 | 9 129 |
| 10–50 | 234 | 4 932 |
| 50–100 | 107 | 7 365 |
| 100–500 | 96 | 19 830 |
| 500–1000 | 15 | 10 082 |
| > 1000 | 13 | 29 307 |
| Total | 2 848 | 80 645 |

Sources: Academia Sinica 1981; Chang 1987

Tectonic movement and river action are the major mechanisms contributing to the formation of Chinese lakes. The Indian subcontinent collided with Eurasia in the Tertiary Period, resulting in the formation of the Himalayan mountain ranges in the southwestern part of China, and uplifting the Tibetan plateau to an elevation of 4000–5000 m. The Himalayan mountain ranges formed a land barrier to the flow of rivers that originally emptied into the Indian Ocean. Large numbers of lakes in the Tibet, Qinghai, and Xinjiang (TQX) region were formed as rivers were diverted by the tectonic uplift.

The collision of subcontinents not only blocked previous river flow routes, but also created barriers to the monsoonal rains that provided most of the freshwater input to the TQX region. In consequence, the TQX region became arid. Today, evaporation exceeds precipitation by up to ten times and is the only type of water loss in many closed drainage basins. As a result, lake area and volume undergo major seasonal changes. Some lakes become semi-saline, others disappear entirely in the fall (Chang 1987; Williams 1991). Geological instability and unique climatic conditions continue to affect the lakes in the TQX region today. Many lakes have been formed and then disappeared as new outlets evolved or old rivers became blocked due to tectonic action, and as the climate of the TQX region become increasingly dry. In addition, river (fluviatile) migration, which can result in isolation of standing water, has contributed to the origin of many seasonally-filling lakes (Williams 1991). These are formed in the late spring by snow melt, the extent of which is reflected by year-to-year variations in lake size and depth.

Most of the major rivers in China flow eastward into the Pacific Ocean. These rivers have their origin in the Tibet and Qinghai highlands and have contributed to the formation of lakes at low elevations (usually < 40 m above mean sea level) in the Pacific drainage plain. Changes in river courses and sediment deposition are the major factors leading to the formation of lakes in this region. When the Yellow River changed its course between A.D. 1194 and 1845 to run along the old course of the Huai River as it drained into the sea, large amounts of sediment were deposited at the mouth of the Huai River. Eventually these deposits blocked access to the sea. The Yellow River formed a new outlet to the sea, while the sediment blocking the Huai River basin gave rise to Chao, Keoyu, Nanse and Hongze lakes as well as many small lakes (Chang 1993).

Similarly, the sediments brought down by the Yangtze and other rivers gave rise to more than 1000 lakes in Hubei Province (Zhang and Chang 1993) and contributed to the formation of Lake Tai as well as chains of small lakes in the Yangtze Delta area, Jiangsu Province. Blockage of old rivers as a result of faulting contributed to the origin of lakes in Yunnan Province.

In China, all of the low-elevation lakes have been used extensively by the inhabitants of the Pacific drainage plain, which is the home of more than 95% of the Chinese population (Chang 1991). Most of these riverine lakes are shallow and well-supplied with nutrients (eutrophic or hypertrophic). They play an important role in the daily life of people in the region, and have been used for food production, flood control, transportation, irrigation and recreation.

## INSTITUTIONAL ARRANGEMENTS FOR LAKE MANAGEMENT

Responsibility for the management of Chinese lakes falls under several different authorities. The Ministry of Water Resources is responsible for flood control and the construction of dams and weirs. The National Environmental Protection Administration deals with pollution-related regulations and the establishment of environmental laws related to lakes. The Ministry of Agriculture provides guidelines for managing fisheries and natural resources, with the primary goal of increasing fish production. The daily management of lakes is, however, the responsibility of provincial, county and township authorities.

The level of the local authority responsible for managing a lake depends on the lake's size, location, and ownership. Nevertheless, a Lake Management Commission has also been established, and has responsibility for lakes of significant economic importance. Because flood control, environmental pollution, and the development and use of natural resources are directed by different agencies, the Lake Management Commission also plays a role in the coordination of these different agencies in an attempt to accommodate various needs and uses. This coordination is sometimes inefficient or unsuccessful, and signs of environmental degradation are apparent at many lake sites (Chang, personal observations; see also Jin et al. 1990).

Lake management in China varies according to the type of use, and is affected strongly by the population densities within the drainage basin and by the region in which a particular lake is situated. The complexity of management strategies employed is, in general, proportional to the density of the human population. The higher the population density, the greater are the demands for multiple uses, leading to increased management difficulty.

For most of the lakes situated in the sparsely-populated TQX region, conservation and retention of freshwater for human consumption and irrigation are primary considerations. This has involved dam construction in the tributaries draining into lakes of the region, but little or no within-lake management has been undertaken. However, very salty (hypersaline) lakes have long been exploited as a source of minerals. In most other parts of China, especially the densely-populated Pacific drainage basin, lake-management practises are more complex than in the TQX region, and will be considered in detail below.

### Flood Control

Water-resource management and flood control are the responsibility of the Ministry of Water Resources. To those ends, the Ministry of Water Resources — in association with regional water authorities — have installed weirs and dams in most major waterways and lake tributaries over the last 40 years. Only Poyang and Dongting lakes on the Yangtze River remain relatively free of regulation of flow, because the quantities of the water flowing in and out of these lakes is so large as to render control impractical.

The management of lake water levels, and decisions regarding the opening and closing of dams and weirs, are the responsibility of regional water authorities. In most cases, lake water is drained in winter to provide the capacity needed to accommodate peak flows in spring and summer; floodgates are closed for most of the rest of the year. In consequence, there is little or no outflow in spring, summer and fall except in cases where lake water levels become unusually high. This regulation of lake water levels reduced potential damage by floods in lowland areas, and facilitated the use of lakes and waterways for other activities such as irrigation and transportation.

The best known examples of the management of Chinese lakes for flood control involve Hongze and Keoyu lakes, which were lagoonal depressions prior to A.D. 1100. Changes in the course of the Yellow River between 1194 and 1845 led to the formation of these lakes. Moreover, large sediment loads deposited by the Yellow River raised lake elevations so that, currently, their beds are 4–8 m higher than the areas to the east. Frequent floods since the 12th century have made containment of flood waters a top priority for these two lakes.

In addition to flood management, these lakes and their water are an important component of the Grand Canal, which has been used for shipping grain to the capital since the Tang Dynasty (618–907) (Liao 1992). Substantial national and local resources have been devoted to management of these lakes involving, in recent decades, dike reinforcements, dams, and drainage canals to the sea. Reinforcement of dikes surrounding the east side of both lakes has become the principal annual task for local water authorities. In addition, several secondary dikes have been built to reduce potential damage by major floods in case primary dikes are breached.

While the construction of dams and weirs has

brought benefits in terms of flood control, they have had deleterious effects on fisheries resources and aquatic life, especially those species which migrate from lakes into rivers to spawn. Recruitment is prevented by dam construction, and reduction of fisheries stocks of some important carp and crab species have become apparent. Fish-stocking programs are now the major means of maintaining lake fisheries in many areas (see the Fisheries and Aquaculture section below).

## Sedimentation

Sediment loads have been responsible for the formation of the large lakes in the Pacific drainage basin. More recently these sediment loads have also been responsible for a substantial reduction in the size and volume of these lakes. High sediment loads are evidence of deforestation and increasing farming activities in the mountainous region. As a case in point, increased agriculture, forest clearance and the cultivation of marginal lands in Hunan Province have raised the water level in its largest lake, Dongting Lake, by 5 cm/year. Over a period of only 152 years (1825–1977), the lake area was reduced from 6300 $km^2$ to just 2740 $km^2$ (Liu 1984; Wong et al. 1984), and lake volume was reduced from 293 x $10^8$ $m^3$ in 1949 to 178 x $10^8$ $m^3$ in 1977.

Exceptionally high suspended loads are apparent in the Yellow River, where sediments can constitute as much as 30% of the water. The impact of sediment loads from this river has been substantial and contributed to the formation of large lakes (Chao, Nanse, Hongze and Keoyu) along the river flood plain.

When combined with the effects of increased rates of sedimentation, filling or 'reclamation' of lakes for farmland has been responsible for the disappearance of many small lakes (< 10 $km^2$). For example, 42 lakes in Jiangsu Province have disappeared since 1957, and one-third (approximately 400) of the lakes in Hubei Province have vanished as a result of farming activities. The total lake area in the five provinces situated in the lower reaches of the Yangtze River was reduced from 28 859 $km^2$ in 1950 to 18 695 $km^2$ in 1984, a reduction of more than 10 000 $km^2$ in less than 35 years (Wong et al. 1984). The extent of wetland and lake marginal zone loss in the Yangtze and Huai River basins was estimated at 13 000 $km^2$ in 1970 (Pu et al. 1989) and the rate of loss has increased subsequently since then.

These figures for reduction in lake area do not take into account those lakes which have been fragmented, nor small urban lakes or impoundments which have been filled in to provide land as urban populations have expanded. The Chinese government has, however, announced a program of returning to lake use the low-productivity farmland that was previously derived from lakes. While it is too early to assess the success of this program, continuing population growth and the demand for land may undermine its success.

Sediment loads have reduced not only lake size and volume but also the capacity to regulate floodwater, because large river expansion lakes tend to regulate river flow volumes. For example, both Dongting and Poyang lakes provide water to the Yangtze River during low water periods, and receive water from the Yangtze River during peak flows. Sedimentation of these lakes has reduced their capacity for regulating floodwaters (Chang 1987). The Chinese government hopes that the construction of the Three Gorges Dam on the Yangtze will restore the flood-control capacity that has been lost.

## Water Quality

Growth in population density over the last 40 years and accelerated industrial development during the 1980s and early 1990s, together with increased urban and agricultural run-off, have made water quality a top environmental concern in China. In general, human population densities within the drainage basin provide the basis for a good first approximation as to the level of lake eutrophication. The higher the population density, the greater the likelihood that serious pollution and water quality problems will be encountered. Water quality is declining (or has already deteriorated significantly) in most lakes close to urban centres (Jin et al. 1990; Shu 1991; Jin 1993; see also Table 2), and the state of many such lakes is already alarming. Water quality is deteriorating further as urban household and industrial wastes continue to drain into them.

Table 2 shows data on selected examples of the lakes close to and inside urban centres in China. Many of these lakes are not only hypertrophic (i.e., over-enriched with nutrients), but also loaded with industrial wastes. Urban trash, debris, and organic matter from die-off of aquatic plants contributes to sedimentation rates of up to 5 cm/year (Shu 1991). As most such lakes are already shallow, the high

**Table 2**

**Trophic Status and Water Quality of Urban Lakes in China**

| *City* | *Lake* | *Area ($km^2$)* | *Depth (m)* | *Volume ($m^3x10^3$)* | *Chl a ($mg/m^3$)* | *TP ($mg/m^3$)* | *TN ($mg/m^3$)* | *pH* | *COD (mg/L)* | *BOD (mg/L)* | *SS (mg/L)* | *$NH_3$-N (mg/L)* | *SD (m)* | *Trophic status* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nanjing | Xuanwu | 3.20 | 1.3 | 4320 | 168.2 | 536 | 4073 | 8.3 | 10.80 | 11.02 | 21.72 | 1.31 | 0.26 | Hypertrophic |
| Jinjiang | Gantan | 1.22 | 2.4 | 3000 | 75.6 | 141 | 1417 | 8.5 | 7.31 | 8.72 | 20.00 | 0.26 | 0.38 | Eutrophic |
| Hangzhou | West | 5.59 | 2.0 | 10956 | 58.9 | 161 | 2478 | 8.3 | 10.41 | 5.52 | 9.50 | 0.37 | 0.43 | Eutrophic |
| Wuhan | Moshui | 3.35 | 1.3 | 4355 | 153.9 | 232 | 15692 | 8.1 | 13.50 | 22.35 | 15.65 | 10.28 | 0.25 | Hypertrophic |
| Changchun | South | 0.91 | 3.0 | 2730 | 120.6 | 228 | 2630 | 8.8 | 8.22 | 14.30 | 21.10 | 1.60 | 0.27 | Hypertrophic |
| Huangshi | Ci | 8.15 | 1.8 | 14263 | 14.5 | 77 | 1000 | 8.1 | 3.70 | 4.43 | 16.00 | 0.52 | 0.36 | Eutrophic |
| Guangzhou | Dongshun | 0.32 | 2.0 | 624 | 149.5 | 428 | 5350 | 8.0 | 13.42 | 13.38 | 41.87 | 3.37 | 0.29 | Hypertrophic |
| Guangzhou | Li | 0.21 | 2.4 | 504 | 119.5 | 372 | 3038 | 8.5 | 9.95 | 8.27 | 30.33 | 1.04 | 0.34 | Hypertrophic |

TP = total phosphorus; TN = total nitrogen; SD = Secchi disc depth; otherwise standard abbreviations apply

sedimentation rates may lead to their disappearance in one or two decades.

Moreover, many of these urban lakes have little or no water exchange; they are foul-smelling and anoxic and, in some cases, more than 70% of their water consists of household sewage and industrial effluents. They show all the signs of hypertrophication (Table 2) and, indeed, nutrient levels in some of these lakes are comparable with values recorded in sewage retention ponds. At the time of writing, many urban lakes have ceased to provide any amenities and have become instead sources of infection and disease.

The Chinese National Environmental Protection Administration (NEPA), the major agency in China dealing with environmental issues, has conducted several national lake surveys to better understand the extent of lake pollution problems, and has provided funds for dealing with eutrophication. For example, during the Seventh Five-Year Plan (1985–90), the NEPA provided support for a study aimed at improving water quality in West and Dian lakes, and joined local authorities in following the recommendations from the study which called for dredging those areas of the lake beds which contained highly polluted sediments.

East Lake in Wuhan is one which has received attention from NEPA, the Chinese Academy of Science, and Hubei Province with the aim of monitoring and researching effective ways to improve lake water quality. Chao Lake in Anhui Province has also received a sizable grant from NEPA and Anhui Province to study and improve the lake water quality. Despite such efforts, water quality continues to worsen in many Chinese lakes, leading to the development of seasonal and/or site-specific anoxia in the water column, and species richness of indigenous and even endemic fishes has been reduced significantly (Jin et al. 1990).

For example, a reduction in species richness of over 30% has been recorded in Chao Lake, where the waters have developed a foul smell and are no longer suitable for drinking. However, surrounding residents are forced to utilize the water from this and other polluted lakes.

In addition to eutrophication caused by organic wastes, it is clear that industries are a primary source of lake pollution and in some urban areas may contribute more than 75% of the total untreated run-off. Toxic industrial wastes also have a severe effect on lake biota. Monitoring and controlling industrial pollution is the responsibility of NEPA which issues guidelines for industrial effluents. The actual responsibility for monitoring and controlling industrial pollution rests on local Environmental Protection Agencies (EPAs), but the NEPA provides assistance in monitoring run-off from factories.

The level of regional supervision of potentially polluting industries depends upon their official classification. For example, the provincial EPA supervises the provincial industries, while the county EPA has authority with respect to county enterprises and factories. In general, those factories which have received national attention are monitored carefully and have installed pollution control devices to meet the Chinese water quality standards. However, these factories are very much in the minority. Despite the creation of national and regional environmental agencies in China, the enactment of environmental laws, and the creation of an impressive network to enforce these regulations, most industrial wastes are not monitored, and routine water quality surveys are not carried out in most lakes.

A recent government estimate indicates that industries are treating only about 25% of their effluents, but even that may be an optimistic estimate. High levels of metal and toxic organics have already been found in lake sediments, fishes and benthic organisms, and raw effluents containing toxic organics are suspected to have been discharged into lakes. Known contaminants include mercury, arsenic, phenol, copper, cyanide, zinc, lead, and chromium, which can be readily associated with nearby major industrial sources (Nanjing Institute of Geography 1982; Chang 1987).

Prior to the early 1980s, most major industries were situated in urban areas. However, in the late 1980s many small industries, usually those operated by one or a few families, sprang up throughout rural communities in China. These enterprises are generally poorly equipped, with little or no effluent-treatment facilities. As a result, rural industries have become a major source of toxic chemicals, and are responsible for the spread of industrial pollution of Chinese lakes to include those which are quite distant from large centres of population.

## Fisheries and Aquaculture

The major lake-management mission in China is to increase food production to feed a burgeoning population. The market-based economy announced in

1992 by the Fourteenth National People's Congress provided an additional incentive for farmers and fishermen to expand lake fisheries and aquaculture. As the market begins to play an increasing role in regulating the economy, the price of aquatic products, as well as total yield, will become a major consideration in the development to lake fisheries.

Several fisheries-management approaches have been used to increase production, and can be divided into three categories: stocking, fisheries protection and regulation, and lake farming.

### *Stocking*

Stocking programs were first used in China during the 1950s when both fish and crabs were stocked in lakes (Zhang 1992). Gains from a stocking program could account for as much as the 80% of the total yield of a small lake and 20% of the yield of a large lake. Put another way, 1 kg of stocked fingerlings may yield, on average, 10 kg of adult fish (RFRI 1987; Zhang 1992). The number and the type of fish stocked depend on the ecology of the lakes and the range of food present (Chang 1987). As each species has a different diet and exploits different natural resources, several species may be added so that the management concept resembles the polyculture approach used in ponds.

For example, planktivorous species such as bighead carp (*Aristichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) are stocked in large numbers when the water is eutrophic. If the lake is choked with dense aquatic vegetation, grass carp (*Ctenopharyngodon idella*) and Wuchang bream (*Megolobrama amblycephala*) make up a high proportion of the stocked fingerlings. However, no ichthyophagous species are stocked in Chinese lakes. In fact, predator-control programs are often carried out in small lakes to reduce the ichthyophagous fish population.

Since the total fish yield is a major consideration in management strategies, selection of optimum fingerling size has also become an important factor in minimizing predation loss. In general, the greater the average size of stocked fingerlings, the higher the fish yields from the stocking program, because predation rates on the fingerlings are greatly reduced (IHB 1976; Zhao 1981).

### *Fisheries protection and regulation*

In cases of intensive use of a fishery resource, the protection of spawning grounds and restrictions of fishing seasons may be appropriate steps to sustain lake resources. In large Chinese lakes, bans are enforced on fishing during the breeding period in spawning habitats. The protected area generally occupies approximately 5% of a lake's area, and typical fishing bans last 45 days but may be extended for 3–6 months. Other steps to protect young fish include minimum size for a fish which may be landed, and minimum net mesh size. The current minimum landing size is 0.2 kg for most carp species, but this level may be insufficient to protect fish with decreasing populations, and it has been suggested that the level be increased to 1 kg for species such as grass, bighead, silver and black carp (*Mylopharyngodon piceus*). At the very least, a particular minimum size should be established for each important targeted species according to its growth rate and size at first reproduction.

### *Lake farming techniques*

The principal goal of lake management is to increase the total fish yield. The particular strategy used to attain this goal is related to the lake's trophic (i.e., nutrition enrichment) status. For example, in managing oligotrophic (i.e., low nutrient) shallow lakes, the first step is to increase nutrients. This enrichment may involve direct addition of organic fertilizers. Alternatively (or in addition), vegetation may be planted on the exposed lake bed during the drawdown periods, and herbivorous fish (such as grass carp) stocked after water levels rise. Consumption of the vegetation by fish remineralizes the nutrients from vegetation and enhances plankton growth. Both methods can increase lake fish production, but may also lead to unwanted algal blooms and degraded water quality. The management method for mesotrophic lakes (i.e., those with moderate amounts of nutrients) containing aquatic macrophytes involves initial stocking of primarily herbivorous fish to remineralize the nutrients from the vegetation, followed by stocking a small percentage of planktivores to increase the total fish production (Zhang and Chang 1993).

Raising fish in enclosures is widespread in the large, shallow (< 3 m depth) lakes of the Pacific drainage plain (Zhong 1986), especially the Yangtze River basin where the total area under enclosure exceeds 350 km$^2$ (Zhang 1992). Production using this method can reach 37 500 kg/ha (Kao 1988).

However, the investment needed for this type of system is also high and in order for fish enclosures to be viable, production must exceed 3750 kg/ha. However, in order to cover the cost of aquatic vegetation for fish food, labour costs, and essential investment in construction materials, the optimal production level for such systems is around 15 000 kg/ha.

Of the various enclosure systems that are used in Chinese lakes, the most cost-effective and common approach is integrated lake farming involving stocks of fish and aquatic plants as its major components. This system involves the cultivation of high-yield aquatic plants that can be used directly as food by fish in enclosures and by humans (Chang 1989, 1993). The plants used are floating macrophytes — such as water chesnut (*Trapa natans*) and water spinach (*Ipomoea aquatica*) — which use solar energy more efficiently than submerged macrophytes (Chang 1989), and are more efficient than phytoplankton at fixing solar energy (Edwards 1980). Floating plants have a higher protein and lipid content than do emergent or submerged macrophytes (Wetzel 1975), and because they have little lignified tissue they are a relatively high-value fish food. Rotation between fish enclosures and areas of the lake used for aquatic plant cultivation ensures efficient utilization of the excess nutrients that accumulate in the sediment during the fish culture period.

Grass carp is the most important herbivorous fish used in integrated lake farming, making up more than 40% of the fish stocked. Because the grass carp has a short gut for a herbivore (no more than 50% of its body length), the vegetation consumed is only partially digested (Ling 1967; Chang 1989). The faeces are either directly utilized by detritivorous fish or serve to enhance the production of natural food such as phytoplankton, zooplankton, and benthic organisms (Stott and Orr 1970; Chang 1989). The percentages of planktivorous or detritivorous fish stocked are variable, but bighead and silver carp are stocked where both phytoplankton and zooplankton are abundant. In recent years, the Yangtze River crab (*Eriocheir sinensis*) has also become a preferred species for enclosure culture, because it commands a price several times higher than that of fishes based on the same level of investment.

### *Environmental impacts of integrated lake farming*

Integrated culture practices can greatly increase fish production, but may also cause unwanted environmental changes including reduced dissolved oxygen levels and negative impacts on indigenous or endemic fish. The growth of dense aquatic vegetation frequently results in major diurnal fluctuations in dissolved oxygen and carbon dioxide. The characteristics of these fluctuations differ depending on the type and density of the aquatic plants cultured (e.g. Edwards 1980; Chang and Ouyang 1988; Chang 1989, 1993). Oxygen levels below dense mats of floating plants may be < 10% those in open areas of water (Schelpe 1961) or even anaerobic in extreme cases (Ashton and Walmsley 1976). The deleterious effects of such depressions in oxygen levels on aquatic life are well known.

Another environmental impact of the intensive culture of large water plants (macrophytes) for lake farming is an increased level of nutrient enrichment (eutrophication), because grazing by herbivorous fish becomes the major nutrient recycling route. As a result, remineralization of nutrients from macrophytes does not occur seasonally during the senescence or die-off of the plants, but continuously as the herbivorous fish consume the aquatic plants and then release the nutrients to the water. Indeed, areas with high densities of grass carp exhibit increases in inorganic nutrients (phosphorus and nitrogen) and nitrogen-rich detritus which can lead to unwanted algal blooms (PRFRI 1982).

An aggressive fish stocking program is necessary in China because dams and weirs have blocked the annual fish recruitment (see Flood Control above). However, such a program can rapidly reduce the diversity of indigenous fish species as well as the genetic diversity of targeted species. Liu (1984) reported the reduction of indigenous fish species in East Lake, Wuhan, as a result of stocking carp fingerlings over several years. Moreover, if exotic species are used in lake farming, additional precautions must be taken to ensure that they do not establish themselves outside lake confinements and cause ecological problems.

### *Future research needs*

In order for lake farming to be both economically sustainable and environmentally less damaging, research into several little understood areas needs to be undertaken:

(i) The appropriate proportion of the extent or area of a lake given over to fish farming and aquatic

plant production in relation to the size of the whole water body needs to be determined. The appropriate balance will depend upon such factors as net economic return, environmental gains (such as improved water quality) and risk assessment (chances of fish diseases, incidence of anoxic conditions in the water column, and the frequency of natural calamities) (Chang 1993).

(ii) Research is needed on the production and growth of various aquatic macrophytes, with particular emphasis placed on ensuring that accumulation of plant biomass does not occur at the expense of oxygenation of the water column.

(iii) Additional work on the appropriate levels and types of fish to be stocked in enclosures is needed (e.g. Kao 1986), so as to ensure high economic returns. Grass carp — as well as a few other planktivorous carp species — have been widely used in the integrated farming system, but the potential for use of other species such as *Tilapia rendalli*, *Tilapia zilli* and *Puntius gonionotus* should be investigated.

(iv) Economic analyses, including environmental considerations, should be undertaken for lakes in different parts of China with different stocking densities and mixtures of species. While maximizing net profits is a desirable end-result of lake farming, optimization of near-term profits should not come at the price of unsustainable practices; somewhat lower yields of fish could be offset, for example, by the higher value of the water in the lake for other purposes (e.g., drinking, recreation) due to improvements in lake water quality achieved through nutrient reductions.

## LAKE MANAGEMENT OPTIONS

### Control of eutrophication

Remarkable increases in human population in this century in China have resulted in major changes in the ecology of Chinese inland waters (Dudgeon et al. 1993). These changes — and especially declines in water quality — are most notable in the lakes close to large population centres (Jin et al. 1990; Shu 1991; Jin 1993). To mitigate the increased nutrient loads, two approaches have been used: firstly, reduction, removal or diversion of nutrients from the lakes; and, secondly, channelling the increased nutrients into plant or fish production followed by removal of the nutrients by harvesting these aquatic products.

Since more than 70% of urban eutrophication is from point sources of industrial and household effluents, control of these sources of loading could be effective in reducing the enrichment of urban lakes. Waste-water treatment plants are an efficient means of retrieving large quantities of nutrients, and cities in China including Shanghai, Beijing, Hangzhou have begun to construct sewage treatment plants. Lakes which are not in the vicinity of large population centres receive most nutrients from rivers. Removal of the nutrient loads by biological nutrient uptake techniques using aquatic macrophytes has been attempted at selected sites in the tributaries of Tai Lake and Chao Lake, but the approach is not very efficient and its application is limited by the type of plants available and the duration of their growing periods (Chang, personal observations).

Reducing loadings from external nutrient sources to shallow lakes has a limited effect on the reduction of eutrophication in those lakes with a long history of nutrient enrichment. In such cases, sediment resuspension by turbulence is the source of a large proportion of the nutrients in the water. For these lakes, sediment removal is the most efficient way to reduce the level of eutrophication. For example, there was little improvement in total phosphate (P) and nitrogen (N) concentration levels in West Lake (Hangzhou) before and after diversion of the tributaries through which the most of the pollution load entered the lake (N = 2.78 and 2.46 mg/L; P = 0.120 and 0.117 mg/L before and after, respectively). This reflects the fact that total phosphorus loads in the sediments exceed 1500 mg/L, while total nitrogen exceeds 9000 mg/L (Shu 1991).

The main alternative approach to reducing eutrophication involves channelling the increased nutrients into the production of aquatic products, then removing the nutrients by harvesting these products. Integrated lake farming is an example of this approach. However, if eutrophication is to be controlled, the ratio between stocked fish and the biomass of aquatic macrophytes must be adjusted to ensure that the large amount of nutrients remineralized by fishes can be taken up by plants. Obviously, such a system can reduce eutrophication only when the decrease in nutrients due to plant uptake and fish harvest is greater than the increase

in loadings resulting from nutrient addition and remineralization. While major refinements will be needed if this methodology is to be used to control eutrophication, integrated lake farming could be a sustainable method of involving large numbers of farmers in improving lake water quality, with economic benefits and incentives accruing from the harvest of aquatic products.

## Institutional coordination and conflict management

Chinese inland waterways and lakes are governed by several different agencies of the central government in Beijing, including the Ministry of Water Resources, the Ministry of Agriculture, and NEPA (see Institutional Arrangements above). However, since the mandates of these agencies are not coordinated, management conflicts have arisen. The conflict posing the greatest concern deals with the regulation of water levels in lakes by controlling the opening and closing of floodgates (Pu et al. 1989). In most cases, the floodgates are opened in winter to drain lake water and are closed for most of the rest of the year. Fish recruitment, however, occurs in spring when the adults migrate from lakes to spawn in rivers, following which the new recruits find their way into lakes to settle. Current regulation of lake water levels prevents natural recruitment in most lakes, leading to the depletion of aquatic resources.

Clearly there is a need for effective coordination among those institutions with responsibility for lake management. This coordinating role should be assigned to Regional Lake Management Commissions which, in turn, must be given the authority to ensure compliance with its directives. Regional Lake Management Commissions would be best placed to fill this coordinating role as they would have a knowledge of the local environmental conditions, and could best accommodate the specific needs of end-users in the light of the requirement for sustainable use of particular lakes.

Social conflicts over how to manage lake resources have increasingly become important issues in China. Increases in human population and greater demands placed upon limited resources — especially water — have increased the incidence of such conflicts. Conflicts are most serious when a water body is administered by more than one regional authority, and there are major stakes for each involved party. The most frequent sources of conflict arise from the different requirements of those who need water for drinking, irrigation or fish culture, those who wish to convert the littoral zone to farm land, rice paddies or residential land, and those whose activities lead to water pollution which results in a loss of amenity value to other users as well as the associated health implications that can arise from serious pollution. Conflict resolution with respect to the multiple use of lakes has so far received limited attention even in developed nations. In developing countries such as China, where sound management of inland waters is critical and would be of great benefit in sustaining the use of lake resources, a sound approach to conflict mediation and resolution must be developed urgently.

If a worthwhile social and legal framework is to be established to provide a basis for integrated and sustainable lake management in China, then more attention must be paid to the environmental costs of development. To date, the focus has been on boosting aquatic production and industrial outputs. As a result, China's lakes have become increasingly degraded.

Unfortunately, one apparent consequence of the new market-driven economy is that incentives for focusing on sustainable use of inland waters are low, because the most common concern is with near-term profits. International funding organizations such as the World Bank, the Asian Development Bank, and the United Nations Development Program could play an important role in promoting sustainable development by including environmental costs and the protection and conservation of natural resources in development projects. In addition, they could promote integrated development planning, which would include developers, environmental scientists, government officers and local representatives from the onset of project planning.

While outside funding agencies can play a role, the ultimate responsibility for lake management rests, of course, with the Chinese people and government. Unless they recognize the importance of sustainable use of lakes, and implement appropriate management strategies, many lakes in China will cease to serve the people who have depended upon them for centuries.

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# Environmental Monitoring and Audit of a Major Construction Project in Hong Kong: The West Kowloon Reclamation

*J.M. Nash*

## ABSTRACT

Massive construction associated with the development of the new airport in Hong Kong has required new types of teams (called environmental project offices) for project-specific environmental monitoring and auditing. The first of these offices has been set up in the West Kowloon reclamation area. The reclamation currently being formed will reach a maximum size of over 330 hectares and will support transport links. The constructional impacts predicted by the original environmental impact assessment include: a reduction in water quality as reclamation encloses embayments of polluted water; daytime and overnight noise on nearby sensitive receivers; and, fugitive dust problems.

The main tasks of the Environmental Project Office (ENPO) are to monitor and audit the effects of the construction work in terms of multi-media cumulative impacts and to anticipate and investigate related environmental problems whilst adopting a proactive approach towards cost-effective mitigation measures. Pragmatic solutions to developing problems must be found which do not conflict with the existing contractual framework.

***Keywords:*** *environmental monitoring and audit, environmental impacts, major project infrastructure, dredging, reclamation*

## INTRODUCTION

Within the next four to five years a new expressway, an airport railway and the access to a cross harbour tunnel will be constructed on newly reclaimed land adjacent to the existing Kowloon waterfront. The reclamation under the West Kowloon Project Area (WKPA) forms a massive development site in which the shoreline will be extended westwards by 500 to 1200 m to form a large new land area. The reclaimed land will support essential elements of the transport corridor to Hong Kong's new airport at Chek Lap Kok linking it with the central business districts in Hong Kong Island and Kowloon (Hong Kong Government 1991) and later will accommodate new residential, commercial and industrial developments. Their timely completion is thus an essential element of the overall airport core programme scheduled for completion in 1997.

The pace, scale and complexity of the required works together with their location close to an existing urban area means that significant and cumulative environmental impacts are inevitable. The major impacts are likely to arise from multiple rather than

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individual sources and are expected to include: fugitive dust pollution resulting from the natural materials (sand) used to form the reclamation; the operation of earth moving plant used in the construction works; high noise levels at nearby sensitive receivers (e.g., residences) emitted from static and mobile works plant which will include piling equipment; and, water quality deterioration resulting from the gradual embayment of enclosed water bodies which are currently subject to high pollution loadings.

Water pollution will be further exacerbated by dredging of contaminated mud from the near-shore areas and the rapid placement of clean dredged sand to form the reclamation. As a result of these potential problems local concern groups and the public have voiced considerable apprehension regarding the scale of the likely impacts. These groups have also exerted considerable pressure on the government to ensure that environmental impacts are reduced to an acceptable level.

These concerns resulted in the Environmental Protection Department (EPD) of the Hong Kong Government setting up an independent Environmental Project Office (ENPO) to conduct continuous investigations of the construction sites and environs through the process of environmental monitoring and audit (EM&A), and to develop an on-site working relationship with the works engineers to seek solutions to emerging environmental problems. The ENPO was established in August 1992 under the management of EPD and is formed by a joint venture of consultants.

The on-going site works are divided amongst a large number of current contracts. The environmental pollution from these may be cumulative and pose particular difficulties in isolating emission sources. Although the initial stages of the construction programme are not causing major problems, the expectations are that as the works proceed closer to the existing waterfront the sensitive receivers will become more exposed to impacts from the development. Continuous monitoring and audit of the WKPA will be required to enable innovative approaches for meeting environmental problems when they arise. These initiatives will help contain the problem where legal and contractual controls do not adequately cover the anticipated impacts, or where more conventional methods of environmental control are as yet unavailable.

## THE ENVIRONMENTAL PROJECT OFFICE (ENPO)

Based on the recommendations of the 'Constructional Environmental Impact Assessment' for the WKPA and the early realisation of the potential for serious cumulative impacts from the construction work at West Kowloon, a new approach to environmental monitoring and audit was adopted (Tang and Choi 1992). The scale, complexity and magnitude of the core programme of airport related infrastructure and the complexity of the contractual arrangements meant that a conventional M&A approach would be unsuitable. Formerly the piecemeal nature of the monitoring effort tied to each individual contract, and inability to react in a coordinated and timely fashion to assist in rapid environmental problem solving resulted in public concern regarding possible wholesale environmental degradation.

The new approach described here takes account of these factors by unifying the monitoring and audit function for all Airport Core Programme (ACP) contracts within the WKPA under one umbrella organisation (the ENPO), and appointing a specialist team of consultants to undertake the work. The selection of the project team was by competitive tender and a joint venture consortium of two consultants and a commercial laboratory was appointed to form the project office.

The work of the project office commenced in August 1992. It will operate initially for a period of two years under an agreement with EPD. At the time of writing, the project has been in progress for about nine months. The results presented here therefore reflect the situation during that initial period of the project.

### The Objectives of ENPO

The broad purpose and objectives of ENPO can be defined as follows:

(i) to control pollution and reduce adverse environmental impacts and nuisance arising from works in the West Kowloon Project Area;

(ii) to identify sources of pollution, impacts or nuisance particularly of a cumulative nature (from multiple sources), which arise as a result of the works;

(iii) to propose timely, cost effective, and practical solutions to problems through liaison with the site engineers, contractors and government works agencies;

(iv) to ensure implementation of appropriate mitigation measures;
(v) to collect and maintain an up-to-date multimedia database of monitoring information from the project area;
(vi) to audit the results by determining baseline pollution levels for the area and to set trigger, action and target exceedance levels;
(vii) to provide regular notification of existing or predicted problems via regular reporting procedures;
(viii) to ensure the accuracy of all sampling and monitoring information; and
(ix) to provide independent professional advice and support to government in public consultation and liaison.

The project office therefore has an interactive liaison role between the EPD, the works departments, the contractors and the community. In addition, it must retain a high degree of credibility in its dealing with the engineers, particularly in proposing cost effective and pragmatic solutions to environmental problems resulting from the complexity of the works programmes. It must also remain credible in the eyes of the public and media who are demanding increasing consultation.

## WEST KOWLOON PROJECT AREA SCOPE OF WORKS

The WKPA comprises two main current works areas, the northern area and the southern area. These areas are under the respective control of the Project Manager — Urban Area Development (Territory Development Department) and the Civil Engineering Department of the Hong Kong Government (Lo and Tsui 1992). The works are further subdivided into operational contracts. These are normally undertaken by consortia of large construction companies which have entered into joint ventures for a specific contractual commitment. The scope and complexity of the works can be gauged by reference to Table 1 which outlines the scale of the works and some of the volumes and quantities involved.

The WKPA consists of a major area of reclaimed land (334 hectares) which will support major transport infrastructure. The major developments are:
(i) the land reclamation;
(ii) related drainage infrastructure;
(iii) a section of the new Airport Railway;
(iv) the West Kowloon Expressway; and
(v) the Western Harbour Crossing Tunnel entrance.

Each of these developments forms a strategic

**Table 1**
**Construction Details West Kowloon Projects**

| | *Scope of Works* |
|---|---|
| West Kowloon Reclamation | Reclamation Area: 334 ha<br>Dredging: 35 $Mm^3$<br>Sand Fill: 67.1 $Mm^3$<br>Sea-wall: 6.3 km<br>Breakwaters: 1.4 km<br>Multi-cell Culverts: 8.6 km<br>Local Roads: 12.5 km |
| West Kowloon Expressway | Length: 4.2 km<br>Concrete: 300 000 tonnes<br>Reinforcing Steel: 40 000 tonnes<br>Viaducts: 134 043 $m^2$<br>Road Surfacing: 160 000 tonnes |
| Airport Railway | Configuration: Twin lines (Airport Express and Lantau Lines)<br>Stations: Two in WKPA at Kowloon and Tai Kok Tsui<br>Alignment: Tracks run at grade and underground (through cut and cover and immersed tube construction) |
| Western Harbour Crossing | Configuration: Dual 3 lane immersed tube (concrete) tunnel<br>West Kowloon Exit: Tunnel portal plus 20 lane toll plaza<br>Infrastructure: Ventilation building at each end of the crossing |

part of the required transport links between Hong Kong Island, Kowloon and the new airport at Chek Lap Kok.

The reclamation at West Kowloon is to be formed by the hydraulic placement of over 67 million cubic metres of dredged sand behind sea-walls (Plate 1) to form a land platform capable of supporting major roads, railway alignments, viaducts and buildings (Hong Kong Government 1993). For reasons of foundation stability and in order to construct the reclamation and infrastructure within the required time frame, pre-dredging of over 35 million cubic metres of soft mud from the existing sea-bed has also been required. Some of these muds are highly contaminated with heavy metals and organic pollutants arising from uncontrolled discharge of industrial wastes from the Kowloon hinterland.

Pollutants which have hitherto been allowed to discharge to the sea have resulted in contaminated muds accumulating near the sewerage and drainage system outfalls. These muds are required to be removed by grab dredger and disposed at a remote marine dumping ground. When completed, this facility will be securely capped and sealed preventing toxic pollutants from escaping into the marine environment. New drainage structures including multiple-cell box culverts (Plate 2), a new sewerage system, and the introduction of increased legislative controls will help alleviate pollution loadings in the area within the next few years.

The West Kowloon Expressway will comprise a 4.2 km section of dual three lane highway, which will emerge from the new cross harbour tunnel in southern Kowloon. The expressway will include major interchanges and an elevated section which will support part of the alignment of the new airport railway. This railway will be constructed both at grade beneath the expressway and rising from the tunnel alignment. Two stations will also be constructed within the West Kowloon area. A large proportion of the works described above will be carried out within 500 m of the existing shoreline (Plate 3) close to existing sensitive receivers.

**Plate 1** Rainbowing sand from a large dredger to form the reclamation.

**Plate 2** Formation of a multiple-cell box culvert on the West Kowloon Reclamation.


**Plate 3** Proximity of the works to sensitive receivers in the Kowloon hinterland.

## THE MONITORING AUDIT SET-UP

At the same time as the appointment of a joint venture consultant to undertake the coordination of the monitoring and audit (M&A) work, it was necessary to establish the basic framework for a monitoring network which the successful consultant would take over and develop. The initial monitoring regime for the project area comprises ten air quality monitoring stations, seven noise and five water quality monitoring stations. The specifications of these are shown in Table 2. The main concerns arising from the ongoing works are:

(i) impacts on the local community from air borne dust in the form of total suspended particulates;
(ii) noise from the large variety of plant and machinery operating on the site;
(iii) overnight noise from works which are required to continue for 24 hour periods due to tight programme constraints; and
(iv) deterioration in water quality as the reclamation proceeds towards the former shoreline and the embayed water bodies reduce in size as the reclamation expands.

The distribution of monitoring stations for air, noise and water are shown in Figure 1. The locations were determined by the Environmental Impact Assessment (EIA) on the construction impacts of the WKPA which identified the position of the most sensitive receivers, normally located in the hinterland immediately adjacent to the former shoreline.

### Monitoring Equipment

The monitoring equipment used during the programme is summarised in Table 3. Regular calibration of on-site monitoring equipment is undertaken by the ENPO. Laboratory analysis of samples as well as data recorded in the field is also regularly subjected to quality assurance and control procedures.

## CURRENT ENVIRONMENTAL CONDITIONS

### Governing Standards

Currently, three main pieces of legislation are implemented to control emission standards. The Air Pollution Control Ordinance governs emissions to the atmosphere and sets air quality objectives for the Territory for various parameters as shown in Table 4.

Dust emissions measured in the form of total suspended particulates are the main air quality concern in the WKPA. Carbon monoxide and nitrogen dioxide although a problem in the Kowloon

**Table 2**
**Summary of Monitoring Requirements**

| *Item* | *Air* | *Noise* | *Water* |
|---|---|---|---|
| Parameters | TSP (24 hour) and Ad hoc 1 hour | 3 consecutive readings of $L_{eq}$ (5 mins) | 2 consecutive readings of turbidity, DO, and DO% sat$^n$. Lab analysis of SS |
| Locations | 10 | 7 | 5 at 3 depths with 2 control stations |
| Baseline Frequency | every day for 2 weeks | every day for 2 weeks | 4 working day/week for 4 weeks |
| Baseline Check | 4 times/ year | 4 times/ year | Daily for 2 weeks 4 times /year |
| Normal Frequency | 1 in 6 days | weekly | 3 working days/week |
| Scheduling Requirements | None | None | On mid-ebb and mid-flood. Gaps between sampling > 36 hours |
| Additional Requirements | Occasional ad hoc monitoring | In restricted hours where permits apply | Daily monitoring if levels are above trigger until quality is acceptable |

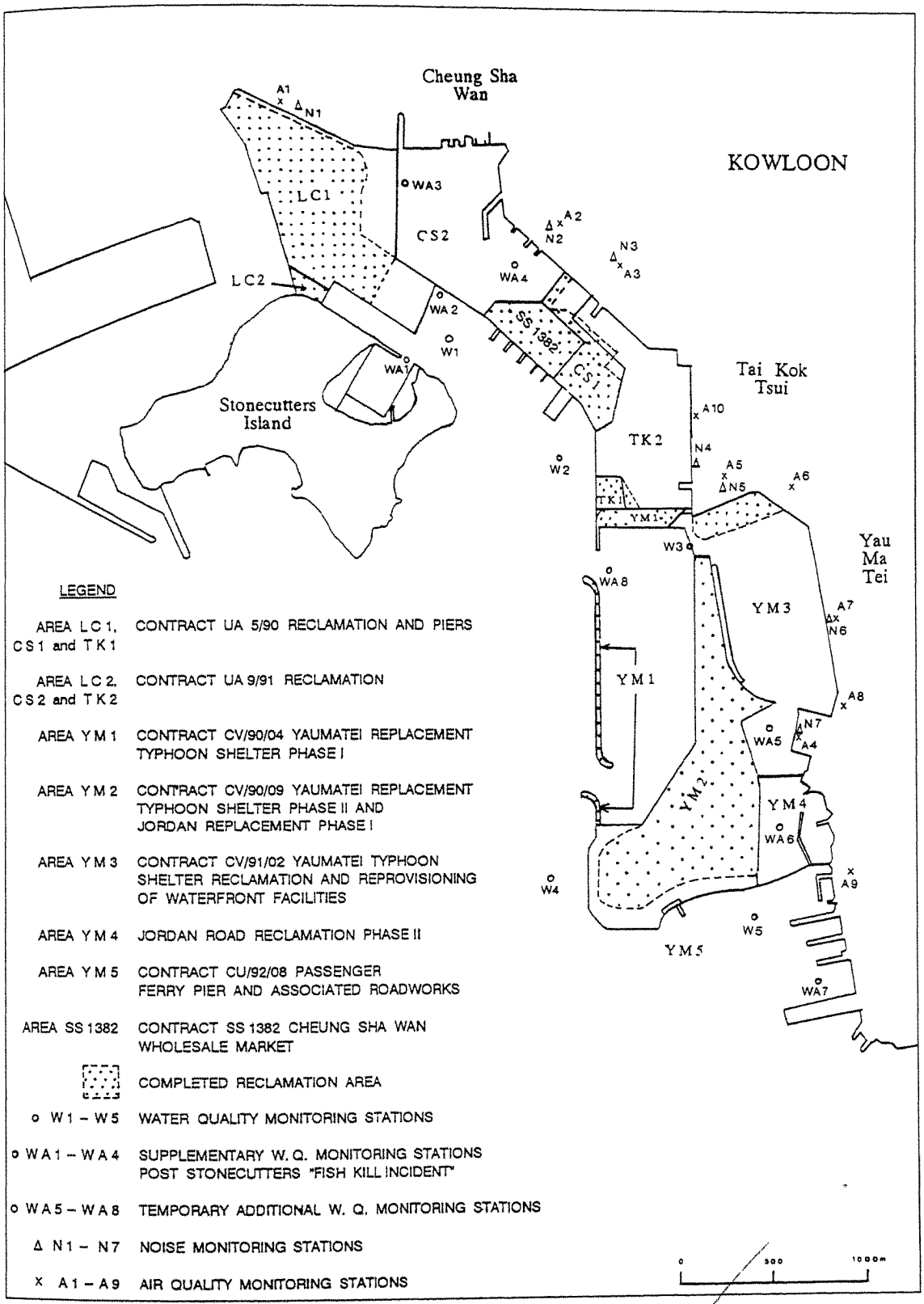


**Fig. 1** Environmental monitoring networks for the West Kowloon project area (May 1993).

**Table 3**
**Monitoring Equipment Employed in West Kowloon**

| | |
|---|---|
| Air | ***Dust (TSP):*** GMWL –2000 High volume air sampling system |
| | ***Wind:*** WD401 Wind speed and direction sensor connected to a MET EL 8 data logger |
| Noise | Bruel and Kjaer modular precision sound level meter type 2231 with statistical analysis module BE 7101 |
| Water | ***Turbidity Measurement:*** Hach 2100P |
| | ***Dissolved Oxygen/Temperature:*** Model 58 DO meter with 30m cable and YSI5739 probe with YSI 5739A submersible stirrer for in situ DO measurements; YSI Model 33 conductivity meter for salinity for calibrating DO meter; YSI temperature sensor |
| | ***Navigation:*** Magellen NAV 5000 |
| | ***Sampling at Depth for SS:*** Kahlsico water sampler with vented drain and messenger |
| | ***Depth Finding:*** Seafarer Model 701 echo sounder |

**Table 4**
**Hong Kong Air Quality Objectives**

| *Parameter* | *Average Concentration µg/m³* | | | |
|---|---|---|---|---|
| | *1 hour** | *8 hour* | *24 hour*** | *Annual* |
| CO | 3000 | 1000 | – | – |
| $NO_2$ | 300 | – | 150 | 80 |
| TSP | 500+ | – | 260 | 80 |

* Not to be exceeded more than three times a year
** Not to be exceeded more than once per year
\+ In addition to the above established legislative controls, it is generally accepted that an hourly average TSP concentration of 500 µg/m³ should not be exceeded. Such a control limit is normally applied to construction work rather than traffic particulate emissions.

**Table 5**
**Selected Noise Standards from HKPSG**

| *Use* | *Road Traffic Noise, $L^{10}$ (1hr), dBA (A)* |
|---|---|
| Domestic Premises | 70 |
| Educational Institutions | 65 |
| Nurseries & Kindergartens | 65 |

**Table 6**
**Acceptable Noise Levels for Construction Noise**

| *Time Period* | *ANL, dBA (A)* | | |
|---|---|---|---|
| | *ASR=A* | *ASR=B* | *ASR=C* |
| Evenings (1900–2300), holidays during day-time and evening (0700–2300) | 60 | 65 | 70 |
| Night-time (2300–0700) | 45 | 50 | 55 |

hinterland are unlikely to pose major problems during construction.

Construction noise is controlled by the Noise Control Ordinance. Through this legislation a Technical Memorandum defines the statutory limits to be applied during construction and operation of any facility. The Hong Kong Planning Standards and Guidelines (HKPSG) also sets out limits for acceptable levels of noise from various sources although these do not have any statutory basis (Table 5).

Noise from the WKPA will arise during the daytime from both piling activities and from other construction plant and at night-time from works such as the erection of bridge decking. During the evening and night-time noise levels are regulated through construction noise permits issued by EPD. These are area specific (Area Sensitivity Ratings — Table 6) and depend on the location of the nearest sensitive receiver and the degree of background noise or acceptable noise levels (ANL). The permits set noise limits on the plant intended to be operated in the area which must not exceed the background noise level. No piling is allowed during the evening and night-time.

Water quality is controlled under the Water Pollution Control Ordinance which defines water control zones (WQZ) in Hong Kong. The WQZ for

Victoria Harbour has not yet been declared and hence there are at present no statutory controls over water quality emission standards in the WKPA.

The ENPO has however set limits based on the overall water quality objectives established for the harbour area. These standards are used to establish water quality targets within the project area.

## Monitoring Results: Non-compliance With Action and Target Levels

Monitoring results in the form of exceedances for the period September 1992 to March 1993 are shown in Table 7. Results from the monitoring of air quality, noise, and water quality monitoring are discussed below.

### *Air Quality Monitoring Results*

Monitoring results from four stations were available in January, six in February and seven in March 1993. Delay was experienced in setting up the air monitoring network, and sampling did not commence until December 1992. Eight stations are currently operational with the remaining three expected to be on line shortly. In addition, two wind speed and direction monitoring stations have been commissioned.

The data have shown the prevailing wind to be from the north-east quadrant during the autumn and winter months, and indicated no exceedances. One reading thus far has approached the Air Quality Objectives (AQO) (Fig. 2) in late December 1992. This was associated with the entrainment of fine particulates after a period of exceptionally dry weather. Wind speed and direction information became available in February 1993 and showed winds predominantly from the north-east. Tentative trigger, action and target levels have been set at 220, 240 and 260 $\mu g/m^3$/day, respectively. The target level in this case is actually Hong Kong's AQO for total suspended particulates (TSP).

### *Noise Monitoring Results*

Night-time noise level exceedances are mainly attributed to high background (traffic) noise levels within the project area. Some contravention of night-time construction noise permits has occurred resulting in complaints from the general public. However, at certain locations, the background levels often exceed any noise emanating from the works site.

As a result in February 1993, ENPO recommended, as part of the six monthly review that site specific night-time ANL's be increased to 60 dBA to accommodate the high background noise levels. This recommendation does not constitute a relaxation of statutory standards for construction noise, merely a realization that ENPO will not be able to detect and act upon construction noise unless it exceeds background levels. Figure 3 shows noise

**Table 7**

**Exceedances of the ENPO Action and Target Levels September 1992 to March 1993**

| *Parameters for Monitoring and Audit* | *Number of Days with Exceedance* | | | *Number of Action Plan Implementations* | | |
|---|---|---|---|---|---|---|
| | *Trigger* | *Action* | *Target* | *Trigger* | *Action* | *Target* |
| Air | 0 | 0 | 0 | 0 | 0 | 0 |
| Noise (day) | 0 | 0 | 1 | 0 | 0 | 0 |
| Noise (evening) | 0 | 0 | 1 | 0 | 0 | 0 |
| Noise (night) | 0 | 0 | 19 | 0 | 0 | 0 |
| Water DO (surface) | 9 | 5 | 3 | 0 | 0 | 2 |
| Water DO (bottom) | 8 | 10 | 1 | 0 | 0 | 0 |
| Water SS | 14 | 14 | 8 | 1 | 0 | 0 |
| Water Turbidity | 19 | 22 | 13 | 0 | 0 | 0 |

Note: *Trigger Levels* are defined as the levels beyond which there is an indication of a deteriorating ambient environmental quality for which a typical response can be increasing the frequency of monitoring.
*Action levels* are defined as the levels beyond which appropriate remedial actions may be necessary to prevent the environmental quality from going beyond the target limits, which would be unacceptable.
*Target levels* are defined as the levels stipulated in relevant pollution control ordinances, or Hong Kong Planning Standards Guidelines, or established by EPD for a particular project, beyond which the works should not proceed without appropriate remedial action, including a critical review of plant and work methods.

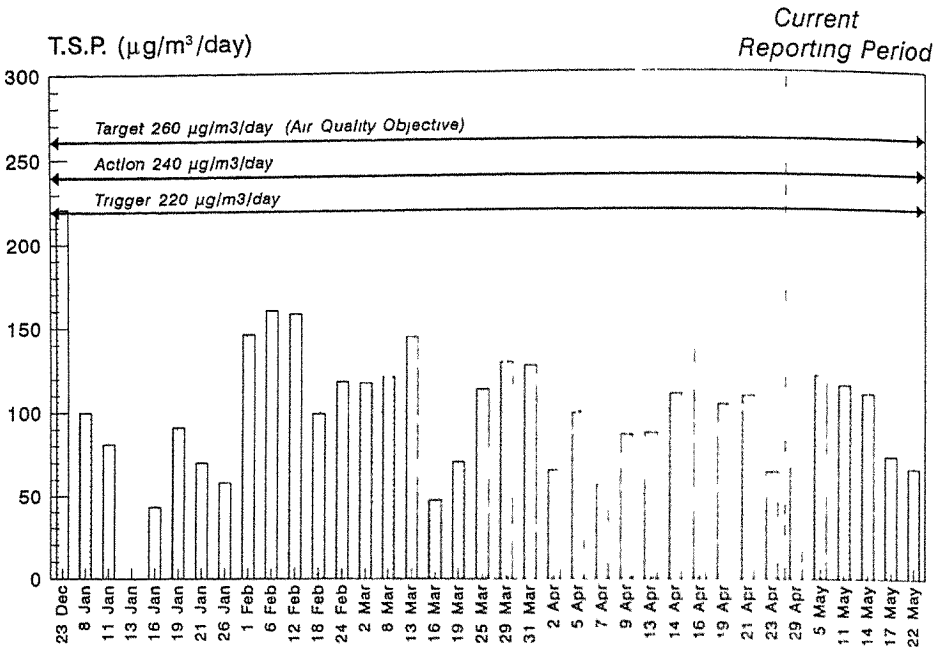


**Fig. 2** Total suspended particulates Station1

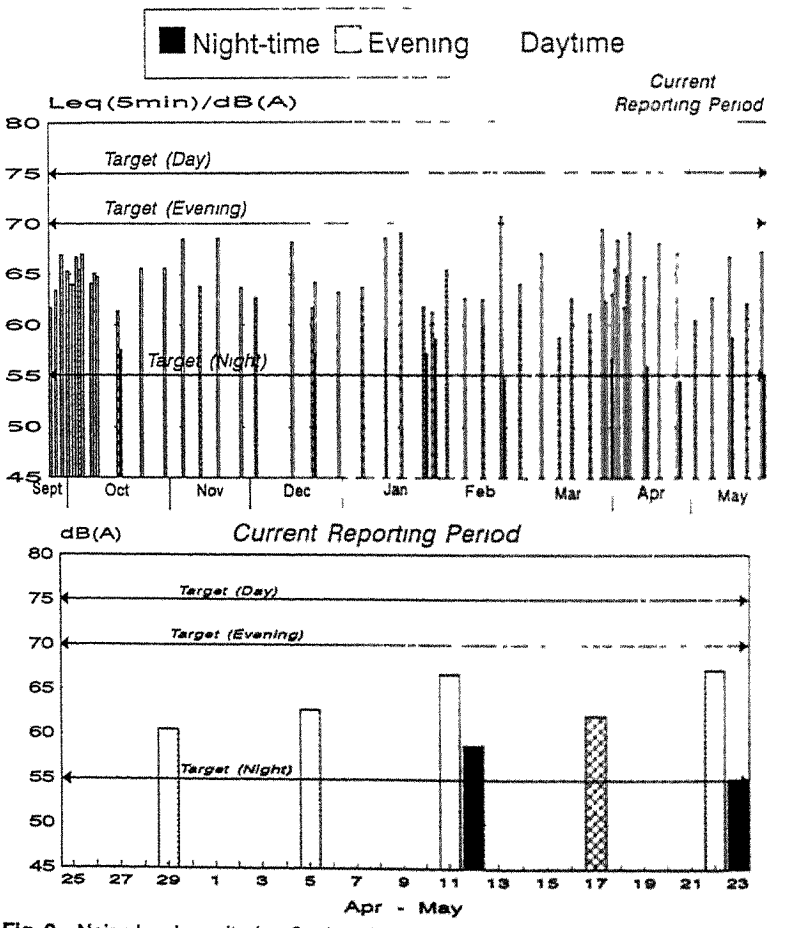


**Fig. 3** Noise level monitoring Station N3.

levels recorded during the first six months of the project at a station in Yau Ma Tei. Target levels for daytime and evening have not been exceeded but night-time levels have been exceeded on a number of occasions. These exceedances are mainly attributable to traffic noise rather than constructional activities.

### *Water Quality Monitoring Results*

Action and Target levels were exceeded frequently in the early part of the project. However, conditions improved markedly during the months of winter and spring 1993. Dissolved oxygen levels (Fig. 4), turbidity (Fig. 5) and suspended solids (Fig. 6) have also reduced significantly due to drainage improvements, tidal effects, cooler weather and the reduction or cessation in fill placement.

Water quality is predicted to deteriorate again in the summer months as a result of the initial flushing of accumulated pollutants in drainage channels by the first heavy rains combined with adverse tides. Pollution inputs to the inshore water bodies at West Kowloon have reduced by over 70% since September 1992 with the commissioning of the new sewerage scheme and dry weather interceptors at various locations in the immediate hinterland. This has led to a much improved situation with regard to overall water quality.

Nonethless, it should be noted that a great deal of variability exists within the project area depending on location, tidal effects, and seasonal effects. Flexible monitoring arrangements are built-in to the agreement to cope with unforeseen incidents such as the major fish mortality incident — the

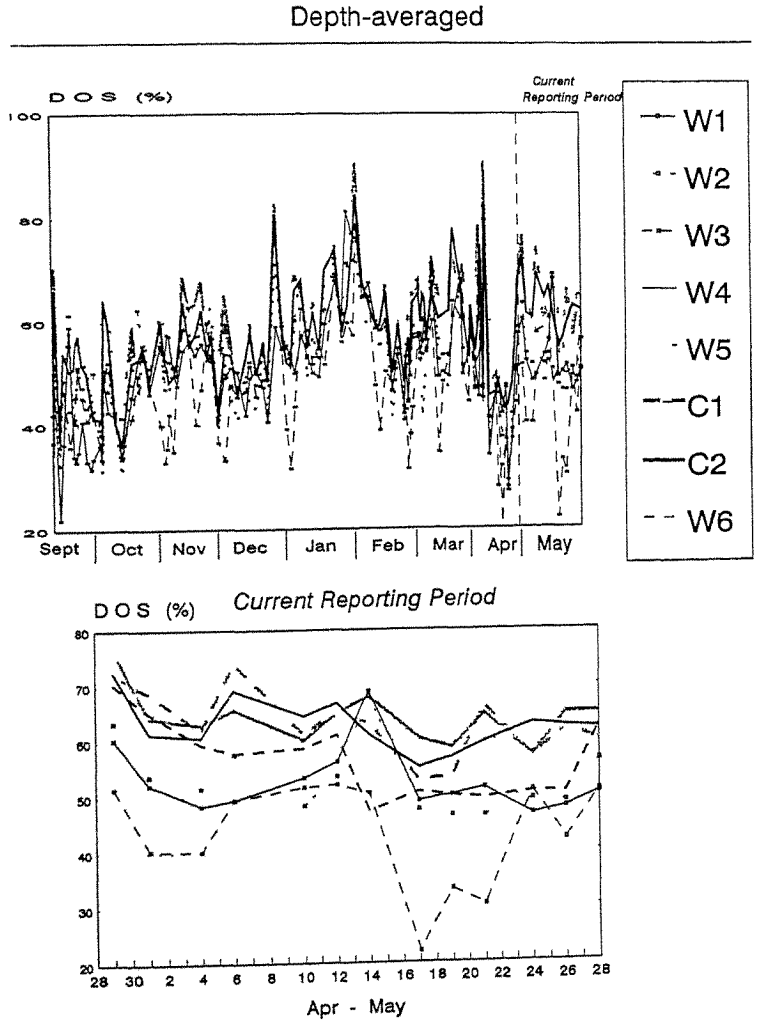


**Fig. 4** Dissolved oxygen saturation.

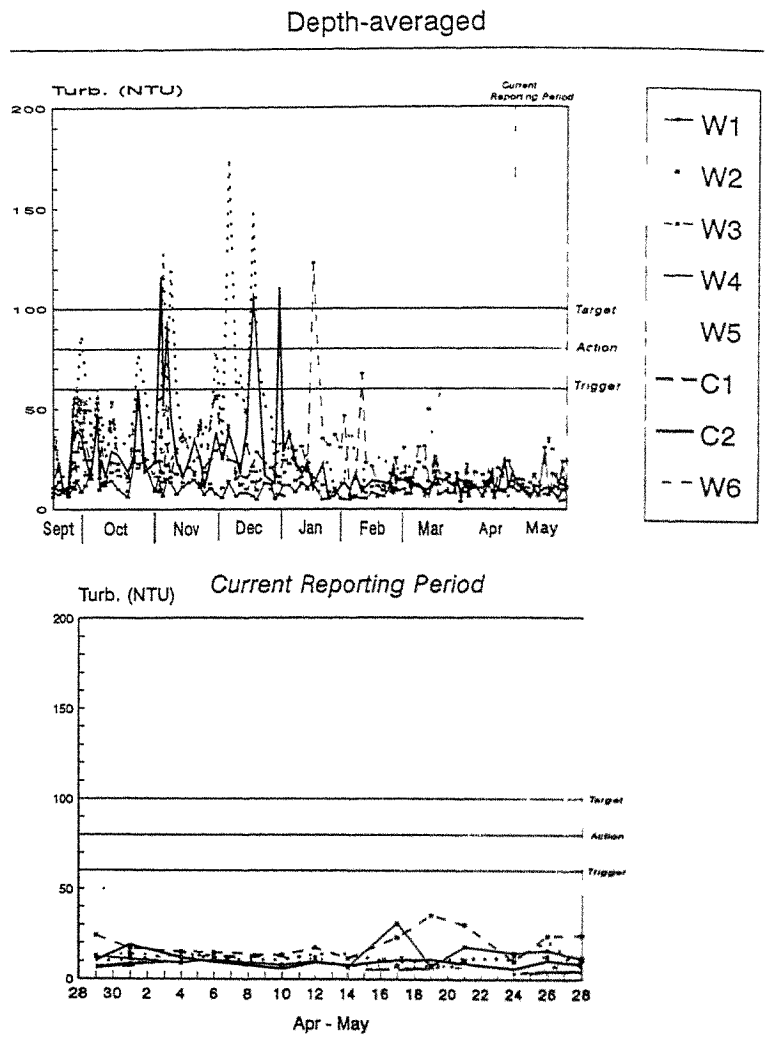


**Fig. 5** Turbidity.

'Stonecutters fish-kill' — which occurred in August 1992 which resulted in considerable publicity and attention focused on that particular area. Additional stations can be added on an 'as needed' basis and monitoring frequency can be increased.

## Audit Results: Implications of Non-compliance

### *Air Quality*

Although no measured exceedances have been reported thus far, complaints have been received regarding dust from sand surcharge piles on the reclamation adjacent to Mei Foo Estate (Plate 4). Failure to prevent dust emissions in future is likely to result in more complaints from the public particularly as the works move closer inshore. The embayment of stagnant and polluted waters in the short-term near Mei Foo and elsewhere may result in complaints of odours from the public.

### *Noise*

Continued non-compliance with noise permits will result in complaints and legal action by EPD against the contractors involved. Increase in daytime noise levels will also result in complaints from the public. The Hong Kong Planning Standards and Guidelines only provide *advice* on day time noise limits. There is no statutory control of day time noise at present.

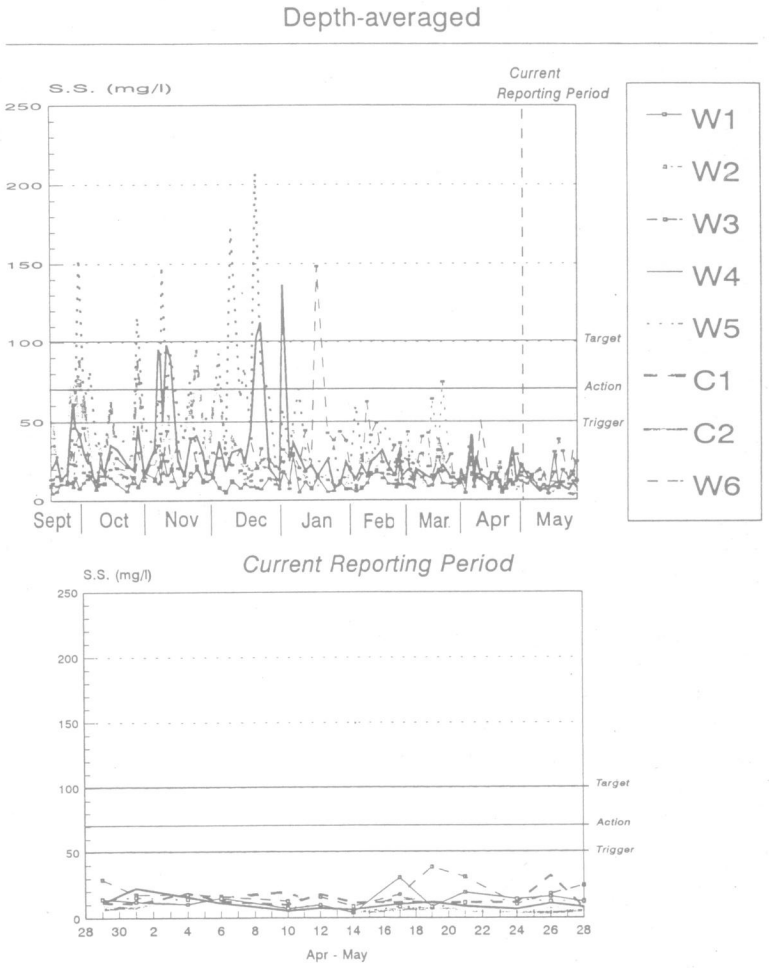


**Fig. 6** Suspended solids.

**Plate 4** Temporary embayment of polluted waters adjacent to Mei Foo Estate — note also the proximity of the reclamation and associated works

*Water*

Continued non-compliance may result in deteriorating water quality and the possibility of foul odour and public health implications. Recent results have, however, indicated a considerable improvement in local water quality. The water quality control zone for Victoria Harbour has not yet been declared under the Water Pollution Control Ordinance. It is intended that this will be brought into operation in stages commencing around 1995.

## Action Plans

Action Plans are implemented by the ENPO on the basis of exceedances and or complaints received from the general public by the EPD's *Pollution Control Hotline*. The protocol for implementation of Action Plans is 'parameter' dependent. For example, in the case of air and noise, certain levels must be exceeded for a specific period of time and be accompanied by at least one complaint from the public. Water, by contrast, is not complaint dependent and is further broken down into exceedance levels for each of the various monitoring parameters (e.g., dissolved oxygen). A summary of Action Plan initiation appears in Table 8.

## PROPOSALS FOR REMEDIAL MEASURES AND FOLLOW-UP ACTIONS

The ENPO has made a number of proposals to improve site works from an environmental perspective, these include:

(i) early commissioning of dry weather flow interceptors and drainage culverts;
(ii) installation of temporary pumps, effluent detouring, creating greater tidal circulation to flush out stagnant water and redirection of polluted inflows to sewer;
(iii) ENPO recommendations regarding dust suppression and good site housekeeping to minimize fugitive dust emissions — these

**Table 8**
**Guidelines for Initiation of Action Plans**

| | *TAT* Exceedance Levels* | | *Action Plan Implementation* |
|---|---|---|---|
| Air | T = 220 μg/m³/day<br>A = 240 μg/m³/day<br>T = 260 μg/m³/day | | Receipt of complaints in addition to exceedances |
| Noise | Daytime<br>T =<br>A = > 75dB(A)<br>T = | | Complaint Received |
| | Night-time<br>TAT = > 55dB(A) | increase to > 60 dB(A) due to high background traffic noise | Complaint Received |
| Water | DO<br>T = < 2.50 mg/L<br>A = < 2.25 mg/L<br>T = < 2.00 mg/L | | Readings less than specified level on 2 consecutive monitoring days |
| | SS<br>T = > 50 mg/L<br>A = > 70 mg/L<br>T = 100 mg/L | | Readings above specified level on 2 consecutive monitoring days |
| | Turbidity<br>T = > 60 NTU<br>A = > 80 NTU<br>T = >100 NTU | | Action Plan deactivated if daily depth averaged readings below specified levels |

*TAT = Trigger, Action and Target Levels

include reduction of sand surcharge piles, demarcation and watering of site haul-roads, creation of wind-rows on exposed areas of sand, and the placement of a tack-coat layer on elevated surcharge piles;

(iv) modifications to the method of sand placement from dredgers to reduce suspended solids (SS) in local waters,

(v) fast-tracking of contaminated mud dredging to take advantage of locally improved water quality; and

(vi) marine disposal (at East Sha Chau) of non-floatable contaminated solids dredged up from within the old typhoon shelter.

The above remedial or proactive solutions have been taken up by the Engineers and have been implemented by their contractors during the first six months of the ENPO project. If problems continue or appear not to be resolved under the usual means of liaison, then resolution can be sought via intervention at a higher level (Branch Secretary level) by representatives of the Works Branch, and by the Planning, Environment and Lands Branch of the Hong Kong government.

### Complaints From the Public

Complaints are received through the EPD Pollution Complaints Hotline and are passed on to the ENPO for investigation (Table 9). The engineers are also contacted in all complaint cases and various remedial actions are devised and implemented in consultation with EPD and the works agencies.

**Table 9**
**Monthly Distribution of Complaints Received September 1992 to March 1993**

| | *Sept/Oct* | *Nov* | *Dec* | *Jan* | *Feb* | *March* |
|---|---|---|---|---|---|---|
| Air | 3 | 0 | 2* | 1* | 0 | 2 |
| Noise | 11 | 0 | 0 | 1 | 0 | 3 |
| Water | 0 | 0 | 0 | 0 | 0 | 0 |

*odour from drainage waters

These have included investigation of overnight noise, reducing stockpile heights, placement of protective layers to prevent dust blow, re-establishing tidal flow in the vicinity of Mei Foo, and re-routing drains and pumping foul waters away to sewer. Breaches of noise permits have resulted in contractors being initially cautioned and warned of possible prosecution if repeat offenses occur.

### *Community Liaison*

In order to better inform and involve the public, information on the project is provided to public meetings and representations including District Boards and various concern committees and green groups on a regular basis. In addition, interviews are given periodically with the press and television. The Environmental Pollution Advisory Committee (EPCOM) is kept informed through periodic presentations as well as tours of the site works areas to view the environmental monitoring programme and on-going works.

## CONCLUSION

The ENPO is a new concept in environmental monitoring and audit in Asia. It has been devised to cater for a complex works situation which is likely to create significant and cumulative impacts particularly on the local community adjacent to the works area.

Currently in Hong Kong there are many large and essentially similar construction projects, either already underway or substantially planned, associated with the airport and port development. The ENPO style of monitoring and audit offers a realistic option in achieving an adequate level of environmental control and provides a vehicle for rapid mitigation of problems arising from the works. This is particularly important in the case of the massive on-going works programmes in Hong Kong which face very tight completion schedules and are likely to severely stress the local environment.

The scale of works associated with the ACP projects in Hong Kong is such that environmental impacts of one form or another are inevitable. The task at hand is to keep these to a minimum.

The ENPO arrangement has enabled a much more rapid response to environmental problems than has been possible hitherto. Anticipation of likely impacts associated with certain parts of the works programme and the establishment of early dialogue between the works agents and those involved with environmental protection has resulted in timely

mitigation and remedial actions. In the initial nine months of the project, the ENPO has anticipated many potential works associated environmental problems. Through its timely environmental monitoring and audit approach and continued on-site presence, ENPO has provided rapid, pragmatic and innovative mitigatory solutions to environmental problems.

The major benefit of ENPO has been the alliance of systematic and reliable monitoring programmes with practical on-site observations by works engineers. This has resulted in impacts being reduced to a tolerable or acceptable level in an area of intense construction activity.

To date, therefore, the project office has registered considerable success and, although its influence is restricted to only one of the many ACP projects, expansion of the concept to adjacent areas is imminent. Consideration of other project areas for inclusion under an ENPO arrangement is already in the pipeline.

The ENPO concept could be considered to be equally applicable to other areas of Asia undergoing rapid development. Consideration of this style of monitoring and audit exercise should therefore be included as part of the initial planning procedure, especially for massive works projects involving substantial construction activities and changes to existing land or water systems. In short, establishment of an environmental project office with designated authority for action as an integral part of large-scale works projects certainly warrants careful consideration as a flexible and expedient mechanism of environmental control.

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# Multiobjective Analysis for Discharge Management Programmes: A Case Study of the Tung-kang River Basin, Taiwan

*Jehng-Jung Kao, Edward Ming-Yang Wu and Jeun-Ren Hwang*

## ABSTRACT

Total waste mass load based discharge regulation was recently promulgated by the EPA, Taiwan, R.O.C. for the purpose of improving the water quality of natural water bodies. A multiobjective analysis and evaluation procedure has been developed in this research to assist the implementation of this new regulation. Transferable discharge permit (TDP), an economic incentive based policy, was analysed using several scenarios for examining the policy risk in violations regarding current water quality standards. Analysis results are intended to provide decision makers with appropriate information for implementing planning and management tasks. A case study of the Tung-kang River basin in Taiwan was adopted in order to demonstrate the applicability of the procedure. QUAL2E, a water quality model, was utilized for water quality simulation. Four criteria: water quality, waste load, equity, and the area under the BOD curve, were employed for evaluating the results derived from several different discharge management methods. The use of the ideal solution approach to locate a best-compromise solution was also discussed. Four different scenarios, three of them based on previous work and another on economic incentives, were adopted for simulating a TDP market. The outcome on water quality following permit redistribution was analysed by QUAL2E. A good compromise discharge program is expected to be identified by using this multiobjective evaluation procedure.

***Keywords:*** *water pollution discharge management, multiobjective analysis, transferable discharge permit*

## INTRODUCTION

A recent national policy amendment (ROCEPA 1991) on water quality management in Taiwan will require local environmental protection agencies to determine an appropriate discharge permit program based on the total pollution load of a river basin. The previous policy for river water quality control was primarily based on effluent concentration (EC). The EC method is simple and easy to understand and is based on the assumption that good water quality can be secured by ensuring a low pollutant level. Unfortunately, a low effluent concentration does not always guarantee good river water quality, because it can deteriorate significantly as a result of a large waste volume at low concentration. The increasing number of dischargers generate mounting waste flows into some rivers in Taiwan, and thus their water quality is deteriorating.

The EC method also does not consider the social

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cost and equity (Brill et al. 1976). Using a uniform concentration limit for all dischargers is not cost-effective because of the economies of scale and, due to its high financial burden, using this approach may not be fair for dischargers with small waste flow at high concentration. Because of these drawbacks, the EC method failed to control the water quality of some rivers in Taiwan. A new policy based on total mass load was therefore initiated.

Discharge management based on total mass load (TMLWQM) is a complex activity. In determining an appropriate program, many issues such as cost, equity, and environmental quality should be carefully evaluated. Decision makers are expected to review the trade-off among these conflicting issues before making a decision. The new policy initiates a management scheme which is significantly different from the one that previously existed. Regional officers may thus not be aware of the problems which might be encountered in implementing the new program. A series of research projects have been launched in the hope of developing a systematic evaluation procedure which regional officers may follow easily.

Figure 1 shows a preliminary analysis process of the new program. As part of the series of research projects, the goal of this study is to develop an

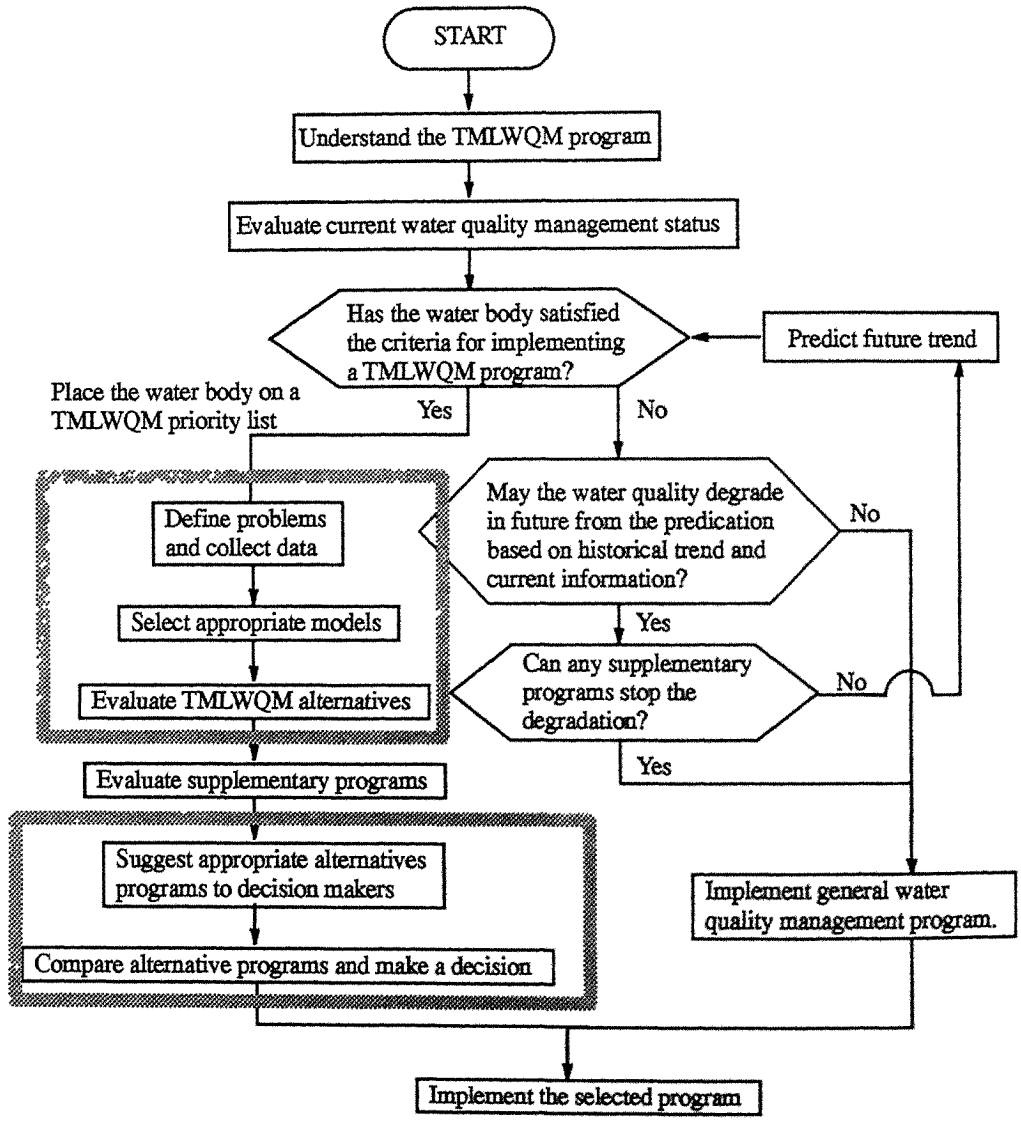


**Fig. 1** A preliminary evaluation procedure for TMLWQM programs.

evaluation procedure for comparing several TMLWQM programs. Other than the data collection and problem definition (Fig. 1), an appropriate mathematical model is usually required in order to select an appropriate waste allocation program in the early stage of the evaluation procedure (Chadderton and Kropp 1985; Rossman 1989; Orlob 1992). Expertise to determine an acceptable waste load based on assimilative capacity and reaeration of the waterbody is also necessary. Once the acceptable load is computed, an optimization or decision making model for discharge is then incorporated into the selection process to resolve a best compromise program. To this end, other approaches were also proposed. Some researchers use statistics based approaches to analyse discharge management problems, such as the chance constraint method (e.g., Ellis 1987) and risk analysis (e.g., Hathhorn and Tung 1988). In this study, TMLWQM programs can be categorized into two types: command-and-control and economic incentive. The former is the conventional method using rigid regulations to control water quality, and the latter places a lower regulatory burden on the dischargers. The economic incentive based program utilizes the market mechanism to balance the trade-off between environmental quality and social cost. The transferable discharge permit method (sometimes called market based permit) is a promising approach and has been applied for several years in the United States (Eheart 1980; Lyon 1982; O'Neil 1983; Lence et al. 1988; Malueg 1989; Malueg 1990). This economic incentive-based method is also evaluated in this study for the possible risk of it leading to violation of water quality standards.

## TMLWQM PROGRAM EVALUATION PROCEDURE

The evaluation procedure proposed in this research for analysing TMLWQM programs is shown in Figure 2. This procedure is used as part of the process shown in Figure 1 for tasks indicated inside the shaded boxes. It is assumed that the water body considered was not effectively controlled by the conventional EC method before applying this evaluation procedure. The main purpose of applying the procedure is to provide decision makers with adequate information derived from multiobjective analyses. The information is expected to provide decision makers with a valuable insight into the problem and thus a better decision may be made. The major components of the procedure include problem definition and data collection, selection of an appropriate water quality model, definition of the objective, formulation of TMLWQM program models, program evaluation, and evaluation of the TDP program. These components are described in detail below. Following these component descriptions, a case study of the Tung-kang River Basin in the south of Taiwan is presented and the usefulness of the proposed procedure is discussed.

### Problem Definition and Data Collection

Once a water body is placed on the priority list for implementing TMLWQM, the problems to be addressed must be defined. For example, questions such as which pollutants are to be controlled, what is the water quality goal, and the time schedule for the pollution control, should be answered. After the problems are clearly defined, data collection should then be implemented for related information such as water uses, water quality standards, relevant water quality parameters for different uses, pollution load characteristics, pollutant source distribution, etc.

### Selection of an Appropriate Water Quality Model Simulation/Calibration/Verification

The acceptable pollutant load of a water body is calculated based on its assimilative capacity. This computation is usually implemented by a computer model. Orlob (1992) gave a detailed discussion of water quality models. Water quality models are categorized by three major characteristics: dimension, time, and state (steady or dynamic). General issues other than the model availability considered for selecting a water quality model are:

- Available functions and applicability: the selected model should at least include the water quality parameters which are required for analysis. The applicability of a model for rivers in Taiwan should be carefully evaluated for special situations, which are not frequently observed in other countries. For example, sections of rivers in Taiwan frequently divide into several small flow lines and later rejoin at a downstream location. The rivers are usually shallow and some riverbeds are covered by boulders. These special situations are difficult

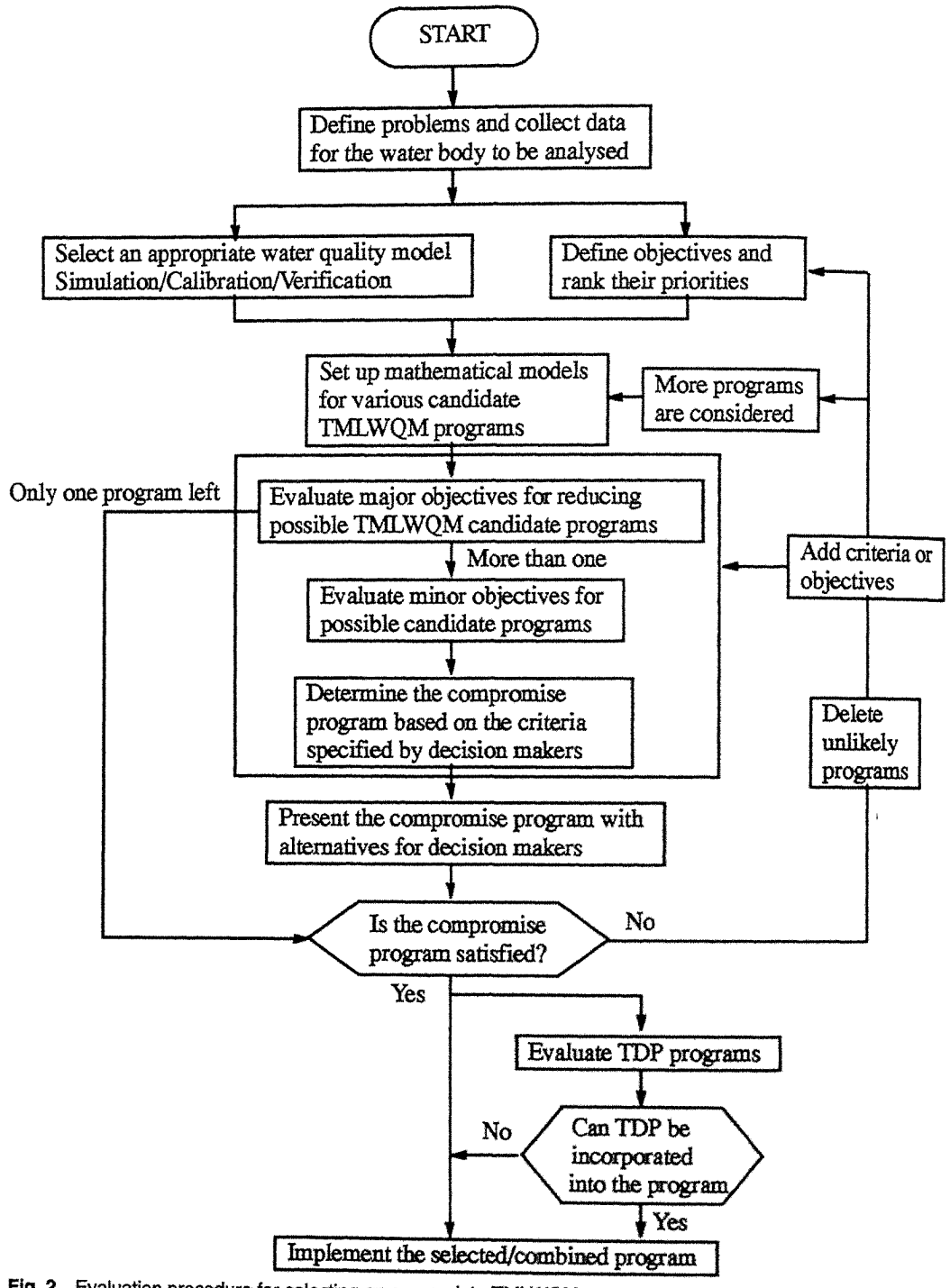


**Fig. 2** Evaluation procedure for selecting an appropriate TMLWQM program.

to simulate and an appropriate model should be carefully selected or developed in order to avoid error caused by improper simulation which may result in an inappropriate decision.

- Complexity: a complex model may be able to simulate complex situations. Unfortunately, it usually requires expertise to carry out the modelling task and the effort made to overcome

the model complexity may not be justified by the additional information or accuracy gained. Furthermore, for a water body with simple and general characteristics, a simple model may perform as well as a complex model.

Data completeness: frequently an appropriate model is available but not enough data are available to run it. In such a situation, either a simpler model is selected or more information should be collected. If data collection is not possible at the modelling stage, a simpler model should be selected.

Required modelling time: the time required for implementing the modelling tasks with the selected model should be estimated for meeting an analysis schedule and coinciding with available resource (e.g., manpower, computing time) constraints.

Required accuracy level: for different WQM tasks, the level of accuracy required for the model result is usually different. For example, for a planning task, modelling accuracy is usually less than for waste allocation tasks.

Predictive capacity of various scenarios: other than simulating the current situation, the selected model should be able to predict the outcome of parameter changes for various scenarios for supporting decision making.

Once the model is selected, model parameters should be calibrated and verified based on observed data. Simulation of the water quality of the target water body can then be implemented. This process is time-consuming and requires expertise. Consequently, additional research is therefore proposed for developing a formal quality control/ quality assurance (QA/QC) procedure for the implementation of these tasks by general users.

## Objective Definition

A TMLWQM approach, as mentioned above, usually requires a consideration of multiple objectives, and these objectives are frequently in conflict among themselves. Four objectives are defined in this research: water quality, waste load, equity, and the (violation) area under/above the water quality curve.

- Water quality: a water body where TMLWQM is to be implemented should be analysed for those pollutants which are of the greatest concern. Usually, general water quality parameters such as dissolved oxygen (DO) or biochemical oxygen demand (BOD) are selected as the target water quality indicators. The water quality standard or the required level associated with the water use is generally used as the goal of this water quality objective.
- Waste load: in conflict with the water quality objective, the waste load objective is to be maximized for better cost efficiency.
- Equity: although the maximal waste load solution may have good cost efficiency, the fairness among dischargers is usually challenged. The definition of equity is however a controversial issue. Group meetings for all related or affected sectors should be held to negotiate a generally acceptable equity definition. This process is time-consuming and may encounter political obstacles. In this research, the equity objective, from the engineering viewpoint, is defined as the summed deviation of waste treatment levels of all dischargers (Brill et al. 1976). The best equity level is defined when all dischargers remove their raw waste loads at the same treatment level.

The (violation) area under/above the water quality curve: to compare alternative programs, possible water quality violations are usually assessed. Hathhorn and Tung (1988) used the river length to define the violation level. The violation river length, however, does not reflect the true violation level. For example, in Figure 3, the violation lengths of cases 1 and 2 are the same when the water standard is equal to two, but the extent of violation is significantly different. Even when the standard is raised to five and both cases can satisfy the new standard, case 1 is still significantly worse than case 2

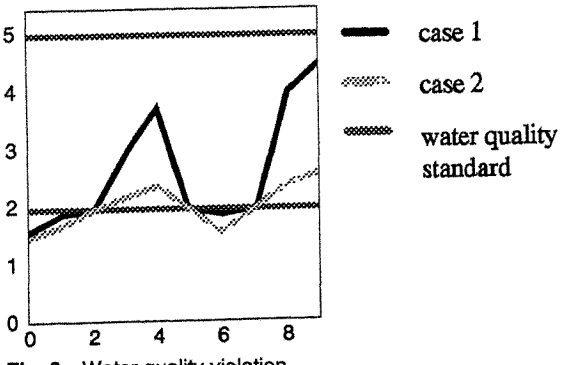


**Fig. 3** Water quality violation.

and has a greater possibility of violating the new standard in the future. The area above the water standard is thus proposed to represent the violation level. (NOTE: if the water quality standard is set for the minimally required level, then the area under the water standard curve should be computed instead.)

Another objective, risk, is not formerly defined but can be analysed through statistical simulation for evaluating TDP programs (which are discussed in a later subsection). The generally considered objective, cost, is not included because no appropriate cost estimation function exists in Taiwan for evaluating the cost objective. The waste load objective, however, can be used as a substitute for the cost objective because the treatment cost is approximately proportional to the total waste load.

## Formulation of TMLWQM Program Models

Four programs are modelled in this study: maximal total waste load (TWL), uniform treatment (UT), zone uniform treatment (ZUT), and functional removal (FR) programs; their model formulations are listed below. The total waste load model is used as a substitute for the generally used least cost model. This substitution is valid because usually at the least cost solution the total waste load is at its maximum. This model is however not practical because bias exists in allocating discharge permits and it is usually employed only as a basis for comparing other alternative programs. Uniform treatment and zone uniform treatment models are therefore commonly utilized (Chadderton and Kropp 1985). The former assures the best equity by requiring a uniform treatment level across all dischargers but with less cost efficiency, and the latter is intended to improve the cost efficiency by dividing all dischargers into several zones or groups, when equity is preserved in each zone or group. The functional removal model uses a pre-specified function to determine the waste reduction policy. A 'weight function' defined based on the magnitude of the raw waste load of a discharger, is tested in this study, while some other functions can be specified by an analyst. The purpose of the weight function is to require large dischargers to remove more waste load. A large discharger who removes more waste load is cost effective because of the economies of scale. Other than the four programs described above, additional programs have also previously been proposed by Chadderton et al. (1981), Chadderton and Kropp (1985), and Burn and Lence (1993).

Total wasteload (TWL) Model

$$\text{Maximize} \sum_{n=1}^{n} WQPL_i$$

subject to

$0 \le WQP_j \le S^*$ for all j;

$$WQP_j - \sum_{i=1}^{n} IC_{ij} * WQPL_i = WQP^b_j$$

for all j; (check points)

$(1 - R^u_i)* WQOK^*_i \le WQPL_j \le WQPL^*_i$

for all i;

other constraints.

where

variables:

$WQP_j$ is the concentration of the water quality parameter at the jth element (mg/L);

$WQPL_i$ is the final discharge waste load form discharger i (kg/day);

constants:

$WQPL^*_i$ is the raw waste load of discharger i;

$WQPL^b_j$ is the background waste load at element j;

$IC_{ij}$ is the pollutant impact coefficient for discharger i on element j (mg/L/kg/day);

$R^u_i$ is the treatment upper limit level of discharger i;

$S^*$ is the water quality standard;

n is the number of dischargers.

Uniform Treatment (UL) Model

$$\text{Maximize} \sum_{i=1}^{n} (1 - R)* WQPL^*_i$$

subject to

$0 \le WQP_j \le S^*$ for all j;

$$WQP_j - \sum_{i=1}^{n} IC_{ij} * (1 - R)* WQPL_i = WQP^b_j$$

for all j; (check points)

$R^l \le R \le R^u$.

other constraints.

where

variable:

R is the uniform treatment level to be found.

constants:

$R^u$ is the treatment upper limit level;

$R^l$ is the treatment lower limit level;

Zone (Group) Uniform Treatment (ZUT) Model

$$\text{Maximize} \sum_{z=1}^{n_z} \sum_{k=1}^{k_z} (1 - R_z)^* \, WQPL^{*z}_k$$

subject to

$0 \le WQP_j \le S^*$ for all j;

$$WQP_j - \sum_{z=1}^{n_z} \sum_{k=1}^{k_z} IC'_{jk} * (1 - R_z) \, WQPL_i = WQP^b_j$$

for all j; (check points)

$R^l_z \le R_z \le R^u_z$ for all z;

other constraints.

where

variable:

$R_z$ is the uniform treatment level of zone (group) z;

constants:

$WQPL^{*z}_k$ is the raw waste load of discharger k in zone (group) z;

$R^u_z$ is the treatment upper limit level of zone (group ) z;

$R^l_z$ is the treatment lower limit level of zone (group) z;

$n_z$ is the number of zones (groups).

Functional Removal (FR) Model

$$\text{Maximize} \sum_{n=1}^{n} (1 - F_i(R))^* \, WQPL^*_i$$

subject to

$0 \le WQP_j \le S^*$ for all j;

$$WQP_j - \sum_{i=1}^{n} IC_{ij} * (1 - F_i(R)) \, WQPL_i = WQP^b_j$$

for all j; (check points)

$R^l_i \le R_i \le R^u_i$ for all i;

$$F_i(R) = \frac{WQPL^*_i * R}{\max(WQPL^*_i)}$$

for all i; (removal function)

other constraints.

## Program Evaluation

Program evaluation based on multiple objectives is usually poorly defined. Although techniques are available for locating the best compromise solution based on the utility or preference function obtained from decision makers' responses, the utility function is filled with uncertainty and dynamically changing knowledge. For example, decision makers may change their preferences based on a group meeting, a political event, a poll survey, etc. This situation becomes even more complex when group decision makers are involved (Cohon 1978). In this case study, when group meetings are suggested to decide the final allocation in the proposed evaluation procedure, the uniform treatment method is used for the initial permit allocation. This research also demonstrates the use of the ideal solution method to derive a best compromise solution. The ideal solution is the one in which every objective value is at its maximum. This solution is, however, infeasible but can be used as a good basis for comparison of alternatives. By defining a 'distance measure', the feasible solution which is the closest one to the ideal solution can be regarded as the appropriate compromise solution.

## Evaluation of TDP Programs

The conventional command-and-control strategies have been challenged for their cost efficiency and equity. The transferable discharge permit program was thus proposed for inducing cost efficiency and equity (David et al. 1980; Eheart 1980; Brill et al. 1984; Deimer et al. 1988; Lence et al. 1988; and Lence et al. 1990). Effluent permits issued to dischargers under this program can be transferred among the dischargers under a free market. For achieving overall cost efficiency, a discharger with an improved treatment capacity will operate at a higher removal level while selling permits to the others, and a less efficient discharger will operate at a lower removal level while buying more permits. The dischargers are willing to look for advanced waste treatment technology and management so as to be able to sell extra permits.

A drawback exists, however, in implementing a TDP program. The transferred permits can happen at any place on the stream. Waste loads discharged at different locations may have a significantly different impact on water quality, and thus the water quality violation risk of a TDP program should be

evaluated beforehand. Four scenarios are simulated in this research for assessing the risk of a TDP program: length weight, development, anti-development, and buying market. The first three scenarios are adapted from Brill et al. (1984). The length weight scenario assumes that the probability of obtaining permits within a river section is proportional to the river length of the section. The probability can be estimated from the following function:

$$P_i = \frac{L_i}{\sum_{i=1}^{n} L_i}$$

Where $P_i$ is the probability of obtaining permits for river section i;
$L_i$ is the river length of river section i;
n is the number of river sections considered.

The development and anti-development weight scenarios assume the probability of obtaining permits is proportional and reverse proportional, respectively, to the magnitude of the waste load of a discharger. It is assumed that a large discharger will tend to expand/reduce its load in a development/anti-development environment. The probability function for this scenario is given below:

$$P_i^* = \frac{W_i * P_i}{\sum_{i=1}^{n} W_i * P_i}$$

Where $P_i^*$ is the probability of obtaining permits for river section i;
$P_i$ is the probability computed based on the length weight scenario;
$W_i$ is the development or anti-development weight.

The last three scenarios assume that the total permits are redistributed randomly based on the probability function provided above. They do not consider the real buying power for each discharger. Thus, it is useful to consider a buying market scenario. Based on economy of scale, the large discharger usually incurs a lower marginal cost and is likely to sell permits to smaller dischargers. The probability of a permit transfer between two dischargers is determined by the difference of their waste loads, as in the equation shown below:

$$P_{ij} = \begin{cases} \dfrac{WLP_i - WLP_j}{\sum |WLP_i - WLP_j|} & \text{for } WLP_i \geq WLP_j; \\ 0 & \text{for } WLP_i \leq WLP_j; \end{cases}$$

$$(1 - R^u)WL_i \leq WLP_i \leq (1 - R^l)WL_i$$
$$(1 - R^u)WL_j \leq WLP_j \leq (1 - R^l)WL_j$$

Where $P_{ij}$ is the probability of obtaining permits for river section i;
$WLP_i$ ($WPL_j$) is the current waste permit of discharger i (j);
$WL_i$ ($WL_j$) is the raw load of discharger i (j);

Figure 4 illustrates the TDP program evaluation procedure proposed by this study. Since a TDP program can achieve higher cost efficiency through market mechanisms after the initial waste allocation, the initial allocation in this research is based on the uniform treatment program for equity. An appropriate scenario is then selected for exploring the risk of implementing the TDP program, after the initial allocation has been determined. The permit transfer market is then simulated by a statistical approach based on the probability function described above. At the end of each simulation, a water quality model is incorporated for assessing water quality effect. The simulation results are then presented to decision makers. Note that the probability function in the buying market scenario must be recomputed at the end of each permit transfer simulation, while the probability functions of the other three scenarios are the same during the entire simulation process.

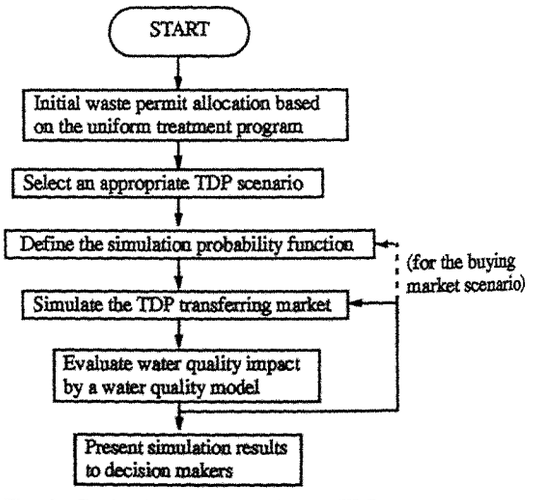


**Fig. 4** Evaluation procedure for the TDP program.

## A CASE STUDY OF THE TUNG-KANG RIVER BASIN

The Tung-kang River Basin is located in the south of Taiwan and flows south-west. The river is 44 km in length with 14 major dischargers, as listed in Table 1. Case A is the data reported by Wen (1989); case B is a worst case predication (Kao and Hwang 1993) for the river.

QUAL2E (Brown and Barnwell 1987) was used for water quality simulation. The river was divided into six reaches with 86 computation elements. Reaches 1–6 have 11, 13, 18, 12, 12, 20 elements, respectively. The 14 major dischargers were located at elements 10, 16, 25, 38, 42, 43, 46, 52, 54, 56, 60, 63, 67 and 84. Data required for running QUAL2E were extracted from Wen (1989) and Kao and Hwang (1993). BOD was the water parameter selected for this demonstration, although other parameters might be used. It was assumed that by reducing BOD loads to an acceptable level, other water parameters would be significantly improved as well. The total waste load objective for achieving better cost efficiency was used as the primary objective for the preliminary program screening procedure.

Two programs, TWL and UT, were analysed initially because they represent two extreme cases based on cost. The maximal waste load solution is an approximation of the least cost solution, and the uniform treatment solution is the worst cost efficiency solution. The results shown in Table 2 and Figure 5 were computed by the TWL and UT models described in the previous section for various BOD limit levels between 2.5 mg/L and 11 mg/L. The results derived from both programs were close to each other, as shown in Figure 5. In other words, the two programs for Case A are similar based on the total waste load objective. However, when the equity objective was considered, the TWL program was significantly dominated by the UT program and thus it is eliminated from the candidate program list. Based on the proposed procedure shown in Figure 2, the analysis procedure would stop here and the UT program could be presented to the decision makers for final decision.

**Table 1**
**Point Source Loads on Tung-kang River, R.O.C.**

| *No.* | *Distance (km)* | *Flow (cms)* | *BOD (mg/L) A* | *BOD (mg/L) B* | *DO (mg/L) A* | *DO (mg/L) B* | *BOD Load (kg/day) A* | *BOD LOAD (kg/day) B* |
|---|---|---|---|---|---|---|---|---|
| 1 | 28.0 | 0.30 | 6.55 | 42.2 | 2.7 | 0 | 169.78 | 1093.82 |
| 2 | 26.3 | 8.42 | 4.46 | 10.0 | 6.2 | 0 | 3244.60 | 7274.88 |
| 3 | 23.5 | 0.09 | 10.34 | 400.0 | 4.6 | 0 | 80.10 | 3110.40 |
| 4 | 10.7 | 0.19 | 18.40 | 300.0 | 2.8 | 0 | 302.05 | 4924.80 |
| 5 | 18.4 | 0.66 | 6.68 | 14.4 | 4.2 | 0 | 382.06 | 821.15 |
| 6 | 18.2 | 0.09 | 12..41 | 70.0 | 4.3 | 0 | 96.42 | 544.32 |
| 7 | 17.2 | 4.46 | 19.58 | 8.0 | 4.5 | 0 | 7552.74 | 3082.75 |
| 8 | 15.3 | 0.12 | 13.22 | 32.2 | 2.0 | 0 | 136.86 | 333.85 |
| 9 | 14.9 | 0.17 | 6.20 | 33.8 | 0 | 0 | 91.07 | 496.44 |
| 10 | 14.3 | 0.20 | 38.33 | 47.5 | 0 | 0 | 661.80 | 820.80 |
| 11 | 13.0 | 7.17 | 12.58 | 8.4 | 5.1 | 0 | 7805.50 | 5203.70 |
| 12 | 12.3 | 2.14 | 9.47 | 10.7 | 3.3 | 0 | 1756.50 | 1978.39 |
| 13 | 11.0 | 0.30 | 13.31 | 16.0 | 0 | 0 | 344.73 | 414.72 |
| 14 | 5.7 | 3.97 | 38.45 | 10.3 | 2.0 | 0 | 13171.50 | 3542.98 |

**Table 2**
**Total Waste Loads Derived from TWL and UT Programs for Case A**

| BOD (mg/L) | 2.5 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| TWL(kg/day) | 8342 | 10250 | 14007 | 17709 | 21406 | 25074 | 28624 | 31957 | 35291 | 35796 |
| UT(lg/day) | 7875 | 9665 | 13244 | 17182 | 20762 | 24341 | 27921 | 31500 | 34710 | 35796 |

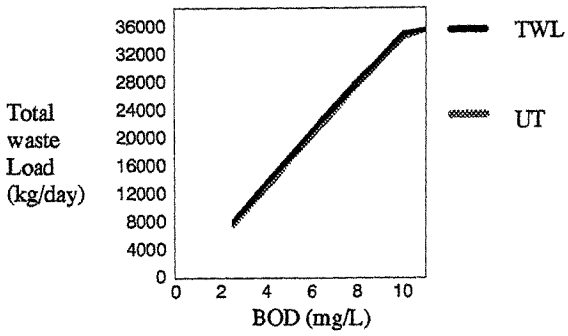


**Fig. 5** Total waste loads derived from TWL and UT programs for Case A.

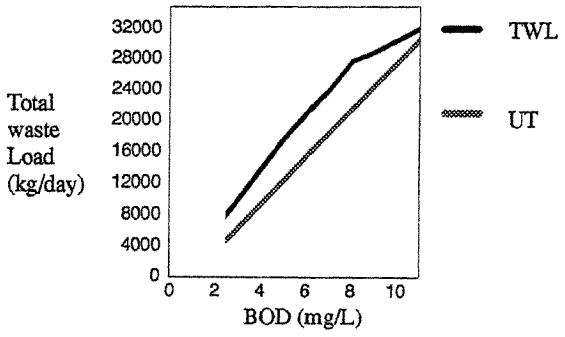


**Fig. 6** Total waste loads derived from TWL and UT programs for Case B.

A similar procedure was also applied to Case B listed in Table 1. The results are shown in Figure 6 and Table 3. One may not be able to assure that the UT program dominates the TWL program because there is a significant difference in total waste loads. Three other programs, two-zone (Z2), three-zone (Z3), and load-based (FRL), were also analysed. The two-zone program divided the six reaches into two groups, each with three reaches, based on similar self-purification capacities within each group (Wen 1989). The three-zone program is similar to the Z2 program except that the most upstream reach was treated as an additional individual group because its assigned water use was different from the others. Both Z2 and Z3 programs were analysed based on the ZUT model previously described. The load-based program requires a larger discharger to reduce more waste and is expected to be cost effective because of economies of scale. The program was evaluated by using the FR model previously described. The results for total waste loads for each program are listed in Table 3. No FR solution was found for a BOD concentration less than 4 mg/L because the required waste treatment level for large dischargers was greater than the maximal possible treatment level. These solutions are difficult to compare by examining only the water quality and total waste load objectives because a trade-off exists between these two objectives. According to the proposed procedure shown in Figure 2, some minor objectives are required to assist the decision making process.

Two additional objectives were then defined: equity and the area under the BOD curve. Equity is defined by the equation shown below for the summed deviation of discharge treatment levels compared with the average treatment level:

$$E = \sum_{i=1}^{n} (u_i + v_i)$$

where $e_i + u_i - v_i = e_{ave}$;

$u_i$ and $v_i$ are both positive and only one of them can be non-zero;

$e_i$ is the removal level of discharger i;

$e_{ave} = \sum_{i=1}^{n} e_i$ is the average waste removal level (%).

The area under the BOD curve was defined as described in the previous section. With these two additional objectives, the programs were analysed further. The trade-off between TWL and equity for all five programs under the same water quality level is shown in Figure 7, and the trade-off between TWL and the area under the BOD curve is shown in Figure

**Table 3**
**Total Waste Loads of TWL and UT Programs for Case B**

| BOD (mg/L) | 2.5 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| TWL(kg/day) | 8342 | 10252 | 14072 | 17886 | 21165 | 24238 | 27297 | 29058 | 30619 | 32156 |
| UT(kg/day) | 5079 | 6619 | 9645 | 12666 | 15673 | 18700 | 21727 | 24754 | 27777 | 30774 |
| Z2(kg/day) | 7605 | 9062 | 12017 | 14686 | 17369 | 20558 | 22482 | 25919 | 28850 | 31742 |
| Z3(kg/day) | 8300 | 10184 | 13933 | 16661 | 19089 | 21887 | 23971 | 26680 | 29279 | 31845 |
| FRL(kg/day) | – | – | – | 14972 | 18110 | 20934 | 23494 | 26002 | 28613 | 31173 |

8. In both figures, an ideal solution is one in which each objective value was the maximum of all five solutions for the objective. If the Euclidean distance is used to measure the difference between all programs and the ideal solution, the Z3 program is the nearest one to the ideal solution in both figures. If this ideal solution criterion is accepted by decision makers, the Z3 program can be presented to them. If an additional alternative is required, the Z2 program may be presented also. Although the above demonstration procedure appears complex, it is actually easy to implement using a computer.

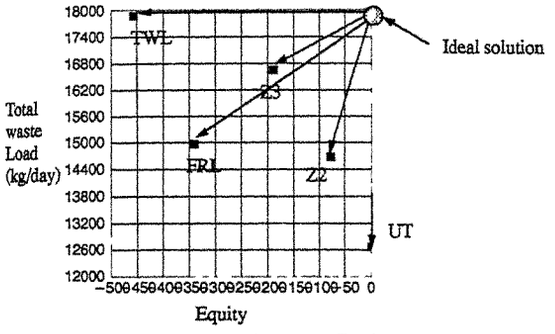


**Fig. 7** Tradeoff between TWL and Equity.

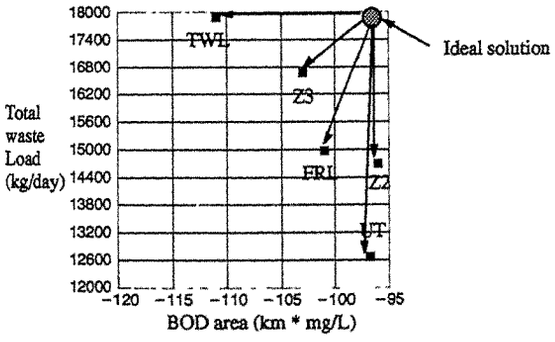


**Fig. 8** Tradeoff between TWL and the violation area under BOD cure.

## Evaluation of the TDP Program

The TDP program has been advanced as a cost-effective and fair method for attaining the water quality goals. The water quality impact should be assessed, however, after permit transfers because permit location changes will alter the impact derived from that achieved by the originally allocated permits. In this demonstration, the initial permit allocation was based on the UT program for the BOD standard = 4 mg/L (Table 4). Four scenarios described in the last section were analysed. The permit redistribution probability of the length weight scenario was determined based on the reach length listed in Table 4. The weights used to determine the permit redistribution probabilities for development and anti-development scenarios are listed in Table 5. For the buying market scenario, the permit transfer probabilities of all pair of dischargers were computed at the end of each simulation based on the function previously described. SNSIM (Pritsker 1986) was used to perform the simulation tasks. One hundred permit redistribution/transfer simulations were implemented. At the end of each simulation, QUAL2E was engaged again to assess the water quality impact. The results are summarized in Table 6. It can be observed that no simulation results significantly violate the original water quality. It is also noted that water quality is improved even further by implementing the TDP program based on the simulation for the buying market scenario. The simulation result suggests that the TDP program can be implemented for the current 14 dischargers with little risk of violating the water quality after the permit redistribution.

**Table 4**

**Initial Permit Allocation Based on the UT Program for BOD = 4 mg/L for the TDP program**

| Reach | 1 | 2 | | 3 | | 4 | | | | 5 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| length (km) | 3.0 | 4.2 | | 5.4 | | 3.6 | | | | 3.3 | | | 6.0 | |
| No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Load (kg/day) | 316 | 2086 | 892 | 1412 | 235 | 156 | 884 | 96 | 142 | 235 | 1492 | 567 | 119 | 1013 |

**Table 5**
**Weights Used for Development and Anti-development Scenarios**

| rank (kg/day) | 0–500 | 500–1000 | 1000–1500 | 1500–2000 | 2000–3000 | 3000–4000 | 4000–5000 | >5000 |
|---|---|---|---|---|---|---|---|---|
| Development | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Anti-development | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 |

**Table 6**
**Simulation Result Summary for All Scenarios**

| | *mg/L* | *BOD = 4 mg/L* |
|---|---|---|
| Initial Permit Allocation | BOD (max) | 4.0 |
| | BOD (min) | 2.25 |
| | DO (max) | 7.68 |
| | DO (min) | 3.38 |
| Scenario 1 length weight | BOD (max) | 3.97–4.14 |
| | BOD (min) | 2.26 |
| | DO (max) | 7.68 |
| | DO (min) | 3.84–3.85 |
| Scenario 2 development | BOD (max) | 4.12–4.19 |
| | BOD (min) | 2.26 |
| | DO (max) | 7.68 |
| | DO (min) | 3.84 |
| Scenario 3 anti-development | BOD (max) | 4.18–4.34 |
| | BOD (min) | 2.16–2.26 |
| | DO (max) | 7.68 |
| | DO (min) | 3.85 |
| Scenario 4 buying market | BOD (max) | 3.79–3.96 |
| | BOD (min) | 1.5–1.6 |
| | DO (max) | 7.68 |
| | DO (min) | 3.86–3.87 |

## CONCLUSION

A multiobjective evaluation procedure has been developed for the screening of candidate waste allocation programs. The procedure has been applied to the Tung-kang River Basin, with 14 major dischargers on the river, as a demonstration for analysing four TWLWQM programs and evaluating the risk of implementing the TDP program. The proposed criterion, indicated by the area under/above the water quality curve, can reflect the true water quality status which can be used to assess water quality impacts of different discharge management programs. The ideal solution approach was demonstrated for selecting a best compromise program while several conflicting objectives are considered simultaneously. Simulation results of the buying market scenario indicate that the TDP program can improve the water quality without violation of the water quality standard. This result suggests that if the TDP market can be controlled under circumstances similar to the buying market scenario, the TDP program can be implemented with little risk of violating water quality standards.

The proposed procedure is effective and valuable, though it appears somewhat complex in this demonstration. A prototype computer-assisted system (Kao and Wu 1993) has been developed to computerize the proposed procedure and to provide a user-friendly analysis environment.

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# Congestion Management and Air Quality: Lessons from Bangkok and Mexico City

*V. Setty Pendakur*

## ABSTRACT

Megacities are growing at unprecedented high rates, doubling their populations every 12 to 20 years. With increasing population and higher incomes, transport demands have been increasing explosively. Motor cars, for example, have been growing at 10 to 12% annually, while motorcycles have been growing 15 to 20% annually, resulting in increasing congestion and decreasing quality of urban living. Asia's economic growth rates are higher than any other region in the world, yet congestion management techniques have not changed significantly in much of the region during the past several decades.

This paper focuses on levels of congestion and air quality and congestion management in Bangkok and Mexico City. It illustrates the need for drastic changes in transportation policy tools and techniques. New approaches to investment and regulatory policy analysis and implementation are suggested. This requires the inclusion of all costs and benefits (economic and environmental) in the policy matrix so that investment and regulatory policies act in tandem.

*Keywords:* *Bangkok, Mexico City, air quality, megacities, transport planning, urban environment*

## INTRODUCTION

In 1990, Mexico City was the largest city in the world with a population of 20 million and Bangkok was the largest in Southeast Asia with a population of 8 million. Both these megacities have become classic examples of the close relationship between uncontrolled traffic growth and deteriorating quality of urban life. Urban traffic, in both cities, often crawls at speeds of only 2 to 10 km/h and deteriorating air quality is a hazard to public health. This paper examines congestion management and air quality in Mexico and Bangkok, and also draws lessons from the Singapore experience, to make policy recommendations.

Asia is the world's most economically dynamic region, with Gross National Product (GNP) growth averaging 7% annually during the 1980s. In contrast, the world GNP growth was around 3% annually and less than 2% for the developing countries (Midgeley 1991). The real growth in Asia was more than twice that in the high income countries and is expected to continue at a comparatively high rate during the next decade.

According to the International Monetary Fund (IMF), several Asian countries had substantial foreign currency reserves in 1992: Taiwan US$76 billion, Japan US$72 billion, China US$43 billion, Singapore US$18 billion and Hong Kong US$14 billion. These reserves should enable these economies to sustain

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their high economic growth rates and a rapid modernisation of their economies, during the short term (IMF 1992). Forecasts by the World Bank indicate that per capita incomes in South Asia may continue to grow at 3.2% per year for the next decade. Per capita income in the Developing Countries (DCs) of East Asia is projected to grow at 5.1%, leading to a 65% rise in average incomes by the year 2000 (World Bank 1990).

The impressive economic performance of Asia, combined with high population growth, is resulting in high rates of urbanisation. Already, more than half of the world's urban population increase occurs in Asia and most of this growth is occurring in the regions of low income countries (Midgeley 1991). Some of the most prosperous countries with large capital surpluses and high rates of economic growth (Japan, Korea, Taiwan, Singapore and Hong Kong) are in Asia. At the same time, 66% of the world's poor live in five countries of Asia: Bangladesh, China, India, Indonesia and Pakistan (Pendakur 1986).

Except for Japan and the Newly Industrialized Countries (NICs) — Hong Kong, Korea, Singapore and Taiwan — Asian countries are generally capital and technology poor. Concurrently, they require massive new transport investments in their megacities. The pressing demand for personal mobility is generating pressures on the road network resulting in congestion and creating serious degradation of air quality. The development of the urban transport sector and its response to the pace, scale and nature of urbanisation will critically influence the quality of living and public health in all the megacities.

## URBANISATION

Cities in the lower income countries are fast reaching the ranks of the world's largest cities. This trend breaks the historical connection between city size and the levels of economic development and/or political power. The major force behind urbanisation is no longer industrialization. Fifty eight of the world's 100 largest metropolitan areas are now in the DCs. Nine of them are in China and another nine in India, despite the fact that almost 80% of the population in these countries is still rural. Of the 33 metropolitan areas with a population of more than 5 million, 22 were in the DCs in 1990 (Camp 1991).

The features of contemporary urbanisation in the DCs differ markedly from those of historical experience. The large cities in the DCs are growing much faster than those in the industrialized countries (ICs). London took 130 years to grow from 1 million to 8 million, whereas it took Los Angeles 50 years, Bangkok 46 years and Mexico City only 27 years. Whereas urbanisation in the ICs took many decades, permitting a gradual emergence of economic, social and political institutions to deal with the problems of transformation, the process in the DCs is occurring far more rapidly, against a background of high population growth, lower incomes and fewer opportunities for international migration (Pendakur 1986). Some of the characteristics are:

- dominance of a very small number of cities;
- decreasing and/or stable costs of transport and communications up to 1970, and geometric increases in those costs since then;
- transport costs becoming a heavy burden on balance of payments since 1975 (Pendakur 1986).

Megacities are dominant in social, political and economic terms. Thirty to 60% of their Gross Domestic Product (GDP) in these countries are produced in these cities. They also have the most severe traffic congestion and environmental problems. Their economic capacity to absorb more people is substantially less than the vast number of people continuing to migrate into them. Typically, they have their nation's highest incidence of poverty and absolute poverty (Pendakur 1992). They also have unhealthy housing and sanitation conditions for large portions of their populations (Camp 1991).

## CONGESTION MANAGEMENT AND AIR QUALITY

The urban transportation planning methods in the megacities are oriented towards accommodating motor vehicles and motor vehicle use is heavily subsidised. It is only recently that some of the megacities are realising that controlling automobile use and thereby reducing air pollution is both economically efficient and environmentally sound. For example, Los Angeles, with its 12 million people spread over 17 000 square kilometers use 8 million cars extensively. These automobiles and 31 000 businesses spew out 1130 tonnes of noxious gases

into the atmosphere every day. Since 1990, the state and local governments are beginning to take action to curb the area's frequent use of the single occupancy car (SCAQMD 1991).

In contrast, the general political-economic strategy in Asia continues to be to build more highways and freeways and launch mega projects, both highway and rail, generally funded in part through international aid and/or borrowing. There is no strong effort, both technically and politically, to reduce single occupancy automobile use in heavily congested corridors except in Singapore (Pendakur 1992).

The urban transportation systems are characterised by city centres which are heavily congested with very slow traffic movement due in part to the fact that a large share of the country's motor vehicles are being used there. Car ownership is increasing between about 6 to 20% annually in these areas, while motorcycles are increasing at annual rates between about 10 and 30%. Significant air pollution is already a problem and no relief is in sight. Trips by private car are still a very small proportion of total motorized journeys, but much of the capital and maintenance expenditures are directed towards accommodating these trips, rather than toward investments in attractive mass transit alternatives. Perhaps even more striking is that non-motorised trips (bicycles, walking) are still substantial, but only a few countries are beginning to assist these activities, while others restrict or even ban them in places (Pendakur 1992).

## MEXICO CITY AND BANGKOK

Mexico City and Bangkok have probably the world's worst levels of traffic congestion and air quality. They are both characterised by governments and technical bureaucracies that appear to primarily cater to the increased ownership and use of the private car. Both Mexico City and Bangkok are primary cities, i.e., they are demographic, economic, political and transport hubs. Tables 1 and 2 show data with regard to population, GDP, and numbers of motor vehicles.

### Bangkok: Traffic and Air Quality

Bangkok has 15% of Thailand's population and 50% of that nation's motor vehicles (Tables 1 and 2). The number of people is growing at 2% annually, while the motor vehicle population is growing at 15% annually (cars 12% and motorcycles 18%). Peak

**Table 1**
**Bangkok and Mexico City Population and Economy**

| | *Bangkok* | *Mexico City* |
|---|---|---|
| City Population | | |
| 1990 | 8 Million | 20 Million |
| 2000 | 10 Million | 26 Million |
| As % of Country Population | | |
| 1990 | 14% | 22% |
| 2000 | 16% | 24% |
| Annual Population Growth Rates | | |
| 1980–1990 | 2.1% | 2.6% |
| 1990–2000 | 2.0% | 3.0% |
| Per Capita GDP US$ | | |
| 1990 | 4420 | 3120 |
| As % of Country Per Capita GDP | | |
| 1990 | 315% | 220% |
| GDP as % of Country GDP | | |
| 1990 | 50% | 32% |
| GDP Annual Growth Rates | | |
| 1980–1990 | 9–15% | 4–8% |

Sources: United Nations 1991; World Bank 1992

**Table 2**
**Bangkok and Mexico City Motor Vehicles and Urban Transport**

| | *Bangkok* | *Mexico City* |
|---|---|---|
| Total Motor Vehicles | | |
| 1990 | 2.8 Million | 2.6 Million |
| Car | | |
| 1990 | 1.2 Million | 2.4 Million |
| 2000 (Projected) | 2.0 Million | 3.2 Million |
| Cars as % Total in the Country | | |
| 1990 | 50% | 68% |
| Cars Ownership as % Total Population | | |
| 1990 | 7% | 16% |
| 2000 (Projected) | 12% | 20% |
| % of All Trips by Car | | |
| 1990 | 19% | 15% |
| 2000 (Projected) | 23% | 24% |
| Motor Vehicle Growth Rates | | |
| 1980–90 Annual Rate | | |
| Cars | 12% | 5% |
| Motorcycles | 18% | N/A |
| All Motor Vehicles | 15% | 7% |

Sources: Complied by the author from various sources

hour *average* traffic flow for the Central Business District (CBD) is between 6 to 10 km/h and at heavily congested times it falls to a mere 1 to 2 km/h (much slower than a leisurely walk).

Tables 3 and 4 show the traffic flow conditions and air quality in Bangkok. It is not unusual for a trip of 40 km, from the airport to the CBD, to take anywhere from one to three hours, even with a limited access toll freeway. It is estimated that the number of motorised trips will increase from 7

**Table 3**
**Bangkok Traffic Flow**

- Peak Hour Average for Central Area 18 Km/h
- Peak Hour Average for CBD 6–10 Km/h
- Peak Hour Worst Crawl Rate 1–2 Km/h
- Peak Hour Worst Condition
  Rama 9 and Asoke, Crawl Rate 1.2 Km, Can Take 30–45 Minutes for 600 Meters
- Peak Hour Suburban Crawl Airport to Rangsit, 15 Km, Can Take 15–150 Minutes
- Traffic Control
  Manual by Police to Operate Signal Timings
  No ATC System at Present but Planned
- Exclusive Bus Lanes — Not Enforced Regularly
- Contra Flow Lanes — Enforced Fully

Sources: Compiled by the author from Thai government, Metropolitan Bangkok Traffic Police documents

**Table 4**
**Bangkok Air Pollution**

- 70% Derived from Motor Vehicles
- SPM — 200% to 400% Times Acceptable Levels
  97 Days SPM > WHO Standard
- CO — 50% Higher than WHO Standard
- Pollution Control Measures — Not Enforced
- Street Level Air Pollution
  8 Hour Exposure to Street Level Air, equivalent to Smoking 9 Cigarettes Per Day
- Most Exposed People to Air Pollution:
  Traffic Police, Tuk Tuk & Motorcycle Taxi, driver/passengers Street Vendors
- Public Health Indicator
  Among 1758 Total Traffic Police
  753 Suffer from Respiratory Deceases
  420 Have Been Suffering > 5 Year
- Global Mega Cities Air Quality Rating — 2/10

Sources: Compiled by the author from Thai government, Metropolitan Bangkok Traffic Police and Population Crisis Committee documents

million in 1990 to 11.3 million in 2000. Thirty five percent of all person-trips were by private motor vehicles (cars and motorcycles). Seventy per cent of air pollution comes from private motor vehicles (including motor bikes). Carbon monoxide (CO), and suspended particulate matter (SPM) levels are very high and far exceed World Health Organisation (WHO) standards. Smoke from traffic is often bad enough that the reduction in visibility is a safety hazard (WHO 1992).

Taxis and motorised tricycles mainly use Liquid Propane Gas (LPG). Many of the full-sized passenger and goods vehicles are diesel because diesel is 25% cheaper than petrol. The sulphur content of the motor diesel fuel is approximately 1%, and is planned to be reduced to 0.5% by 1996. Many car owners with petrol-fueled engines use leaded fuel because it is about 10% cheaper.

$SO_2$ emissions in Bangkok are low and will probably reduce even more during the next decade, if the sulphur content in petrol and diesel fuels is lowered. Anthropogenic (industrial and motor vehicle) Suspended Particulate Matter (SPM) emissions are estimated at 80 000 tonnes/year. Ambient 24-hour mean concentrations of SPM are 200–300 micrograms per cubic meter ($\mu g/m^3$). Short-term SPM pollution situation is quite serious. While WHO guidelines prescribe no more than 230 $\mu g/m^3$, readings at some sites in Bangkok reach 500–600 $\mu g/m^3$. Road side air pollution is quite serious. The maximum 24-hour mean reading reported in 1988 was 1400 $\mu g/m^3$ which is over four times the Thai national standard of 330 $\mu g/m^3$ (WHO 1992).

It has been estimated that an eight hour exposure at street level to Bangkok's air, such as that experienced by street vendors, pedestrians and traffic police, is equivalent to smoking nine cigarettes a day (Panayatu 1991). A recent study showed that among the 1758 Bangkok Metropolitan Traffic Police, 753 suffer from a variety of respiratory diseases including asthma, conjunctivitis, lung cancer, etc., while 420 of these have been suffering from these diseases for more than five years (Pendakur 1992).

Bangkok's environmental problems are serious and are set to become worse. The Thai air quality standards in several cases are more lax than WHO standards, yet even the Thai standards are often exceeded. Concentrations of CO are 50% above the Thai standard of 15 $mg/m^3$, while lead is double the standard. Greenhouse gas emissions are far above the average for a country of Thailand's level of economic development. Although per capita emissions of carbon dioxide ($CO_2$) and methane ($CH_4$), and Chlorofluorocarbons (CFCs) are lower than in the ICs, when compared on the basis of emissions measured against Gross National Product (GNP), Thailand outranks many other DCs and ICs (Panayatou and Phantumvanit 1991).

Since there are no lead-emitting industrial sources, lead emissions come from the transport sector through additives in petrol. The Thai government estimates lead emissions at between 500 to 1000 tonnes/year (Panayatou and Phantumvanit 1991). However, a recent World Bank study reported 20 000 tonnes/year (Faiz et al. 1990). Blood lead levels in children living near the Makasan measuring station ranged from 15 to 28 µg, indicating cause for concern regarding the children's long term health.

No comprehensive inventories of CO emissions have been made in Bangkok. However, World Bank estimates indicate a range of from 120 to 160 thousand tonnes/year in 1980, 280 in 1990 and they are expected to reach 420 thousand tonnes per year by 2000 (Faiz et al. 1990). In the absence of domestic heating in Bangkok, all CO emissions result from incomplete combustion of fuels in motor vehicles. Thus, increasing concentration of motor vehicles and their use can only increase CO emissions. Several roadside one hour mean readings of 50 $mg/m^3$ and eight hour mean readings of 30 $mg/m^3$ have been recorded, while the WHO guidelines specify readings not exceeding 10 $mg/m^3$ for eight hour readings.

Ozone is not a problem in Bangkok because year round monsoon winds prevent the build up of ozone. The maximum one hour ozone measured in 1989 was 100 $\mu g/m^3$ which is below the WHO limit of 200 $\mu g/m^3$.

The main air pollution problem in Bangkok is the very high SPM levels. In traffic influenced areas, a large portion of the SPM consists of respirable particles which have serious consequences to health (asthma, bronchitis, conjunctivitis). More than 60% of SPM are smaller than 10 microns particularly in the range of 0.6 to 1 microns and 5 to 7 microns. These particles are in the inhalable range and hence can cause significant health problems.

In the judgement of the author, the Thai government has not responded constructively to these critical environmental threats. In July 1991, duties and taxes on cars and motorcycles were reduced drastically in the guise of competition. Duties on

cars went down from 300% to 112% and on motorcycles from 180% to 60%. The most likely impact of this policy in Bangkok will be a massive increase in the number of motorcycles and then a significant increase in car ownership. The government is also embarking on major new freeways systems and rail systems (LRT/MRT). These may take 5–15 years to become operational and in the meanwhile, degradation of air quality continues.

## Mexico City: Traffic and Air Quality

As shown in Tables 5 and 6, in 1990, Mexico City had 22% of the country's population and 68% of its private cars. Sixteen percent of the city's population owned cars, with this share expected to increase to 20% by the year 2000. In the urban area there are 2.4 million private cars making 4.4 million trips each day. However, only 15% of all motorised person-trips are by private car and the remaining by public transport (bus, collective taxi, taxi, metro). The number of private cars has grown sharply during the past decade and is forecast to grow at high rates during the next decade. Although private cars carry only 15% of motorised person trips, they are responsible for 63% of total emissions and up to 99% of CO emissions (WHO 1992).

**Table 5**
**Mexico City Air Quality**

| | *1990* | *2000* |
|---|---|---|
| CO Emissions $10^6$ Tons (Cars & Motorcycles Only) | 4.7 | 10.5 |
| Mean Annual Ground Level CO Concentration ppm | 10 | 22 |
| CO Ground Concentration ppm 8 Hour Peak | 22.41 | 60 |
| Ozone ppm | 0.4050 | 0.4500 |
| Exposure to Very High $O_3$, Levels Hours/Year | 1400 | 1800 |
| WHO Standards | | |
| $O_3$ Exposure Hours/Year | <1 | <1 |
| 8 Hour CO Peak ppm | 9 | 9 |
| Once a Year CO Peak 8 Hour ppm | 35 | 35 |

Source: Instituto Autónomo Investigaciones de Ecológicas, Ciudad de México

**Table 6**
**Mexico City Air Quality Management, 1991**

- 76% of Air Pollution Caused by Cars
- 90% Gasoline Leaded
- 40% of Los Angeles Cars but 3 times the Air Pollution
- When Ozone Levels Are Very High (0.35 ppm)
  - 30% Power Cut to Industries
  - School Outdoor Activity Suspended
  - Citizens Are *Urged* to Use Public Transport
  - Cars Are Still Used
- Casieta de Oxígeno — Oxygen Booths US$ 1.70 for Breathing Clean Air!

Source: Instituto Autónomo Investigaciones de Ecológicas, Ciudad de México

$SO_2$ 24-hour mean levels range from 80 to 200 μg/m$^3$. WHO guidelines are exceeded at many locations both for $SO_2$ and SPM. Particulate matter under 10 microns are those with the most pronounced impact on health and visibility. In Mexico City, such small particulate matter may represent 60% of total SPM reported.

CO emissions attributable to transport were 97% in 1989. In addition, an estimated 54% of hydrocarbons, 64% of $NO_x$, 8% of $SO_2$, and 9% of SPM were attributable to transport. Overall, it is estimated that 80% of the total air pollution in Mexico City in 1989 came from transport (Faiz et al. 1992). To the extent that air quality is measured at fixed stations which are at roof-top level and away from the streets with the worst traffic, recorded measures tend to underestimate the exposure of pedestrians, street vendors, and commuters in these areas.

Ozone levels are exceptionally high in Mexico City. In the southwestern part of the city, during 1986–89, high frequency of ozone levels exceeding WHO guidelines, were present for 254 days of the year. Hourly ozone levels often reach 600 μg/m$^3$ with extreme values of 850–900 μg/m$^3$. The number of hours, during which ozone levels exceeded national standards, was 80–100 hours per month and this is not unusual for Mexico City (WHO 1992, pp. 162–3).

Emission standards for petrol vehicles were very permissive until 1992. From the 1993 models onwards, the maximum allowed emissions have been lowered to 2.11 g/km. However, this does not apply to the 2.4 million private cars which are already on

the road now. Recent CO emission assessments show that the CO emitted by an average car now in Mexico City is as high as 60.0 g/km (DDF 1989, p 63).

Tables 5 and 6 show the dangerously high ozone levels and CO emissions. Ninety per cent of the gasoline used is leaded and 76% of the air pollution is caused by cars. Mexico City has 40% of the cars of Los Angeles but has three times the air pollution in Los Angeles (Guerra 1991, p. 12)!

In Mexico City, when ozone levels are very high, schools are closed and all outdoor activity is suspended. All industries are subject to a 30% power cut, which requires many people to have a day off without pay. At the same time, there is no restriction or prohibition of cars coming into the CBD, although 76% air pollution is caused by cars. It might be noted that under these circumstances, car owners are politely requested to use transit (Guerra 1991). Recently, it has been proposed to install oxygen booths (like telephone booths), to enable people with respiratory problems, to stop and breathe clean air for a price.

On 20 March 1992, the air in Mexico City was so polluted that in places the air smelled something like leaking petroleum. The government ordered a 50% to 75% power cut for industries, forcing millions of poor people to take a day off without pay. This was in force for two consecutive days, but yet there was no prohibition of single occupancy cars during the peak hour.

## URBAN LIVING STANDARDS

The Population Crisis Committee (PCC) has measured the quality of living in 100 largest metropolitan cities with more than 2 million people, 35 of which were in Asia (Camp 1991). The livability index consists of the following components, each category having equal weight:

- Public Safety
- Food Costs
- Living Space
- Housing Standards
- Communications
- Education
- Public Health
- Peace and Quiet
- Traffic Flow
- Air Quality and Pollution.

While there may be some disagreements as to the relative weight of each component of the index, the methodology is quite useful in assessing a very complex question. Three components are important to transportation planners: ambient noise levels, traffic flow (average peak hour traffic speeds) and air quality (air pollution measured in levels of SPM, $SO_2$ and $NO_x$ exceeding health thresholds defined by WHO).

Table 7 shows selected indices of living standards in several cities. Mexico City has the worst

**Table 7**
**Urban Living Standards: Selected Cities, 1990**

| *City* | *Population Millions* | *Levels of Ambient Noise** | *Traffic Flow Peak Hour km/h* | *Air Quality and Pollution Exceedence* |
|---|---|---|---|---|
| 1. Mexico City | 20 | 6 | 13 | 0.40 ppm $O_3$ |
| 2. Tokyo | 18 | 4 | 45 | 0.07 ppm $O_3$ |
| 3. São Paulo | 17 | 6 | 24 | 0.15 ppm $O_3$ |
| 4. Shanghai | 13 | 5 | 24 | 16 days $SO_2$ |
| 5. Calcutta | 12 | 4 | 21 | 268 days SPM |
| 6. Buenos Aires | 12 | 3 | 48 | 0.06 ppm $O_3$ |
| 7. Bombay | 11 | 5 | 16 | 100 days SPM |
| 8. Seoul | 11 | 7 | 22 | 87 days $SO_2$ |
| 9. Beijing | 11 | 4 | 42 | 272 days SPM |
| 10. Bangkok | 8 | 2 | 10 | 97 days SPM |
| 11. Singapore | 3 | 7 | 38 | 45 days $\mu g/m^3 NO_2$ |

* Subjective rating 1–10. Noisiest rating 1 = > 90 dBA, 10 < dBA
Source: Camp 1991

levels of ozone concentration in the world. WHO recommends that human beings should not be exposed to ozone concentrations of > 0.1 part per million (ppm) for more than one hour per year. WHO also recommends that ozone safety levels must not be exceeded for more than 30 days per year. People in Mexico City were exposed to more than 1400 hours of high ozone concentrations covering 145 days in 1991. The situation was equally bad in two other Latin American cities: Sao Paulo and Santiago.

Although the Asian cities do reasonably well in terms of ozone levels, many of them greatly exceeded the WHO standards for SPM and $SO_2$. Five cities exceeded these thresholds as follows: Bombay, 100 days; Beijing, 272 days; Calcutta, 268 days; and Delhi, 294 days. Exposure to levels of SPM, $SO_2$ and CO as shown in Table 7 has serious consequences to public health, including the incidence of cancers of the respiratory organs and more people become susceptible to common respiratory diseases such as asthma, bronchitis, emphysema and conjunctivitis.

## INCOMES, MOBILITY AND VEHICLE OWNERSHIP

As household incomes increase, there is typically an investment choice toward greater mobility. In the megacities of Asia and elsewhere this desire has resulted in the extraordinarily high growth of cars and motorcycles. At present only a small number of households in these cities can afford to own a motor vehicle. Yet, as incomes rise, this situation will clearly change. Forecasts for income and car ownership in selected megacities is shown in Table 8.

Singapore offers some interesting insights into the nature of the future problem and some possibilities for trying to limit it. Singapore has higher taxes on automobile ownership and peak hour use than anywhere else in the world. A medium-sized car in Singapore costs 2.5 times that in Manila, 3.0 times that in Jakarta and 4.0 times that in Bangkok. As shown in Figure 1, even in Singapore, there was a consistent and steady increase car ownership during the decade 1980–90, as real (inflation discounted) incomes increased at a rate much higher than in other countries. Under these conditions of the very strong desire for car ownership even in the face of artificially high costs, the planning question becomes one of how to control the *use* of cars, rather than drastic measures to prevent car ownership. An important related planning question is who pays for the associated costs of the car use.

## CONTROLLING THE AUTOMOBILE

Singapore is the only country in the world with a strict Area Licensing Scheme (ALS) requiring all peak hour car users destined for the Central Business District (CBD) to pay a heavy entry fee. The ALS system was instituted in 1975 and has been operating successfully. It is based on the simple principle that car users have to pay nearly the total cost of using the car and no subsidies, direct or indirect, are to be given. In simple terms this means very high road taxes, licenses, insurance, entry fees to restricted areas and high parking costs. Concurrently, Singapore has expanded the bus system vastly and recently built a 44 km MRT system at a cost of US$3 billion. They have also accepted strict limits on car populations as

**Table 8**
**Income and Car Ownership Forecasts**

| | Population in Million | | Income/Capita in thousands $ US/PR | | Cars in thousands | |
|---|---|---|---|---|---|---|
| | 188 | 2008 | 1988 | 2008 | 1988 | 2008 |
| Cairo | 10.0 | 13 | 1075 | 2000 | 702 | 2070 |
| Hong Kong | 5.7 | 7 | 7440 | 1300 | 218 | 240 |
| Manila | 9.5 | 16 | 1069 | 1500 | 357 | 810 |
| Mexico | 11.3 | 16 | 3336 | 5000 | 1632 | 2750 |
| Sao Paulo | 14.4 | 22 | 2419 | 3200 | 2140 | 3500 |
| Seoul | 9.5 | 12 | 3213 | 4700 | 671 | 1490 |
| Singapore | 2.6 | 3 | 7162 | 14900 | 330 | 400 |

Source: Transport and Road Research Laboratory, Crowthorne, UK, 1992

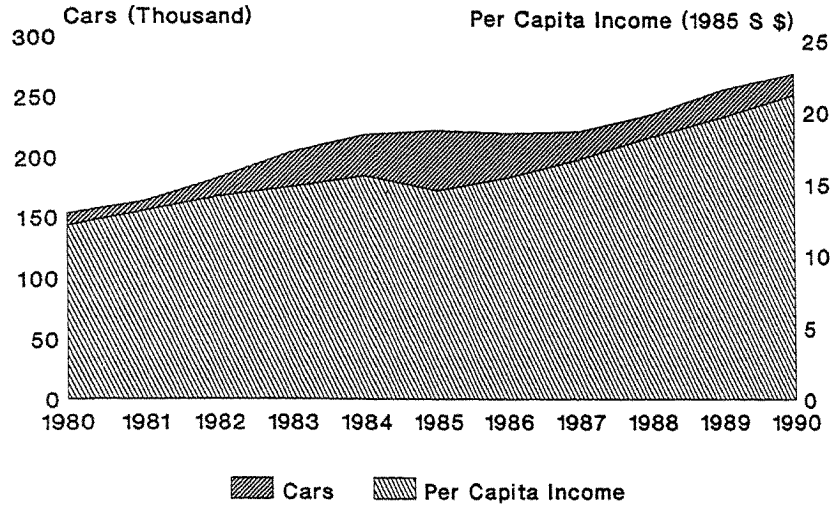


**Fig. 1** Singapore 1980–90 Cars and Per Capita Income.
Source: *Statistical Abstracts 1992*, Ministry of National Development, Singapore

a policy principle. Each of Singapore's auto-related policy tools are economic in nature. The total population of cars and their growth rate is controlled simply by heavy taxes for ownership and use.

In 1990, the government instituted a system of bidding (tendering) for the eligibility certificate to purchase a car. This certificate itself can now cost about US$7000 to 10 000 and simply makes the holder eligible to buy a car! The taxes on six-year-old cars are very high and sufficient to make it uneconomical to keep that car for more than about seven years. These taxes are defended on the basis that most older cars are heavy polluters. In addition, every commercial parking space has to pay a tax of about US$5000. Use of a parking space during the peak period involves an additional monthly ALS fee of about US$60. This ALS fee is not applicable to car pools with three or more people. However, these measures require and are complemented by alternatives to private car transport in the form of an excellent and reasonably priced bus/MTR system. Studies have shown that the auto control measures used in the Singapore ALS are easy to understand, and are effective in reducing the peak hour car use (Pendakur 1984, 1989).

Recently, Singapore has introduced an additional concept, that of the 'Weekend Car'. A vehicle so designated cannot be used between 7 a.m. to 6 p.m. Monday to Friday, and 7 a.m. to 2 p.m. on Saturdays, except for public holidays. The conceptual basis of the 'weekend car' is to enable the car use for social purposes but to severely limits use of this same vehicle for peak-period transport, particularly if it is single occupancy and to the CBD or other high traffic nodes.

Figure 2 shows changes in travel behaviour before and after the ALS system became operational in 1974 and 1975. There was a substantial reduction in the single occupancy cars and a major shift to

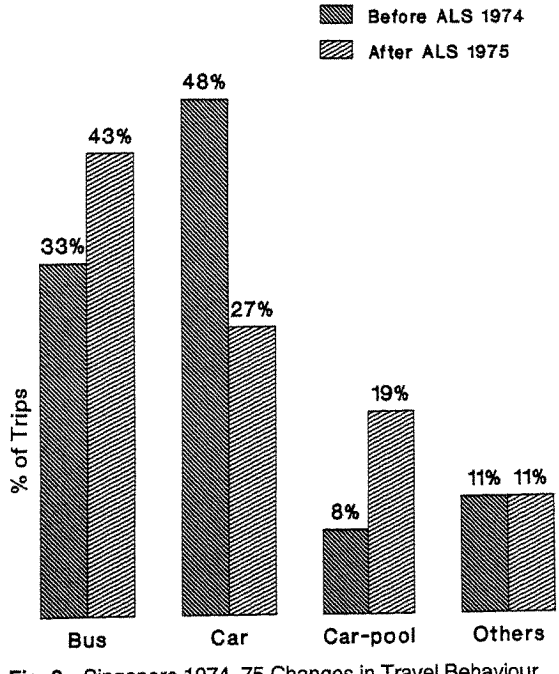


**Fig. 2** Singapore 1974–75 Changes in Travel Behaviour.
Source: Pendakur, 1989

transit. Data for 1980 and 1990 are shown in Figure 3. Peak hour car use has decreased moderately even though incomes have increased substantially over the same period. In the view of the author, the ALS system has succeeded only because the government has been doggedly persistent in its policy of taming the automobile.

Singapore is now seriously considering the feasibility of introducing Electronic Road Pricing (ERP). Studies are being conducted and the ERP is expected to be implemented by about 1995 (PWD 1991).

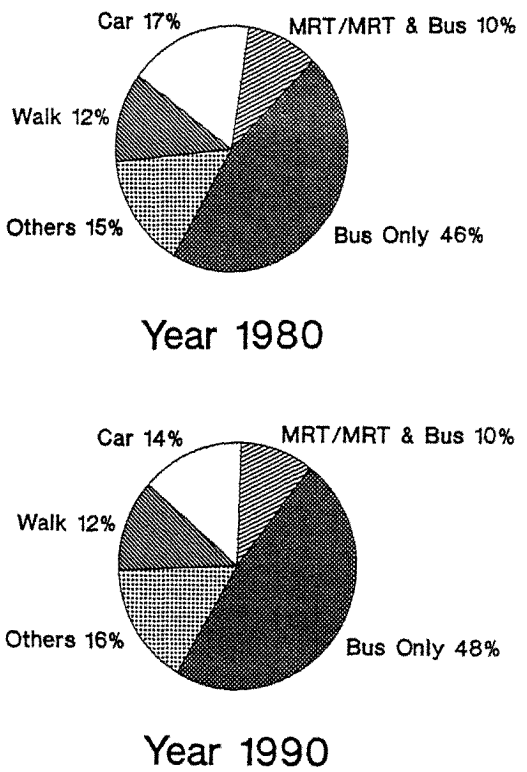


**Fig. 3** Singapore travel modes.
Source: 1990 Singapore Census Data

## URBAN TRANSPORT POLICY AND PLANNING

Investment and regulatory policy responses in most cities, notably excepting Singapore, have focused primarily on facilitating automobile use. In some cities, there are efforts to increase the capacity of transit systems and also build new LRT/MRT systems.

For example, the strongest regulation in Mexico City is to restrict the use of the private car to five days a week. If you have a blue license plate, you cannot drive on Wednesday and Saturday, and similarly if you have a red license plate, you cannot drive on Monday and Friday, and so on. Naturally this reduces some traffic and mostly affects the middle income households. The wealthy Mexicans and corporations simply buy an extra car to assure seven day driving.

In April 1992, Jakarta traffic police began requiring cars using all major routes during the morning peak hours to carry at least three people. They implemented this plan zealously. The results: cars (carrying at least three people) and buses were moving at 80 km/h and travel time was cut by some 40%. However, since this plan had no basis in law, it became undone in June 1992 when courts ruled it illegal (*Asiaweek* 26 June 92).

Tokyo also provides some interesting lessons. One third of all the Japanese companies and employees are in Tokyo. In the service sector, 50% of all Japanese employment is in Tokyo. Each day, roughly 4 million people commute to or within Tokyo. Greater Tokyo has 10% of Japan's land and 32% of the nation's population. The result of all these people attempting to move in roughly the same times period is enormous cost, congestion and fatigue (*Far Eastern Economic Review* 1991).

The bullet trains, once regarded as a deluxe conveyance, have become vastly overburdened. Overcrowding is defined officially as when a rail car is packed to 200% of capacity. At 200% of capacity passengers are pressed together, but still have enough elbow room to hold and read a magazine. At 250% to 300% of capacity, 'you cannot move your hands'. Recently, the Tokyo government announced that rush hour crowding on the trains had *dropped* to 200–240% of capacity.

Figure 4 shows the work trip time lengths in Tokyo. Seventy percent of the people spend more

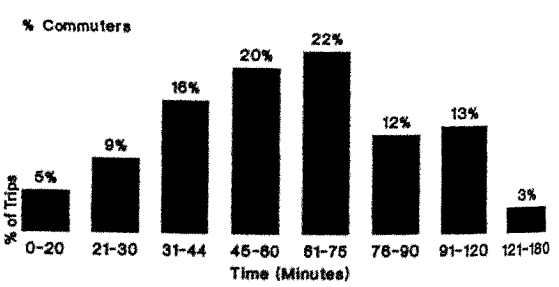


**Fig. 4** Tokyo commuting in 1985 (One way work trips).
Source: *Far Eastern Economic Review* 19 September 1991, p. 58.

than 45 minutes each way for work trips, while 50% take more than an hour each way. What this means is that the work day is actually extended to 10 or 12 hours.

In poorer countries, the consequences are even more serious. In Bangkok, even where employers provide special buses for employee travel, people leave home at 6 a.m. and typically return home at 7 p.m. If employee transportation is not provided, the transport situation may be much worse.

What are the social, environmental and economic consequences of this kind of urban living? Can these cities sustain for any length of time without incurring extremely high inefficiencies? As discussed earlier, the social consequences of dislocation, fatigue and long hours are well-documented. The public health consequences from transport-related environmental degradation also have been well-documented (UNEP 1988; Camp 1991). Recent submissions, to the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, show that in one year, Bangkok traffic jams cost an estimated US$1 billion in extra fuel burned, and work time lost. This does not include the monetary and non-monetary health and other environmental costs of additional air pollution in a city such as Bangkok which is already badly polluted.

If these cities are to be viable in the longer term, there has to be a new policy regime focussed on including all costs and benefits (economic, social and environmental) of transport mode choice. This new regime must be flexible and dynamic over time, fostering efficiency, equity, and with an eye to sustainability.

Figures 5, 6, 7 and 8 indicate the basic elements of new policy approaches necessary for sustainable cities. Figure 5 for example, shows that the primary

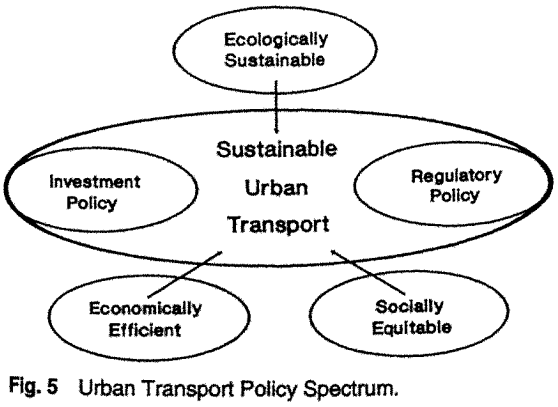


**Fig. 5** Urban Transport Policy Spectrum.

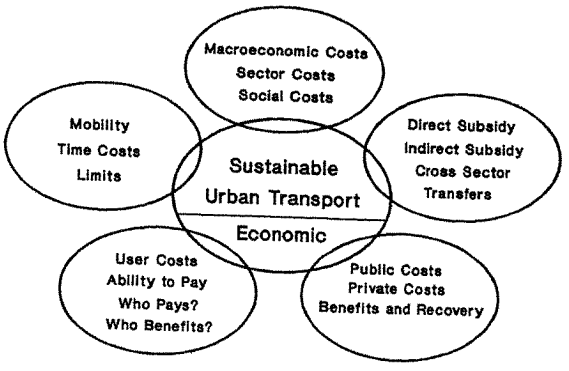


**Fig. 6** Sustainable Urban Transport (Economic System).

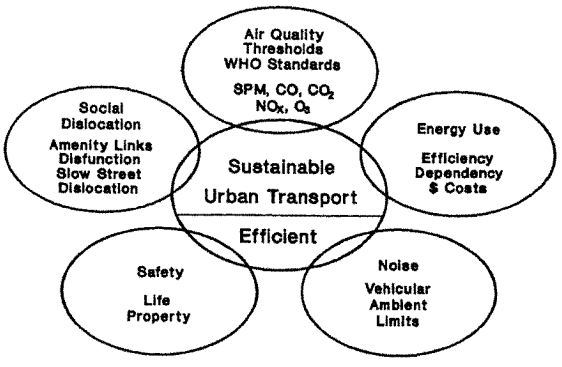


**Fig. 7** Sustainable Urban Transport (Environmental System).

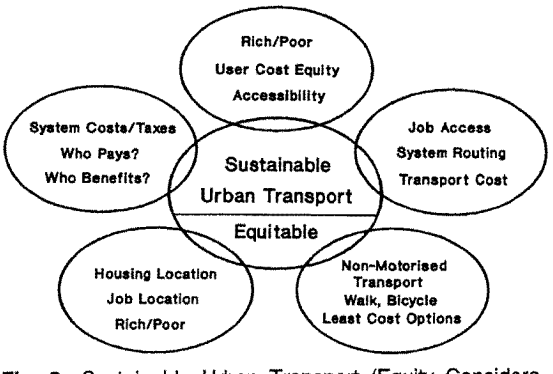


**Fig. 8** Sustainable Urban Transport (Equity Considerations).

requisite for developing sustainable urban transport in the megacities is to construct complementary investment and regulatory policies that are economically efficient, environmentally sustainable, and socially equitable. This requires a systematic and dynamic balancing of the three components, all of which include externalities.

Figure 6 shows the elements of an economically efficient sustainable urban transport system. This approach requires macroeconomic costs (including sector costs and social costs), subsidies (direct, indirect, cross sector transfers) are calculated and balanced against benefits to the environment and human beings, and public and private costs are calculated. Costs are recovered from all beneficiaries. User costs are directly related questions of equity. While aiming for acceptable mobility and time requirements for travel, it should not be public policy to encourage longer travel (therefore be obligated to attempt to save time for those travelling these longer distances). This requires establishing thresholds for time savings as public policy.

Figure 7 shows the construct of an ecologically sustainable system. It requires that policy measures establish air quality thresholds for all pollutants (including specifically ones for at least CO, $CO_2$, SPM, $SO_2$, $NO_x$ and $O_3$) by all transport vehicles. Vehicles which exceed such limits would not be permitted. Another element of an ecologically sustainable transport system is the establishment of clearly defined environment-energy policies that require minimum fuel use and maximum conservation, and reduce dependency for imported petroleum fuels. It is also important to establish noise thresholds for all vehicles and to define safety thresholds both for life and property (e.g., crash integrity standards). Severe social dislocation, degradation and disfunction should not be tolerated in the name of maximising time efficiency of transport.

Figure 8 shows the requirements of a socially equitable urban transport system and it requires the establishment of clear limits to costs and cost recovery in terms of the ability of the poor to pay higher transport costs. It further requires access to employment by the poor and that the modes they use receive high priority. Substantial priority should be given to non-polluting and less polluting modes such as non-motorised transport and High Occupancy Vehicles. There must also be significant improvement in non-transport solutions to transport problems, such as reducing trip lengths by coordinating housing and jobs locations. System costs and benefits should be spread equitably.

This demands an overhaul of the analytical and intellectual bases of transportation policy and planning which have been in vogue since the late 1950s. These older methods have become obsolete with new knowledge on pollutants, public health, and the inefficiencies associated with externalities. If the policy and planning system is not drastically overhauled soon, we may soon be facing the *end of the road* for many megacities.

## ACKNOWLEDGMENTS

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# Electric Power, Economic Development and the Environment in Hainan Province, China

*Lawrence J. Hill*

## ABSTRACT

This paper explores options for Hainan Province to meet rising demand for electricity services as its economy grows. The proposed options are consistent with (i) providing sufficient funds for economic development and (ii) using sound environmental practices in the electric power sector. This can be accomplished by implementing an integrated resource planning (IRP) process in Hainan's electric power sector.

The initial assessment of Hainan's situation presented in this paper conservatively estimates that the implementation of an IRP process could save over one billion watthours of energy by the year 2000, an amount approximately equal to Hainan's 1990 electricity demand. The value of the projected savings correspond to about 20% of the value of Hainan's current gross domestic product. If the projected savings are attained, pollutant emissions from the island's fossil fuel power plants would be correspondingly reduced, with significant environmental benefits.

***Keywords:*** *integrated resource planning, demand-side management, energy and the environment, electric-utility planning, Hainan Province, China*

## AN OVERVIEW OF HAINAN'S SITUATION

The electric power sector poses especially difficult problems in many economies. Adequate supplies of electric power are necessary for growth and development to proceed. However, investment requirements in the capital-intensive electric power industry have high opportunity costs where other social programs are competing for scarce funds to improve the welfare and standard of living of the population. Yet, the very electricity shortages (leading to power rationing and brownouts) caused by inadequate capacity in the power sector constrain living standards. More recently, increased environmental awareness has placed the construction of new fossil-fueled generating stations under more intense scrutiny, and has raised their costs. Hainan Island which lies off the southeast coast of China is confronting this power sector development dilemma today.

In 1988, Hainan was administratively separated from Guangdong Province and organized as a separate province, and designated China's fifth — and largest — special economic zone (SEZ). An SEZ is an area designated to carry out the export-development portion of China's mixed development strategy. That strategy includes both import substitution and export-oriented development: inland areas are consigned to import substitution activities, while the SEZs are engaged in export-related activity. Hainan's export-oriented economic development strategy is loosely modeled after those of South

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Korea, Taiwan, and Hong Kong. Over the long term, the success of that strategy depends on Hainan's ability to harness domestic savings and attract foreign investment by creating the required economic institutions (e.g, functioning stock, foreign exchange, and bond markets). Over the medium term, the economic growth prognosis is favourable. From 1990–95, government planners project the economy to grow at the rate of 16% per year, and to increase six-fold by the year 2000 (Table 1). Gross Domestic Product (GDP) per capita is projected to nearly triple over the same time period, from US$268 in 1990 to US$734 in 2000.

**Table 1**
**Actual and Projected Population and GDP Hainan, 1990, 1995, and 2000**

| Year | GDP[a] | GDP per Capita[b] | Population[c] |
|---|---|---|---|
| 1990 | 1.8 | 272 | 6.6 |
| 1995 | 3.6 | 486 | 7.4 |
| 2000 | 5.9 | 740 | 8.1 |

Source: Hill, Barron, LaRocco, Russell and Shen 1992
[a] In billions of U.S. dollars; based on the 1992 exchange rate of 5.3 yuan per U.S. dollar.
[b] In U.S. dollars; based on an exchange rate of 5.3 yuan per U.S. dollar.
[c] In millions

Historically, Hainan has imported most of its energy and most of that has been from the mainland part of China. Its major imports include coal, diesel fuel, gasoline and charcoal. Hainan has no known reserves of crude oil. Hainan's major energy resources include oil shale, a low-grade brown lignite, and some off-shore natural gas approaching 168 billion $m^3$. Most of the annual production of that gas, however, is destined for the power sector in Hong Kong based on an agreement signed in March 1992.

Hainan has some potentially cost-effective renewable energy forms, including solar, wind, and biomass. The specific potential of these resources can only be determined when in-depth studies are undertaken.

Table 2 shows the electric generating capacity of the Hainan provincial grid. As the table's Footnote 'a' indicates, the total amount of capacity on the grid understates the island's total by 160 megawatts (MW). That amount is owned by self-generators such as sugar mills, small, isolated hydropower stations, and the like. Generating capacity is expected to increase to 866 MW by 1995, with completion of a 240-MW hydropower station at Da Guang Ba. Capacity is then expected to increase to 1590 MW by 2000. As Footnote 'b' in Table 2 indicates, total generating capacity in the year 2000 would almost double if the 1300 MW, coal-fired units at Yangpu were included in the total. This marked growth in electric generating capacity, of course, mirrors the projected growth in electricity demand.

**Table 2**
**Actual and Projected Growth of Generating Capacity Hainan, Provincial Grid 1992, 1995, and 2000 (In Megawatts)**

| Year | Coal | Hydro | Total |
|---|---|---|---|
| 1992[a] | 439 | 187 | 626 |
| 1995 | 439 | 427 | 866 |
| 2000[b] | 1039 | 551 | 1590 |

Source. Hill, Barron, LaRocco, Russell and Shen 1992
[a] Capacity of the provincial grid only, does not include 160 MW of off-grid capacity
[b] Does not include 1300 MW of planned capacity in Yang Pu which will be built by private interests.

Table 3 shows that electricity demand is expected to grow five-fold over the 1990–2000 period, reflecting in large part, the phenomenal growth in industrial use of electricity from 6 terawatthours (tWh) in 1990 to 44 tWh in 2000.

The projections in Tables 1 through 3, of course, are interrelated. For example, a failure to provide electricity services for the increased industrial load

**Table 3**
**Actual and Projected Growth in Electricity Consumption Hainan, 1990, 1995, and 2000 (in GWh)**

| Sector | 1990 | 1995 | 2000 |
|---|---|---|---|
| Households | 233 | 380 | 414 |
| Commerce | 239 | 325 | 650 |
| Industry | 595 | 2003 | 4368 |
| Agriculture | 68 | 92 | 108 |
| Total | 1135 | 2800 | 5540 |

Source: Hill, Barron, LaRocco, Russell and Shen 1992

requirements will stifle economic growth. That failure could arise because of the large capital requirements for building electric generating stations. At the same time, providing electric power services raises environmental concerns, especially in China where the avoided electric generating unit is coal.

In recognition of the environmental problems associated with generating electricity from fossil fuels and, more generally, the importance of environmentally sound development, the Hainan government decided to integrate economic development with environmental planning through a program aimed at assessing the environmental implications of development activities. To this end, stringent environmental regulations were established, and an International Advisory Council was created to link Hainan's development with environmental practices consistent with international standards. As part of this economic development-environmental challenge, an integrated resource planning process has begun in Hainan's electric power sector.

The remainder of this paper explores the electricity-environment-economic implications of Hainan's development and growth. The next section looks at possibilities for increasing electricity services without building new generating capacity. Integrated resource planning (IRP), an electric-utility planning paradigm, is given special attention. Also, the South Korean experience with economic development is used to illustrate some of the major points. The third section of this paper applies IRP principles to the electric power sector in Hainan, to indicate the extent to which such actions may permit deferring construction of more electric generating units. The economic and environmental implications of the analysis are discussed in the final section of this paper.

## PROVIDING RESOURCES FOR ELECTRIC POWER DEVELOPMENT

### Supply-Side Possibilities

A number of electric utilities throughout the world have found the costs of generating electricity can be reduced — or capacity requirements lowered — by addressing problems with power delivery systems. Typically a number of alternatives exist, with the specific ones being determined by local circumstances. For example, in many cases, inefficient or redundant equipment is presently being used. Transmission and distribution losses for electric power supply may also be higher than they need to be. The amount of labor employed is often excessive and/or improperly trained or supervised. Maintenance of generating stations is often inadequate. Load dispatching may not be as economic as possible in many cases. Finally, existing management and accounting systems are often sub-optimal.

In some countries, the efficiency of the electric power sector has been improved by eliminating the monopoly held by state-owned utilities in producing electricity. Some national governments have reevaluated policies dealing with ownership and production of electric power and are now allowing private sector participation in power generation through negotiated buy-back arrangements. The arrangements allow state-owned utilities to purchase power at lower production costs.

South Korea, with little indigenous energy resources (i.e., some low-grade anthracite coal and hydropower) and large commitments of capital to export-oriented industries, is an example of a country that used supply initiatives to provide electric power resources during the formative stages of its development in the 1960s and early 1970s. In July 1961, three existing electric utilities were merged into one, resulting in significant economies. In addition, a number of technical efficiency improvements were introduced, including a power loss prevention program which reduced transmission line losses from nearly 30% in 1961 to 18% in 1966. These initiatives are estimated to have saved approximately 1000 megawatts (MW) of electric generating capacity requirements during the 1960s and early 1970s (Hill 1992).

The Korean government also allowed private companies to construct generating capacity in the mid 1960s when rising living standards and rapid industrialization strained existing capacity on the central grid. More than 1500 MW of electric generating capacity was constructed by the private sector during this period (Hill 1992).

More recently, the Government-Invested Enterprise Management Act was enacted in response to the Korean government's dissatisfaction with the operating performance of public enterprises. The legislation provided incentives for employees of these enterprises to improve the performance of their firms, with rewards accruing directly to the managers rather than the firms. The legislation had a significant impact on the power sector, reducing the Korea

Electric Power Company's operating costs an estimated 33% four years after enactment (Hill 1992).

## Electricity Pricing

Cost-based electricity pricing is a powerful tool to both (i) generate resources for financing expansion of electric power sectors and (ii) manage electricity demand. Again, South Korea is a good example illustrating the former because public policy toward developing the power sector was directed at obtaining as much resources for new electric generating capacity as possible from pricing during the formative stages of its development in the 1960s. Because of its pricing alone,[1] the percentage of capital expenditures financed from within the state power monopoly, averaged close to 50% from 1967 to 1973. And, depending on assumptions made about the capital cost of coal units, this practice resulted in nearly 1000 MW of capacity savings over the 1961–73 period.

Using electricity pricing as a *Demand-Side Management* (DSM) strategy to manage electricity demand is used by many utilities as part of their efforts to reduce the need for new generating capacity. The most widely adopted pricing strategy is time-of-use (TOU) pricing, which generally refers to electricity rates which vary over the course of a year: hour-by-hour, day-by-day, or season-by-season (Hill 1990). Time-of-day (TOD) pricing (rates which vary over the course of a day), a specific form of the general class of TOU rates, has generally been effective in shifting electricity consumption from peak to off-peak periods. And, at least for higher volume users (high-volume residential and higher-voltage commercial and industrial users), it has proven to be cost-effective for many utilities.

Many utilities have also used another form of a TOU tariff, an interruptible or curtailable (I/C) one, to reduce demand on days when capacity utilization is approaching its limit, usually offering rate incentives to large-volume, high-voltage consumers in return for shedding load for a limited amount of time on short notice. From every indication, these tariffs have been successful in reducing capacity requirements for utilities that have adopted them throughout the world.

## Combining Supply and Demand Initiatives: The IRP Paradigm

Currently, many electric utilities are also beginning to run technical demand-side programs to meet energy and load requirements. That is, they are attempting to change the pattern and level of electricity demand (i.e., DSM) through conservation and load management programs are weighed as a resource option on an equal footing with other, more traditional supply resources (e.g., building new generating stations, extending the life of old ones). In the United States, for example, Hirst (1993) showed that 439 U.S. electric utilities, accounting for more than 80% of U.S. electricity sales, spent nearly $1.8 billion on DSM programs in 1991. In return for this spending in 1991 and earlier years, peak load has been decreased by 26 700 megawatts and annual electricity use declined by 23 000 gigawatt-hours. The trend in DSM spending is not limited to the United States. In Asia, for example, the Thai government will invest $190 million in DSM programs to lower electricity consumption by 10% over the next decade (*Wall Street Journal* 1993).

The process of selecting a resource mix on the basis of comparing the benefits and costs of demand and supply resources is referred to as integrated resource planning (IRP). The IRP process is a combination of (1) traditional least-cost planning, a process by which utilities minimized the cost of generating a given amount of electricity and (2) demand-side planning. Its goal is to provide needed electricity at the lowest possible economic, social, and environmental cost.

IRP is a management tool that allows firms (for simplicity, we will concentrate here on electricity supply firms) to consistently compare the cost-effectiveness of all their resource options — those on both the demand and supply side — taking into account their different economic and reliability characteristics. Simply put, the IRP process increases the choices available to an electric firm in meeting its demand. The firm then selects the mix with the lowest cost. Utilities in the West have found that they can cost-effectively lower capacity requirements by more than 25% using the IRP process. This occurs while simultaneously meeting all customer needs, and at lower costs per kWh (Schweitzer et al. 1991).

In Figure 1, DSM planning is placed in the context of a dynamic electric utility planning framework, including (1) factors that motivate utilities to consider DSM planning, (2) the relationship between demand-side planning and the IRP process, and (3) DSM program implementation and evaluation (Hill

et al. 1991). The process is dynamic not only because planning by its very nature is evolutionary but also, as shown in Figure 1, because the effectiveness of DSM programs has feedback effects on both the process of selecting the programs and the way in which they are implemented. The effectiveness of DSM programs, of course, can be determined only by systematic program evaluation (Hill, Hirst and Schweitzer 1992a).

Figure 1 also illustrates how the characteristics of both the power delivery system and customer demand influence decision making on whether to implement an IRP process. For example, the types of generating units used by electric utilities can be a motivating force to engage in the process. Based on statistical analysis of 24 U.S. utilities, for example, the percent of total peak kilowatt (kW) resources projected to be met by DSM is larger for utilities with greater dependence on oil and gas generating units for peaking purposes, which have higher costs per kilowatthours (kWh) generated (Schweitzer et al. 1991).

On the demand side, utilities with low load factors are more likely to seek ways to shave peak load. The goal in all cases is to find the mix of supply and demand resources that lowers present and future costs and, therefore, increases the amount of capital available for reinvestment.

The final two sets of blocks on implementation and evaluation in Figure 1 are also important. DSM programs are implemented and evaluated in the same way that supply resources are. That is, DSM programs are treated parallel to the manner in which a utility chooses to (1) build a power plant, (2) construct it, and (3) evaluate its performance. As we discuss in the next section, a problem that many utilities confront in treating DSM and supply resources in a parallel manner is the lack of data on running DSM programs. The technical savings of these programs are generally well known. It is the marketing side where utilities are deficient because firms do not have enough information to know how their decisions will affect the success of their programs.

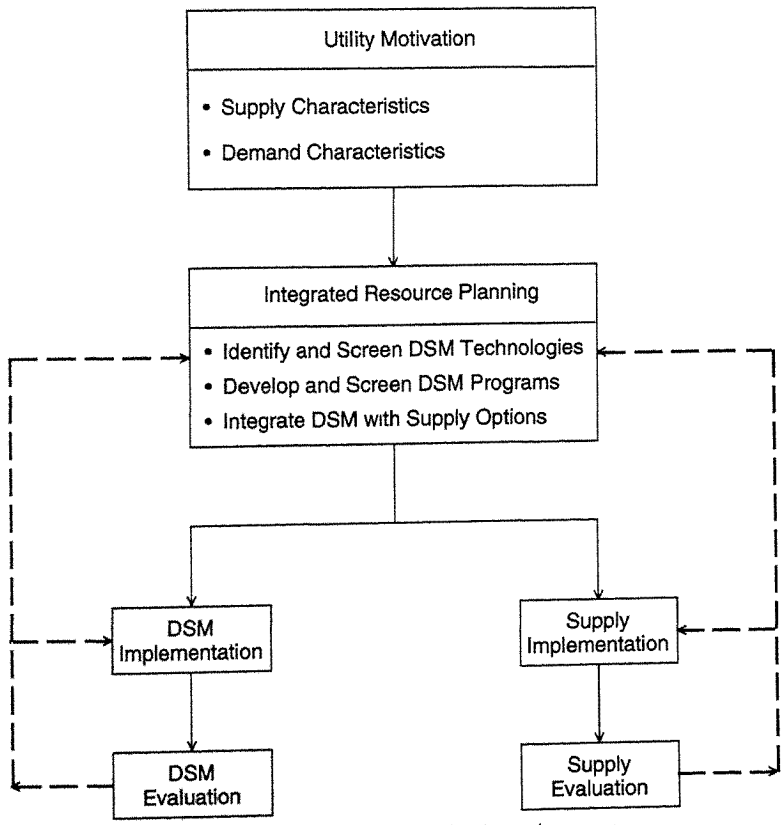


**Fig. 1** Integrated resource planning as part of a dynamic process.

## APPLICATION OF IRP PRINCIPLES TO HAINAN

### An Estimate of Energy Savings Potential

In practice, electric utilities that have implemented IRP processes use different approaches, varying from simple to complex ones. An important reason for different approaches is experience. Because IRP is a recent phenomenon, many utilities are just beginning to wrestle with its more complex aspects such as the type of integrating method to use in comparing very different types of resources (Hill 1991b). Utilities that have engaged in IRP over a period of time are likely to have developed an organizational structure and in-house expertise to use more sophisticated approaches (Hill, Hirst and Schweitzer 1992c).

One important difference in the approaches used by utilities is the way in which DSM options are characterized. Some utilities compare DSM *technologies* with supply resources. Other utilities aggregate DSM technologies to varying degrees and compare the aggregate with supply resources. Aggregating three different commercial lighting technologies on the basis of market segments is an example. A DSM program is a group of technologies combined for marketing to a specific customer group. Ideally, technologies are combined in a package to complement rather than compete against one another (Hill, Hirst and Schweitzer 1992a).

Data requirements for these DSM programs are a limiting factor in implementing an effective IRP process. Information is needed on:

- the number of customers using different types of electricity-using durables and, therefore, the total amount of savings available from a program;
  the possible market penetration of energy-efficient durables;
  quantification of the trade-offs between marketing these durables and their penetration; and
  the most effective financing mechanisms for different programs.

To determine the number of potential participants in a DSM program, a significant amount of information must be known about the targeted group's prospective electricity consuming behaviour (e.g., amount and type of end uses, time-of-day). This is particularly difficult to obtain in a fast-changing situation such as will exist in Hainan. In determining savings from a technology, a distinction must be made between total savings (i.e., the reduction in electricity use by participating customers) and net savings (the portion of total savings that can be attributed to the DSM program). Therefore, a significant effort must be expended on analyzing savings due to secular trends, endogenous and exogenous factors such as income effects and price effects. In a developing economy context, those can be substantial.

Unfortunately, a complete set of data of the type needed to develop comprehensive DSM programs was not available for this study. However, it is possible based upon information on the IRP experiences of Jamaica (Conservation Law Foundation 1991) and the U.S. Virgin Islands (Hill et al. 1993) which share certain similarities with Hainan (such as climate) to identify *potentially attractive*, environmentally benign, energy resource options for Hainan (Hill, Barron, LaRocco, Russell and Shen 1992).[2] Besides climate, one of the most important similarities of the situations in Hainan, Jamaica, and the U.S. Virgin Islands is the insularity of the electric power system. That is, as with many island-based, insular power systems, the avoided cost of power for electricity production in Hainan is higher than otherwise would be the case, because of Hainan's inability to purchase power from neighboring utilities. This results in the need to maintain reserve margins higher than would be the case if Hainan had purchased power sources.

The results of the study for the year 2000 are summarized in Table 4. Projected electricity demand for the year 2000 is based on the Hainan government's forecast in its Eighth Five-Year Plan. The analysis indicates that estimated electricity savings from implementing DSM programs in Hainan would be substantial. Assuming a 0.6 load factor on power plants, the 1139 GWh of *energy* savings from the DSM programs in the year 2000 translate into 217 MW of *capacity* savings. This represents nearly 80% of Hainan's 1992 peak electricity demand. Assuming an avoided capacity cost of US$1000 per kW for a coal-fired unit, the 217 MW of capacity savings translate into a US$217 million monetary saving. If a less conservative cost estimate of US$2000 per kW is used in the analysis, the savings increase to US$434 million or more than one-fifth of Hainan's 1992 GDP.

## Additional Possibilities

The data in Table 4 understate the benefits of implementing these programs. First, because of data and time constraints, the full range of DSM possibilities and their interaction is not explored here. For example, there is no attempt in this paper to quantify the effects of using cost-based electricity pricing as a DSM strategy. The philosophy behind the current tariff in Hainan is to encourage electricity consumption because of excess generating capacity (Hill, Barron, LaRocco, Russell and Shen 1992).

Hainan's generating capacity is very lumpy with over-sized units not allowing load to be followed very easily. Because of the lumpy excess capacity, farsighted price incentives are not in place to encourage electricity conservation over the longer term.

The Hainan Electric Power Industry Bureau faces the classic short run-long run pricing problem confronting many other utilities throughout the world: pricing for excess capacity in the short run, but at the cost of distorting incentives for the longer term because economic development is promoting electricity demand growth rates so large that the utility will be experiencing capacity shortages in the longer term. And, making-up that electricity generation capacity deficit is very costly because of the capital intensity of electric generating systems.

In the immediate future, time-of-day pricing would not seem to be cost-effective for the residential sector in Hainan. For that pricing structure to be cost-effective, average consumption levels should be around 1200 kWh per month, typically caused by the penetration of air-conditioners and swimming pools (Hill 1991c). However, there does seem to be room to implement cost-effective innovative pricing schemes in the industrial sector (Hill 1991b).

Another important omission in the estimated potential savings shown in Table 4 is the energy conservation effects of more stringent building standards, especially in the three rapidly growing cities of Haikou, Sanya, and Yangpu. These cities are currently experiencing a construction boom and every indication is that they will continue to do so in the future. Therefore, this is a particularly favourable time to implement conservation standards for new construction. The recently developed standards for Jamaica may be a good reference point for Hainan authorities because Jamaica and Hainan have similar climates (Jamaica Bureau of Standards 1992).

Finally, the environmental benefits of delaying or eliminating the need for electric generating units were not quantified. These benefits could be substantial. Besides the obvious direct benefits to citizens from reducing pollution discharge, improved environmental quality could be a boon for the tourist industry that the Hainan authorities are trying to

**Table 4**
**Summary of Potential Savings from Selected Demand-Side Management Measures Hainan, 2000**

| *Savings[a] Sector* | *Forecasted Demand (GWh) in 2000[b]* | % | *Energy GWh* |
|---|---|---|---|
| Households | 414 | 25 | 103 |
| Commerce | 650 | 25 | 162 |
| Industry | 4368 | 20 | 873 |
| Total Energy (GWh) | 5432 | 21 | 1139 |
| Total Capacity Savings (MW)[c] | | | 217 |
| Total Monetary Savings ($ Million), assuming— | | | |
| $1000 per kW[d] | | | $217 |
| $2000 per kW[d] | | | $434 |

Source: Hill, Barron, LaRocco, Russell and Shen 1992
[a] Includes only the energy savings. Does not include social and economic benefits; e.g., environmental benefits, macroeconomic benefits, export promotion, etc.
[b] Based on Hainan's Eighth Five-Year Plan.
[c] Assuming a 0.6 load factor.
[d] The cost per kW of constructing a 200-MW coal plant in Hainan.

stimulate. Also, although Hainan is not a major contributor to the greenhouse gas problem because of its small size, it could be a positive force for reducing greenhouse gas emissions by demonstrating to mainland China the process of evaluating resources and using technologies to control energy demand.

## THE ENVIRONMENTAL PAYOFFS FROM IRP IN THE HAINAN CONTEXT

A formal assessment of the effects of burning fossil fuels on Hainan's environment has not been conducted. A recent study on environmental issues in Hainan (Environmental Resources, Ltd. 1991) tangentially addressed the relationship between the production of electricity and environmental damage, without quantifying the effects. However, in that study, the authors pointed out the importance of the relationship between economic development and environmental management in Hainan. Compared to the rest of the world, much of Hainan is virgin land. Its tropical and subtropical environment with exotic flora and fauna comprise unique species and its level of biodiversity is quite high.

Without specific information on the grades of coal burned, power plant siting, boiler characteristics, environmental mitigation, and the like, it is difficult to estimate with precision the environmental savings of the DSM programs suggested in this study. However, there is enough information derived from experiences elsewhere to suggest the magnitude of benefits of implementing DSM measures by avoiding production of electricity from fossil fuels.

For example, using the 1139 GWh estimate of energy savings in the previous section and some conservative assumptions about sulfur content of the coal and its AP-factor, sulfur-dioxide ($SO_2$) emissions in Hainan would be reduced by nearly 3000 tonnes if the DSM programs suggested in this study were implemented. This amount, of course, is a lower-bound on the potential emission reduction.

As noted above, all cost-effective DSM programs are not part of the 1139 GWh savings estimate. Despite the uncertainties, several points are clear: (i) reducing power sector pollutant emissions through DSM is likely to be highly cost-effective compared to end-of-pipe clean-up technologies, and (ii) Hainan still has unique and valuable ecosystems which are likely to be severely stressed by the projected expansion of the power sector.

## CONCLUSION

This paper outlined a strategy for Hainan Province in China that, if effectively implemented, would:

- provide future energy services for Hainan in the least environmentally degrading way;
- eliminate the need to build significant amounts of new fossil-fueled, electric generating capacity, saving capital to invest in other development projects;
- lower the cost that Hainan households and businesses will pay to light their homes and run their industries;
- reduce the future coal import bill; and
- improve the prospects for export industries.

Implementing an aggressive strategy would help promote economic development and growth in Hainan, improve the standard of living, and preserve to the greatest extent possible Hainan's rich environmental resource base, a key requirement for its promising tourist industry.

The crux of this strategy is to adapt *proven* policies and techniques for producing and using energy more efficiently to existing conditions in Hainan. This paper uses information on the Hainan situation as a starting point, and then applies the principles of integrated resource planning (IRP) and the experiences in other countries to outline a strategy for the province. The experience in other parts of the world with IRP in the power sector is that fuel consumption can be reduced *without* lessening the ability of consumers, industry, and the government to obtain the energy services that higher use of fuel would otherwise bring. Further, those energy services can be provided with *less* capital investment than would be necessary if traditional practices were followed. Both of these results have obvious and important development and environmental benefits.

In short, consumers have more money available to buy other things; production costs are lowered, improving the ability of firms to compete in international markets; and more capital is available to invest in new machinery and equipment that produces goods and services to use in Hainan or to export to other countries.

Although Hainan currently has excess generating capacity, this is an ideal time in the island's development process to implement integrated resource planning. For one thing, Hainan's economic output is expected to double in a five-year period

with a corresponding increase in electricity consumption (Hill, Barron, LaRocco, Russell and Shen 1992). That consumption increased by nearly 40% in 1991 and is expected to grow at nearly the same rate in 1993! Before long, Hainan's excess power generation capacity will deteriorate into a severe deficiency.

Second, many of the DSM programs identified in this study have long lead-times before reaching maximum penetration into the market. Related to this, it will take a considerable amount of time to (i) assemble the necessary data to develop DSM programs tailored to Hainan's conditions, (ii) compare them with the costs of building new power plants, and (iii) implement the cost-effective programs.

Third, Hainan's current low level of income implies modest penetration of the most electricity-intensive durables. Economic development implies higher income levels and the penetration of new and different types of electricity-using durables such as water heaters, air conditioners, refrigerators, and lighting. The ability of the government to promote the use of energy-efficient durable goods is much greater before those types of products have had much time to penetrate Hainan's markets. There is inertia in an existing stock of electricity-using durable goods, implying that they will not be readily traded for more efficient new ones in the short term even if better means of meeting needs exist. The longer the delay, the greater the sacrifice in Hainan's future well-being.

Finally, the Hainan government is pursuing a strategy that promotes economic development and growth consistent with principles of sound environmental management. In the electric power sector, their implementation of an IRP process is consistent with both the economic and environmental strategy. The IRP process helps policy-makers move toward the optimum balance among electricity production, economic development, and environmental degradation.

## NOTES

1 The discussion refers to the overall *level* of electricity prices in relation to total costs. The *structure* of electricity prices in Korea—relative prices among different consumer groups—have historically favoured 'productive' sectors of the economy (i.e., export-oriented sectors) at the expense of 'nonproductive' sectors.

2 The options are *potentially* attractive because they were not identified on the basis of rigorous analysis, but rather estimated based on experiences with IRP in other economies. *Attractive* is defined in the economic sense to mean that the benefits of implementing an option exceed its costs, where benefits for electric power options are defined as avoiding the cost of constructing and operating a coal generating unit, Hainan's marginal generating source.

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# Containing Pollution in the Straits of Malacca: Legal and Economic Considerations

*Anthony T.H. Chin*

## ABSTRACT

Shipping accidents along the Straits of Malacca have increased from 77 cases in 1988 to 110 in 1992. These accidents include running aground, collisions, sinkings, engine breakdowns and fire on board vessels. While many of these accidents have not resulted in a great loss of life or major oil pollution, concern has been mounting among governments of the Straits States of Indonesia, Malaysia and Singapore that a 'big one' is in the offing given the increase in risk factors. Sources of oil pollution in the Straits include shipping accidents, tanker cleaning and dumping.

This paper focuses on the problem of oil pollution in the Straits by first assessing the present situation in the light of regional trade developments and the expected increase in cargo movements. Various problems facing the oil tanker industry are then highlighted. Existing legislation of littoral states does not seem to be coordinated and harmonized in response to the problem. Even if they were, the question of validity arises given the international use of the Straits.

***Keywords:*** *oil pollution, Straits of Malacca, oil tanker industry, littoral states, legislation, economics*

## INTRODUCTION

The Straits of Malacca, or 'the Straits,' are the world's second busiest waterway after the English Channel, with an estimated 2000 vessels of all types passing through daily.

Geographically the 1000 km waterway lies between the Indian and Pacific oceans. A narrow definition of the Straits is based on the two main entrances. From the Indian Ocean via the Andaman Sea, the first entrance is either between Pulau Perak (Malaysia) and Diamond Point (Indonesia) which is 146.5 km wide, or Penang (Malaysia) and Ujung Thamiang (Indonesia) (202.8 km wide). The entrance from the Pacific Ocean lies between Tahan Datok in Malaysia and Indonesia's Tanjung Pergam. This entrance is just 17.8 km wide and includes the Straits of Johore and Singapore. A commonly-accepted definition would thus include the littoral states of Indonesia, Malaysia and Singapore. The breadth of the Straits varies between 202.8 km and 12.6 km (near Kukub) (Figs. 1 and 2).

Over the past five years more than 490 shipping accidents have been reported. Incidents have increased from 77 in 1988 to 110 in 1992 and seem to be on a rising trend (Fig. 3). In January 1993 alone there were 20 accidents in the Straits. The number of ships and the kinds of cargo transported raise the possibility of an environmental catastrophe resulting from a major oil spill.[1] Other sources of pollution include dumping sludge and illegal cleaning of tanks just off the coastline. Some of these activities take place over rich fishing grounds.

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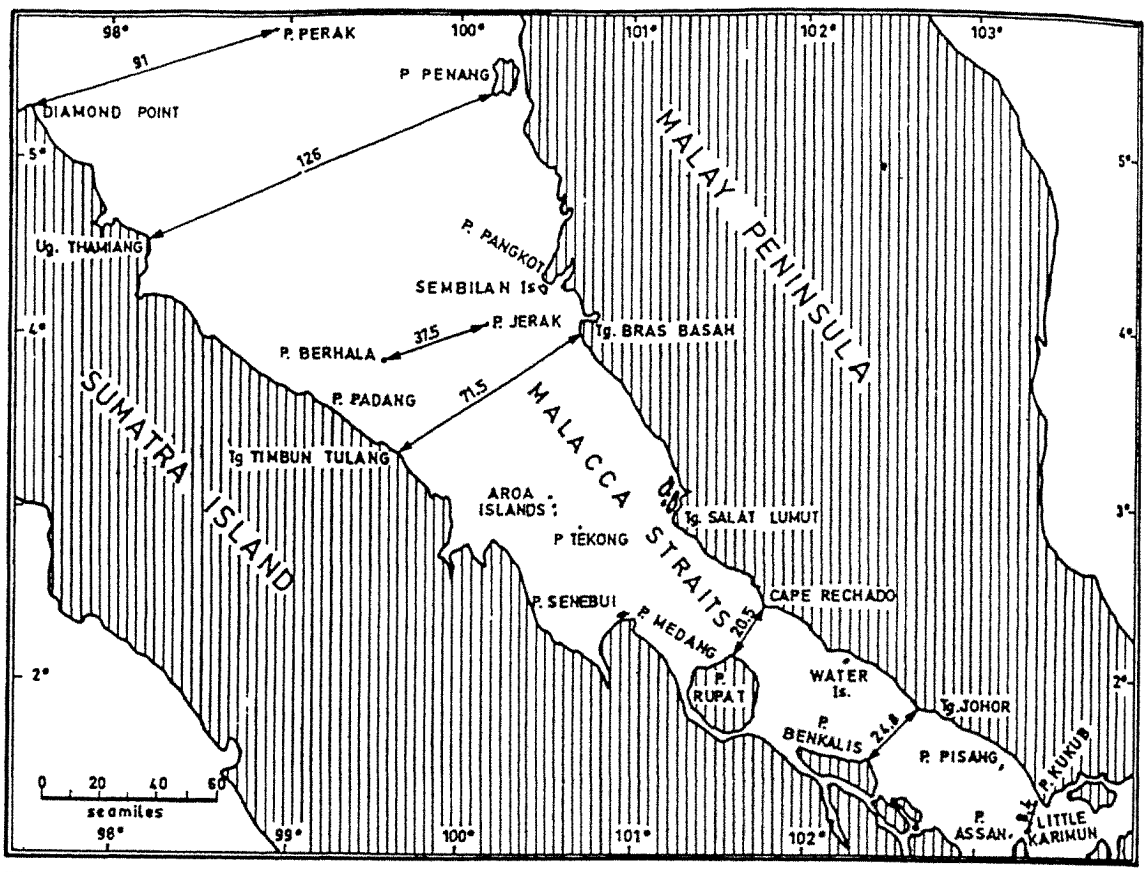


**Fig. 1** The Malacca Straits.

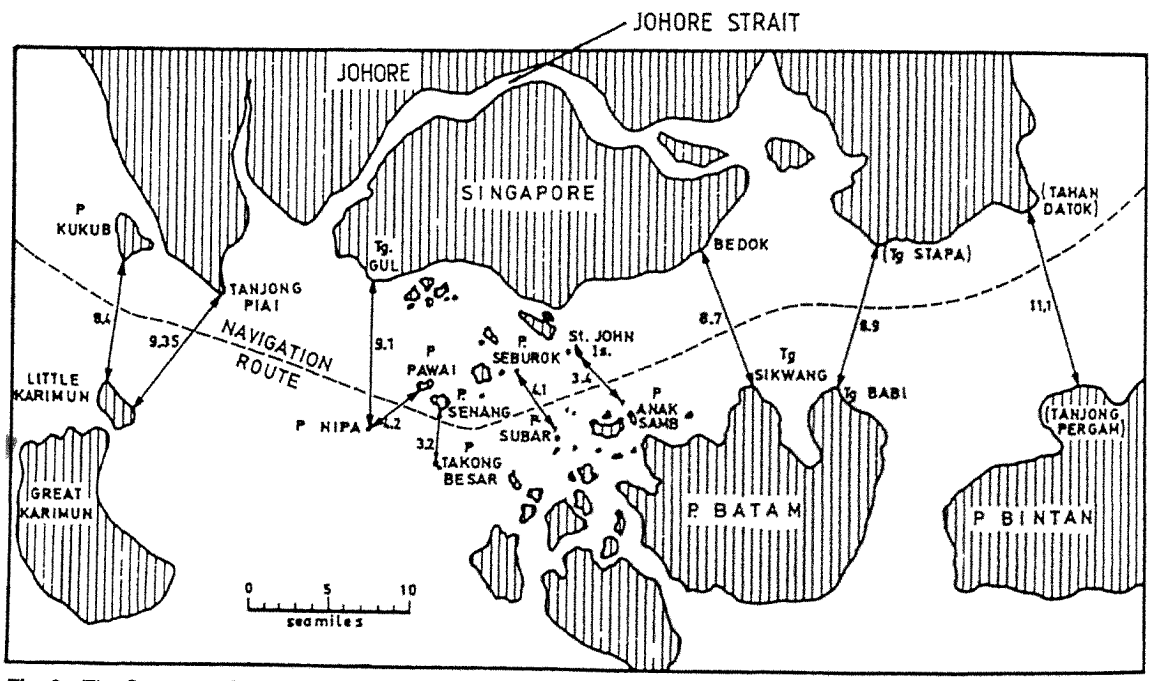


**Fig. 2** The Singapore Straits.
Source: Koh (1982)

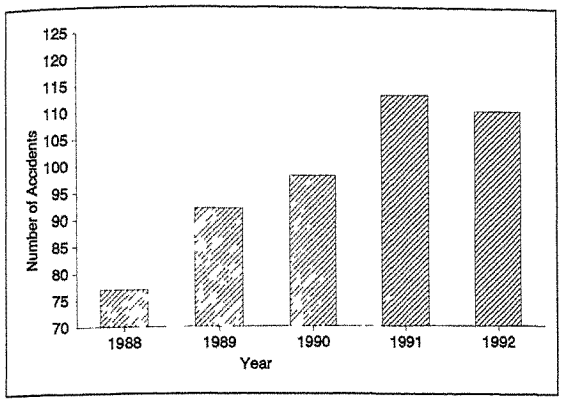


**Fig. 3** Shipping accidents in the Straits 1988–92.
Source: *Straits Times* 3–4 June 1993

This paper examines the economic background to this problem and the responses of littoral states from a legal perspective. Initially, however, we focus on trends in trade within the region and on the oil tanker industry. We then examine the legislation of various littoral states, including Singapore's attempts at environmental protection of the marine environment, which is discussed with reference to the Prevention of Pollution of the Sea Act, 1990. The final part of the paper proposes some legal and economic approaches to remedy existing shortcomings in the environmental management system for the Straits.

## TRADE AND TRAFFIC ALONG THE STRAITS

The increase in traffic along the Straits is a consequence of trade taking place between the dynamic high growth economies of the Asia Pacific Region and the rest of the world. Intra-Asian traffic alone amounted to almost 3 million Twenty-foot Equivalent Units (TEU) in 1991, second only to the Pacific (6 million TEUs) but well ahead of the North Atlantic (2.6 million TEUs).[2] Japan, the Newly Industrialising Economies (NIE) and the Association of South East Asian Nations (ASEAN) accounted for most of the trade, which is expanding rapidly. Intra-Asian exports make up about 39% of the total exports of the region of which 70% were manufactures. Japan and the NIEs account for 69% of total intra-Asian exports (IMF 1990).

Several factors (apart from high economic growth and incomes) have contributed to this increase in trade. These include the high economic interdependence among Pacific Rim nations, the development of regional economic groupings and the economic liberalization of the former Asian centrally-planned economies such as China and the Indo-Chinese states.

The realization of the ASEAN Free Trade Area (AFTA) by the year 2008 is expected to enhance the growth in trade. Though this remains relatively small in comparison in terms of export destination and import source (Tables 1 and 2), it is unlikely to remain so as efficiency and competition will expand opportunities for trade. The increase in intra-Asia trade is exerting considerable pressure on Asia's existing transport infrastructure. For example, ASEAN seaports are especially congested as 80% of the external trade is seaborne (Leinback and Chia

**Table 1**
**ASEAN-5 Exports by Destination 1979–89**

| *Region/Country* | *1970* | *1975* | *1980* | *1985* | *1989* |
|---|---|---|---|---|---|
| World (US-$M) | 6 154.1 | 20 763.9 | 66 534.3 | 68 553.9 | 119 536.1 |
| Asia-Pacific (AP) | 70.8 | 72.1 | 70.2 | 75.2 | 73.1 |
| USA17.3 | 17.3 | 19.9 | 16.9 | 20.3 | 21.6 |
| Japan | 24.0 | 27.0 | 26.8 | 23.9 | 18.4 |
| NIE* | 5.5 | 5.7 | 5.3 | 8.5 | 9.8 |
| ASEAN-5** | 19.8 | 15.7 | 16.7 | 17.8 | 17.4 |
| Rest of AP*** | 4.2 | 3.8 | 4.5 | 4.7 | 5.9 |
| EC | 15.7 | 13.4 | 13.4 | 11.4 | 14.5 |
| Rest of the World | 13.5 | 14.5 | 16.4 | 13.4 | 12.4 |

* Taiwan, Korea and Hong Kong
** Intra-ASEAN-5
*** Canada, China, Australia and New Zealand
Source: Adapted from Ariff and Tan 1992

**Table 2**
**ASEAN-5 Imports by Source 1979–89**

| *Region/Country* | *1970* | *1975* | *1980* | *1985* | *1989* |
|---|---|---|---|---|---|
| World (US-$M) | 7 372.7 | 23 322.3 | 63 178.5 | 63 423.9 | 125 210.9 |
| Asia-Pacific (AP) | 65.6 | 62.7 | 51.2 | 69.3 | 71.0 |
| USA17.3 | 15.1 | 15.5 | 15.4 | 15.7 | 15.6 |
| Japan | 25.4 | 24.0 | 21.8 | 20.8 | 23.8 |
| NIE* | 3.8 | 4.4 | 3.4 | 6.8 | 10.3 |
| ASEAN-5** | 12.5 | 10.1 | 13.3 | 16.3 | 4.2 |
| Rest of AP*** | 8.8 | 8.7 | 7.3 | 9.2 | 7.1 |
| EC | 19.0 | 16.1 | 12.7 | 13.2 | 13.4 |
| Rest of the World | 15.4 | 21.2 | 26.1 | 17.5 | 15.6 |

* Taiwan, Korea and Hong Kong
** Intra-ASEAN-5
*** Canada, China, Australia and New Zealand
Source: Adapted from Ariff and Tan (1992)

1987). Apart from infrastructural constraints there is the all important consideration of 'sustainable development'. The implications of increased trade flows are many. First, the increase in the movement of goods and people will add additional traffic to the already busy Straits. Secondly, this will increase the probability of mishaps and pollution of the marine environment. Thirdly, there is an urgent need for littoral states to respond by taking adequate measures to prevent and minimize accidents, as well as designing appropriate compensation schemes.

## THE OIL TANKER INDUSTRY

Safety standards maintained by the ship operator regardless of age or flag remain the most important factor in determining the risk of tanker accidents. Despite reductions in tanker accidents between 1975 and 1989 (Table 3) recent trends seem to indicate that the situation has deteriorated.

One reason for this is the tanker industry's susceptibility to open competition and low freight rates. This has led to a significant minority of the

**Table 3**
**Accident Statistics Involving Tankers**

| | *Source* | *Average rate per year* | | |
|---|---|---|---|---|
| | | *1975–79* | *1980–84* | *1985–89* |
| No. of Serious Casualties<br>Tankers > 6000 grt<br>% p.a. of ships at risk | IMO | 92<br>(2.7%) | 68<br>(2.2%) | 54<br>(1.9%) |
| No. of Total Losses<br>Tankers > 100 grt<br>% p.a. of ships at risk | LR | 28<br>(0.4%) | 22<br>(0.3%) | 15<br>(0.2%) |
| No. of Oil Spills from<br>Tankers over 5000 bbls | ITOPF | 25 | 8 | 10 |
| Accidental Tanker Pollution Tonnes | IMO | 458 000 | 123 000 | 120 000 |
| Operational Tanker Pollution Tonnes | IMO | 700 000 | N/A | 158 000 |

Source: Shell International Marine Ltd 1992

2000-plus owners to operate below internationally agreed standards in an attempt to cut costs. The situation is exacerbated by the current economic climate which make replacement of ships difficult even though the cost of maintenance is high. It should be noted that approximately 2 million tonnes of oil are estimated to enter the seas each year of which about 10% are a consequence of mishaps involving tankers (Shell Briefing Service 1991). About 12% derives from tanker operations. However, almost 75% of the pollution originates from sewage, industrial effluent, urban/river run off and atmospheric rain (55%), non-tanker shipping (about 10%) and natural sources (about 10%). The remaining sources are refineries and terminals and offshore exploration and production.

Since 1989, Protection and Indemnity clubs and oil spill compensation funds and underwriters have reported escalating claims. Bodies such as the International Shipping Federation have reported a growing shortage of trained seamen, which is expected to become more acute in the future. Human error has been found to account for about 80% of ship casualties. In addition, the over-construction years of the 1970s have resulted in surplus capacity and the present low rates which have made maintenance difficult. High international standards have also contributed to escalating costs.

## Market Structure, Costs and Revenues

The major oil companies own only 12% of the world tanker fleet. Independent oil companies make up more than 60%, with the remaining fleet belonging to oil producers, smaller oil companies and governments (e.g. Kuwait, Saudi Arabia and Iran). Ownership of the independent companies is fragmented with more than 200 owners. One-ship companies, often established for legal or fiscal convenience, are quite common. Users often prefer not to own but rather to hire. It is basically a charter market. Chartering takes place under four categories. First, there is time charter where the owner mans the vessel and hires it out for a specific time period. Demise or bareboat charterers, on the other hand, hire out the vessel without manning it. The hirer, operates and mans the vessel. Spot or voyage charter commits the owner to transport cargo between designated points. Finally, contracts of affreightment require the owner to move specified quantities of cargo over a particular period over a route. He has a choice of vessels.

Tanker costs are typically broken down into capital, operating and voyage costs. The construction of a Very Large Crude Carrier (VLCC) costs approximately US$125 million. A 30 000 dwt tanker starts at US$30 million. Before the early 1980s shipbuilding had been subsidized as governments anxious to protect employment offered soft loans to owners of new ships. Since then loans are generally at 80% of vessel value at 8% interest for up to eight years. In most cases, tankers are financed by leases. Legal ownership remains with the financier with the risks and rewards being passed on to the operator. Terms of leases have been extended to up to 25 years. Tax incentives in some countries, such as Norway, have encouraged private investors to own shares in ships or ship owning companies.

Most of the operating costs are fixed and consist of insurance and administration, repairs and maintenance, stores and lubricants and labour. Labour or manning costs account for almost 40% of operating costs. This is higher for ships manned by European crews. Crew levels on a vessel have fallen from an average of 40 to 50 persons in the early 1950s to less than 20 by the 1980s. Factors such as the regulations specified by the flag states, on board maintenance and the degree of automation determine manning levels. Insurance costs account for between 10% for new and 5% for old ships. Voyage costs are variable, fuel being the dominant element though this varies from vessel to vessel. A VLCC built in the 1970s consumes 140 tonnes daily. In contrast, newly-built tankers consume 60 tonnes per day (t/d). Cargo handling costs, port and canal dues make up the rest of voyage costs.

Freight rates and productivity are the two main factors which determine revenues.[3] The owner would attempt to minimize non-revenue generating activities (such as time spent in ballast, off-hire and in port) and maximize the ship's load capacity. If the vessel is held up in port beyond the time stipulated in the charter agreement, a demurrage or penalty is paid by the charterer to the owner. Market conditions will ultimately determine the rate of utilization and speed at which the tanker is to be operated. For example, it is usually economical to operate at full speed with maximum cargo when rates are high. Conversely, when rates are low this leads to 'slow steaming' (i.e., operating at reduced speeds which saves fuel and compensates for loss of revenue and part cargo).

To appreciate the dilemma, let us consider an

**Table 4**
**Summary of Revenue and Cost for a Typical Voyage by a VLCC**

| *Revenue* | *US$* | *Costs* | *US$* |
|---|---|---|---|
| A. 260 000 tonnes | 2 087 280 | B. Voyage Costs | |
| | | 1. Fuel | 559 000 |
| | | 2. Port Charges | 268 000 |
| | | 3. Other | 26 000 |
| | | | 853 000 |
| | | C. Operating Costs | 754 000 |
| Total revenue | 2 087 280 | Total costs B + C | 1 607 000 |

Earnings for the 66 day voyage A-D = $480 280
Earnings for the whole year @5.3 voyages = $2 546 million
(Excludes costs of financing)

example of a voyage associated with a typical VLCC with a cargo of 260 000 tonnes. The 66 day voyage from Ras Tanura to Rotterdam has been agreed at the rate of World Scale (WS) 45 as at 15 March 1993 (the recommended rate is WS100 = US$17.84 per tonne, thus WS45 = US$8.028 per tonne). Table 4 summarizes the costs and revenue. Assuming that the rates do not change, the ship owners will expect to earn approximately $2.5 million over the year, exclusive of the cost of financing. Assuming that this is a new vessel valued at $100 million financed at 7% over 20 years, an annual income of $9.3 million is required. This corresponds to a Worldscale rate of about WS68 in order to cover all costs. A rise or fall of one point in the WS would lead to about $250 000 more or less per year for training and maintenance, and replacement costs. Observed rates for this voyage for the twelve months up to the end of January 1993 ranged between WS35 to WS58. There is thus very little incentive for investments in new tonnage unless there is a considerable upturn in the world economy and consequently in tanker rates.

The main element influencing tanker freight rates is the rate of utilization of the world fleet, i.e., the active tonnage demand and total fleet availability. High fleet utilization will lead to a shortage of tonnage and an increase in freight rates as was the situation in the early 1970s. The slump between the mid-1970s and mid-1980s led to many tankers being laid up, scrapped or operated at reduced speeds. When rates are low, a sudden increase in demand will not necessarily lead to a significant increase in rates since laid up ships can be brought back into service. Once existing capacity is fully utilized, small increases in demand will have an upward impact on rates. Data concerning single voyage rates over the past 40 years clearly show the tanker market to be highly cyclical with long troughs when freight rates are generally low with brief periods of very high rates (Shell Briefing Service 1991). Given the erratic nature of the business and the difficulty in predicting market adjustments, it is common for orders on new tonnage to be made during a short boom spell only to be delivered during a depressed period.

## Problems in the Tanker Industry and Safety at Sea

One important negative consequence of low and erratic freight rates is cost cutting which owners have undertaken in order to remain in the business. In many cases this has resulted in compromised safety standards and an increase in insurance claims as a result of mishaps. Added to this is the growing shortage of well-trained seafarers, an ageing world fleet, failure to enforce existing safety regulations and the emergence of unilateral legislation. The prolonged excess supply of tanker tonnage throughout the 1980s led to fundamental changes in the structure of the industry. In an effort to contain costs, maintenance and manning expenditure came under severe and continuous pressure. Shipowners are increasingly seeing their traditional roles in financial, ship and manning management being given over to various parties such as Flag States, Classification Societies and Protection and Indemnity Clubs. In an effort to attract patronage, standards have been compromised as many of the agencies lack the will or resources to perform monitoring roles, thus frustrating the attempts of diligent port

authorities, charterers and underwriters to get rid of sub-standard ships.

According to a study carried out by the Marine Department of the Ministry of Communications (Singapore), the main cause of collisions in the Straits is human error.[4] Most collisions occurred outside congested stretches of water where the Traffic Separation Scheme (Fig. 4) is in operation.[5] Captains usually acted too late to avoid an accident. Another problem was the lack of adequately trained crew manning the ships. The crew were either junior or inexperienced, giving rise to poor judgment and bad decisions. Other human errors noted were improper lookouts and negligence.

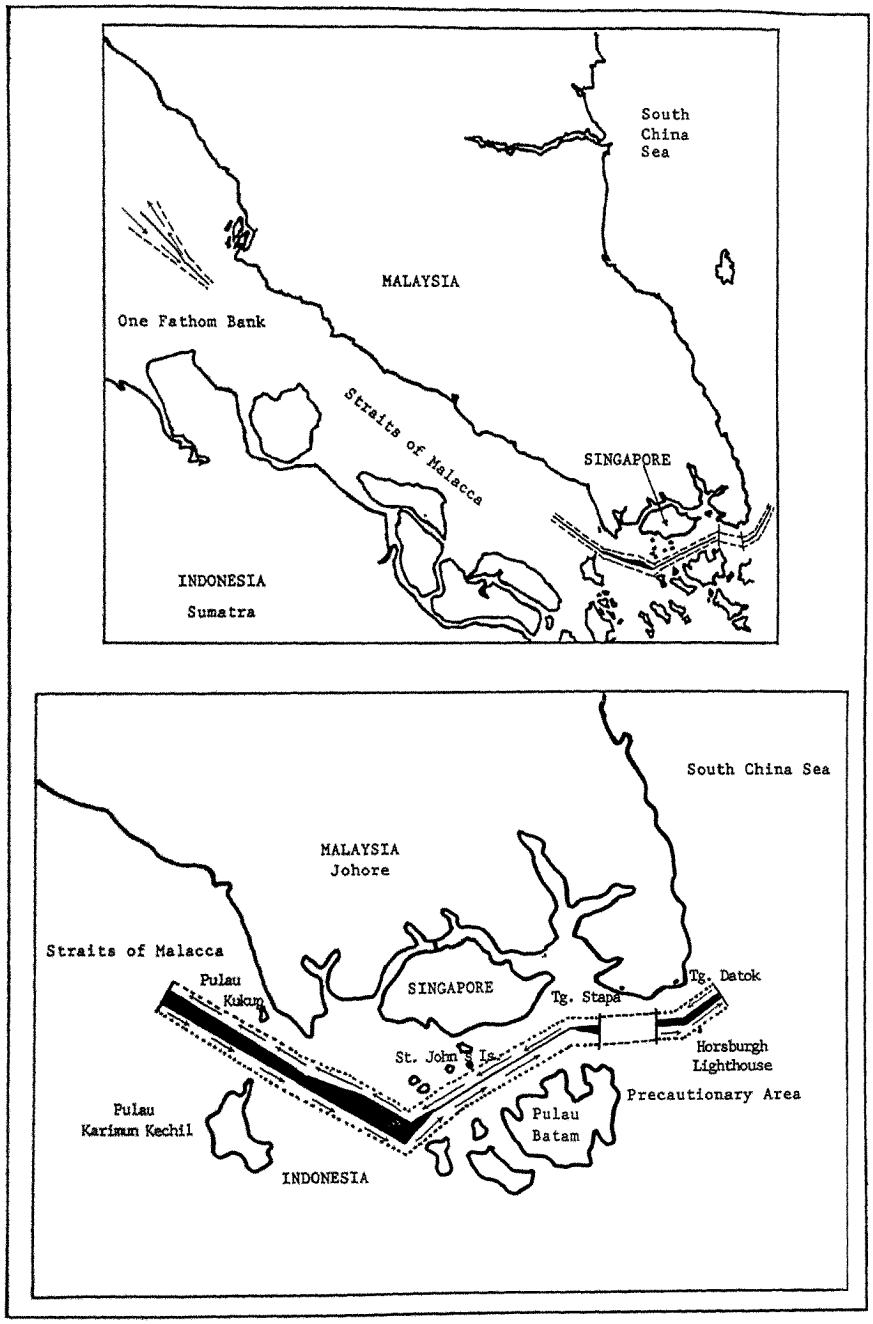


**Fig. 4** Traffic separation scheme for the Straits of Malacca.
Source: The Straits Times 26.9.92

## RESPONSE OF LITTORAL STATES

International maritime law comprises numerous agreements, most of which were drafted under the auspices of the United Nations (UN) or the International Maritime Organization, (IMO) also a UN body. The responses of littoral states have focused on two areas, prevention and ensuring effective clean up and recovery. For example, 20 Malaysian government departments and private companies have filed claims totalling $1.5 million for expenses incurred in clean up operations following an oil spill in September 1992 when the *Nagasaki Spirit* tanker collided with the container ship *Ocean Blessing* off Belawan (north Sumatra). Some 13 000 tonnes of crude oil were spilled into the Straits. Long-term claims for damage to the environment and marine life are expected to be filed at a latter date.[6]

Since 1971, the littoral states have adopted a common position that the safety of navigation should be a matter within their competence to control. A joint statement issued on 16 November 1971 clearly states:

(i) the three governments agreed that the safety of navigation in the Straits of Malacca and Singapore is the responsibility of the coastal States concerned;
(ii) the three governments agreed on the need for tripartite cooperation on the safety of navigation in the two straits;
(iii) the three governments agreed on the need for tripartite cooperation to co-ordinate efforts for the safety of navigation in the Straits of Malacca and Singapore be established as soon as possible and that such a body should be composed of only the three coastal states concerned;
(iv) the three governments also agreed that the problem of safety of navigation and the question of internalization of the Straits are two separate issues;
(v) the governments of the Republic of Indonesia and Malaysia agreed that the Straits of Malacca and Singapore are not international straits, while fully recognizing their use for international shipping in accordance with the principal of innocent passage.[7]

### Indonesia and Malaysia

Concern about marine pollution in Indonesia, particularly from oil, has arisen mainly due to the increase in tanker traffic and oil spill incidents along the archipelago's 81 000 km coastline, and the increase in exploration and oil drilling activities in off shore areas. Sources of marine regulation on the pollution of the environment derive from laws passed during the period of Dutch colonial rule and the post-independence period. Provisions made under Dutch rule on various aspects of pollution were sporadic and can be found in various laws and regulations enacted between 1925 to 1930. Post-independence regulations, however, remain fragmented with no specific law on the pollution of the marine environment. These are subsumed under major laws such as Law No.1 of 1973 (Indonesian Continental Shelf), Government Regulation No. 17 of 1974 (Control and Implementation of the offshore Exploration and Exploitation of Oil and Natural Gas), Regulation of the Minister of Mining N004 of 1973, Prevention and Control of Water Pollution in Oil and Gas Exploration and Exploitation Activities and Pertamina's General Regulation on the Prevention of Pollution.[8]

There are also some local and company regulations. These however, are location specific and do not have a national bearing. Oil spillage and environmental damage from the *Showa Maru* incident in the Straits of Singapore led to an urgent need to prevent future such occurrences, and to design a process of settling legal settlements and damage claims. Indonesia's new policy on marine environmental management is focused on the Straits. One drawback is the lack of manpower to police and regulate the prevention and management of pollution.

Measures governing the prevention of oil pollution in Malaysia are found in Part IV of the Environmental Quality Act, 1974. Under Section 27, the discharge or spill of any oil or mixture into Malaysian waters in contravention of the acceptable conditions as specified by the Minister is liable to a fine of not less than Ringgit Malaysian (RM)* 1000 and not exceeding RM25 000, or to imprisonment not exceeding two years. A person charged under

*1 Ringgit Malaysian (RM) = US$0.39

the offence will have to prove that the discharge or spillage was either for the purpose of securing the safety of the vessel, for the purpose of saving human life, the result of damage to the vessel (and that all reasonable steps were taken to prevent, stop or reduce the spillage), the result of leakage (not due to lack of care and all reasonable steps having been taken to stop or reduce the leakage) and/or the result of effluent produced by operation for the refining of oil (that all reasonable steps having been taken to eliminate oil from the effluent).

The discharge of waste other than oil is liable to a fine of RM10 000 or to imprisonment not exceeding two years, or both. Section 47 subsection 1 empowers the authorities to remove, disperse, destroy or mitigate the pollution and recover from that person all costs and expenses incurred in connection therewith. Where the discharge or spillage of oil, or mixture containing oil or wastes is from a ship or two or more ships, the owner or owners shall be liable or jointly and severally liable.

If the spillage is from any apparatus used, the person in charge and the employer of that person shall be jointly and severally liable. In addition, the authorities have the power to detain the ship if there is reason to believe that any discharge was from the vessel. The owner is to deposit a sum or any security adequate to meet the cost of a clean up. If the ship proceeds to sea before being released, the owner, master or any person who sends the ship to sea shall be guilty of an offence and shall be liable to a fine of not less than RM10 000 or to imprisonment not exceeding two years or both. Inability to pay could lead to impounding of the vessel for sale. The Act also empowers the entry and inspection of a vessel and prohibit its use if found to be capable of causing pollution.

## Singapore

Laws concerning marine pollution derive from four sources:

- The Prevention of Pollution of the Sea Act (PPSA) Chapter 243;
- Merchant Shipping (Oil Pollution) Act (MSOPA) Chapter 180;
- Singapore Port Regulations Chapter 236;
- the common law.

In November 1990, Singapore acceded to the International Convention on Prevention of Pollution from Ships 73/78 (MARPOL).[9] On 30 August 1990, the Prevention of Pollution of the Sea Act was passed. It came into force on 1 February 1991. A hybrid from different jurisdictions, it draws primarily upon various acts from the United Kingdom and Australia, in addition to the MARPOL Convention.

The Act covers the prohibition of discharge of oil from land or apparatus as well as pollution from ships. The latter is specifically dealt with under Part III on 'Prevention of Pollution from Ships'. Fines of up to 500 000 Singapore dollars (S$) (S$1 = US$0.61) can be imposed on the master, the owner and the agent of the ship if found guilty. This is because it is intended to prevent carelessness on the part of the master as well as to prevent collusion with the owner or agent who could save a great deal of money by cleaning the ship's tanks at sea.

The discharge of any oily mixtures or oil from Singapore ships in any part of the sea and from foreign ships into Singapore waters is prohibited in Section 7. However, exemptions apply if it is either for securing the safety of a ship or saving of life at sea or due to unintentional damage and all precautions have been taken after the occurrence of damage or discovery of discharge or discharge for the purpose of combating specific polluting incidents. Upon conviction of the discharge of oil residues, a fine not exceeding S$500 000 can be imposed. Section 9 obliges the importer, exporter and master of the ship carrying a noxious liquid substance to notify the Port Master so that an evaluation can be carried out. Failure to do so carries a fine upon conviction of S$5000. Discharge of these harmful chemicals carries a fine of not more than S$10 000 or two years imprisonment or both upon conviction.

Section 11 authorizes the Port of Singapore Authority or any terminal operator to provide reception facilities for ships using the port or any terminal to discharge or deposit residues containing oil or harmful chemicals. Information on the quantity and content of the discharge should be given in advance. Every Singaporean ship and all ships in Singapore will be required to carry an oil record book containing information such as the loading and unloading of oil cargo, ballasting and cleaning of oil tanks and internal transfer of oil during a voyage.

One important MARPOL requirement which is to be strictly adhered to is the imposition of construction standards and fitting of special equipment on tankers. A ship which does not hold a MARPOL certificate may be denied entry to a port

by a foreign state party to the Convention. Ships in Singapore must have in their possession the Singapore Oil Pollution Prevention Certificate (SOPP) and the Singapore Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk (SNLS). These certificates are issued after surveys have been carried out to ensure compliance with MARPOL requirements. Section 15 requires the master of the ship to report any discharge so as to enable the authorities to contain and remove any pollutant.

The recovery of costs is provided for in Part IV and gives the Port of Singapore Authority powers to recover the costs of cleaning up spills. The owner of the ship is liable for the costs of 'reasonable' measures undertaken to remove discharges and marine pollutants from Singapore waters. It applies to all pollutants discharged into any part of the sea or waters outside Singapore which subsequently drifts into Singapore waters. The enforcement of the Act is dealt with in Section 22. This gives extensive powers to inspectors for ensuring that obligations under the MARPOL Convention are exercised. If a ship is considered a threat to the environment it will be subject to a thorough inspection. If it fails the inspection, the ship will be denied entry or detained if it has incurred a liability to pay compensation. Section 24 makes it an offence for a detained ship to proceed out to sea before being released, the owner, master and any person who sends the ship to sea shall be guilty of an offence and liable on conviction to a fine not exceeding S$10 000 or to imprisonment for a term not exceeding two years, or both. If the fine imposed is not paid, the court may order the sale of the ship and all furnitures therein.

A major shortcoming of the Act is the lack of provisions for persons who have suffered from the consequences of pollution to claim compensation. Fines are paid to the State. There are some compensation rules for oil damage but none for damage caused by other pollutants. However, common law and special rules may help correct for this. Under common law, the claimant would have to base his claim in negligence just as in an ordinary collision. To provide a better deal for oil pollution victims, IMCO (Inter-governmental Maritime Consultative Organization) recognized the International Convention on Civil Liability for Oil Pollution Damage 1969 (CLC). The CLC has been given effect in the Merchant Shipping (Oil Pollution) Act of 1985 (MSOPA). The shipowner is strictly liable without proof of fault for damage caused by oil escaping from his tanker under CLC. The owner alone has CLC liability and cannot be sued at common law if the CLC applies. A claimant is not allowed to sue the servants or agents of the owner and bypass CLC. However, the provisions in MSOPA apply only to pollution damage caused in contracting states by tankers actually carrying oil in bulk. It does not apply to any pollution damage caused to tankers on ballast runs or by bunkers of ordinary ships. The liability is for pollution damage only, i.e., contamination damage in the area of Singapore and its waters. As with PPSA, MSOPA rules do not apply to warships and Government vessels wholly engaged on public or non-commercial duties. Salvage operators who might cause pollution in the process of trying to save a ship are exempted under Section 5(b). If an action is initiated three years after the claim arose or six years after the occurrences, the claim is extinguished. There are powers to detain ships and for the sale of ships in order to enforce payment of fines.

In addition to PPSA, MSOPA and common law, Regulation 104 of the Port of Singapore Regulations provides that no person shall throw, deposit, discharge or cause to be thrown in to the waters of the port any ashes, solid ballast, sludge or any other matter without the permission of the PSA.

## POLICY RECOMMENDATIONS

It appears from the previous section that Singapore's marine pollution laws are the most up-to-date and capable of dealing with the containment of marine pollution. Preventive as well as remedial measures and strict liability for compensation are covered. Adequate enforcement powers are given in the form of denial of entry, sale of offending ships and detention. Future changes in the laws are expected to take the form of acceptance of various Annexes of the MARPOL and whatever changes IMO may make to these Annexes.

The Straits, however, are basically open seas, which Japan, for example, depends on for transporting almost 75% of its crude oil needs from the Middle East. One alternative is to avoid the Straits and ply through the Straits of Lombok but this takes three days longer and adds 3% more to shipping costs. Various proposals made by the littoral states to control marine pollution are presented below:

(i) transit duties which vary between peak and off-peak (a form of congestion charge);
(ii) imposition of weight restrictions. The Indonesian proposal is for ships of more than 200 000 tonnes or more to take the route around Sumatra and through the Straits of Lombok. These ships can carry cargo of up to a million tonnes. Some of these cargoes may be dangerous;
(iii) improving and extending the Traffic Separation Scheme (TSS). At the moment the two way scheme operates only in three areas where the Straits are narrowest (i.e., near Port Klang, Raffles and Horsburgh Lighthouses in the Straits of Singapore). Most accidents occur outside the TSS area. There is a need to divide the waters more clearly than at present for vessels going in either direction;
(iv) introduction of a safety scheme based on a network of air and ground-based radar surveillance of ships plying the Straits. Information on ship movements can be relayed to avoid collisions. The navigational information could be operated in much the same way as aircraft systems. All vessels would be subject to compulsory reporting of their positions. The electronic mapping of the entire Straits would help reduce the risk of collisions and mishaps. Malaysia plans to install ten radar stations from One Fathom Bank off Port Klang to Tanjong Piai in Johor under Phase One of a project to enhance navigational safety in the Straits. Phase Two is expected to cover the northern part of the coast stretching up to Langkawi. Phase One is expected to be operational in two years time;[10]
(v) passage toll or levy to be used for pollution clean ups.[11] The toll could also be used for installing preventive measures. Malaysia has spent RM30 million on cleaning up oil spills since 1979 and has called for a consortium to manage the fund;
(vi) oil companies and frequent user states to help provide financial, technical resources, vessels and equipment to fight oil spills.[12] To date, the Petroleum Association of Japan has supplied 250 million yen worth of equipment to combat oil spills. ESSO, BP, Shell, Caltex and Mobil, together with the port authorities of the littoral states have some stockpiles of equipment but these arrangements are largely uncoordinated;
(vii) insurers have been called upon to play a more proactive role in raising standards by applying pressure on flag states, classification societies and shipping companies to shape up or ship out. Insurance premium for bad ships or ships with bad records should be raised. This is the stand taken by the Oslo-based International Association of Independent Tanker Owners (Intertanko) which represents 300 independent shipping companies from 35 countries.
(viii) compulsory reporting of all ships to the nearest port in any of the three countries. This is an outcome of meetings with the IMO which have yet to be officially ratified. States will cooperate closely in communicating, coordinating and informing each other of all ships entering and leaving the Straits. Implementation will be in phases with the assistance of IMO experts.[13]

## International Legal Initiatives

It is immediately apparent that there is a urgent need to harmonize and coordinate statutes and regulations of the littoral states pertaining to the prevention and containment of marine pollution and related penalties. The existence of different legislation can lead to confusion among users as ships move across national boundaries. Added to this is the need to develop a comprehensive framework providing compensation for environmental damage and to persons whose economic activity has suffered from the adverse effects of oil spills. Present fining arrangements do not compensate the disadvantaged. Redress is usually a long and drawn out process which individuals can ill afford. Central to any compensation regulation is that of clean up and restoration. One other aspect of legal improvement and enforcement is at the international level. Regional legislation (unilateral or multilateral) may be undesirable given the international character of the Straits as the question of the validity of the legislation and enforcement arises.[14] Furthermore, multiple and differing standards add to confusion and costs. Moving beyond national and regional boundaries, coordinated international strategies should focus on the following:
(i) more relevant and effective policing of existing standards;
(ii) information pooling on tankers with sub-standard operations;
(iii) increased stringency in mandatory inspection of hulls.

The root of the problem facing the oil tanker industry today is the ability of substandard ships with substandard crew to evade the authorities and continue trading rather than be forced to the scrapyard. This alone is delaying the recovery of freight rates which would allow shipowners to invest to improve safety standards. Improvements in legal arrangements must take on a international dimension and should focus reform within the regulatory bodies, states and other players listed below.

***Regulatory Bodies***

*(a) Classification Societies and the International Association of Classification Societies (IACS)*
Increased stringency in inspection has resulted in shipowners hopping from one classification society to another. Requirements should be tightened and Society Rules amended to allow surveyors the right of unannounced inspection, to allow underwriters and Protection and Indemnity Clubs access to all survey reports, and to increase the stringency of periodic surveys.

Rules controlling extensions for intermediate and special surveys should be tightened, for example, IMO's Safety of Life at Sea Convention (SOLAS) precedent rule for statutory surveys dating one year from the year of build with a maximum of three months tolerance.

Support for recent guidelines in the 'Recommendations Addressing the Structural Integrity of Oil Tankers' by Oil Companies' International Marine Forum (OCIMF) and IMO 'Guidelines on Intensified Inspection for Oil Tankers' should also be strengthened.

*(b) Underwriters*
Premium policies should be amended to penalize non-IACS Societies.

*(c) Protection and Indemnity Clubs*
Owner/ship records should be subject to greater scrutiny and more access should be given to Classification Society records and regular updating of rating policies should be carried out to encourage owners to improve standards.

***States***

*(a) Flag States*
The policing of IMO-based legislation should be intensified and improved. States should support the upgrading of IMO's Standards of Training, Certification and Watchkeeping Convention (STCW) to minimize problems of communication between multilingual crews, develop internationally enforceable minimum manning standards and address the consequences of double hull designs on safety standards;

States should also support IMO moves to tighten links between ship ownership and country of registration, curtail the freedom of owners to move from one registry to another and publish lapses by Flag State administration as reported by Port States.

*(b) Port States*
Port States should undertake inspections more frequently and selectively, and publish inspection deficiencies. Enforcement of international standards by port administrations should be strengthened. Standards were first introduced in 1929 and strengthened in Europe by the 1982 Paris 'Memorandum of Understanding'.

*(c) Others*
Shipowners and managers need to adopt the ship management practices laid out in IMO and ISMA (International Ship Management Association) Ship Management Codes. They should adhere to the requirement to advertise records of recruitment, training and retention of seagoing staff and should contribute to and implement industry codes of practice.

Major tanker owners should continue to feedback and publicize structural problems through the Tanker Structures Forum. Classification Societies should improve scantling standards.

Charterers and oil traders can contribute by ensuring that tankers are thoroughly surveyed before and periodically during time charters. This should be made mandatory for older vessels.

A comprehensive data bank on all tankers likely to be offered for charter should be kept. Chartering of a suspect sub-standard ship be subject to formal procedures and minimum risk policies should be adopted.

Owners should be required to report all accidents and defects to the Classification Society. OCIMF initiatives on ship standards should be strongly supported.

## Economic Initiatives

The problems associated with marine pollution stem from the fact that there is a lack of a well-defined and enforceable system of property rights governing

environmental resources. Since no one owns the Straits there is no price attached to their use. Secondly, the internationally accepted rule of right of passage makes the Straits an international public good, the maintenance and management of which rests with the littoral states. However, acceptable standards of traffic management have to be maintained and policed. Resources cannot be allocated to the user who places a high value (as opposed to one who does not) on the use of the Straits.

The classical approach to solving the problem revolves around imputing a cost which is charged to the polluter, the imposition; of safety standards and the control of entry of ships. Legal initiatives have focused primarily on prevention and compensation.

One dimension of economic initiatives is to focus on changing the cost structure of tanker investment and operations; i.e., tanker operations and investments must reflect their true costs. Many ships were built with subsidies subject to political preferences. The result has been overbuilding leading to low freight rates and substandard maintenance. Thus, with the recent demands made on quality and safety, rising insurance costs and unattractive freight rates should lead to inefficient operators scrapping these ships. An inspection of tankers in 1992 found that about 20% of the world's tankers are sub-standard but nearly all carried valid certificates.[15] The role of various regulatory bodies in enforcing these standards is the key to reflecting actual costs.

Secondly, identifying a comprehensive set of criteria upon which the actual costs (of restoration, rehabilitation, replacement or acquisition of equivalent resources plus the diminution in value of those resources pending restoration) of an incident can be assessed and recovered. However, these procedures should not impose unreasonable burdens on the shipowner and his insurer. This is particularly so in the case of loss of use claims. The valuation of environmental damage is itself a subject of debate. The methods employed thus far include the hedonic property method and contingency valuation. All the methods have shortcomings and there is a need to develop objective and rigorous methods to value environmental damage. As a step forward, countries should speedily ratify the 1992 IMO Protocols for Oil Pollution Compensation. The mechanisms for speeding payment of compensation under the International Oil Pollution Compensation Fund needs overhauling.

The use of a price or charge to regulate the flow of traffic into the Straits is very tempting. However, there is very little justification unless it is implemented as a form of congestion toll. Severe congestion not only slows down the passage of ships and thus adds to costs of operation but also increases the probability of an accident occurring. Until such time as congestion becomes unbearable, passage tolls should not be implemented. The IMO has turned down Malaysia's request to levy maintenance fees on the grounds of the right to free passage.[16] The costs associated with radar surveillance and policing are to be borne by Malaysia. All ships crossing into Malaysian waters would have to report the nature of the cargo and destinations. Costs of maintenance could be shared under some arrangement which could be worked out between frequent users.

## CONCLUSION

One element which has overshadowed the rapid economic growth of the ASEAN countries in 1992 has been the series of accidents occurring in the Straits. Safety at sea and the protection of the environment have become major issues serving to concentrate the attention of governments all over the world. However, unlike the aviation industry which is tightly controlled, shipping is not. Perhaps the reason is that aviation accidents involve greater loss of life. This explains the fact that investigations into airplane disasters are quickly initiated, concluded and necessary actions taken. In contrast, the maritime industry has been slow to respond despite the fact that since 1990 there have been 30 major accidents involving bulk carriers (18 involving sinkings with the death of over 300 crew members). Structural problems, poorly loaded cargoes, sub-standard ships, uncaring owners and untrained crew were to blame. Two major conferences in 1991 brought ship operators, shipbuilders, ship surveyors and port authorities together. The final responsibility seemed to be placed on ship owners as none of the regulatory bodies or systems had any power to enforce rules.[17]

Two major incidents in the Straits in 1992 involving supertankers have led to calls for the littoral states to set up a system of compulsory pilotage of ships and shoreside radar surveillance. The problem is that of funding. Traffic management improvement schemes have been suggested but this may give rise to potential hazards at each end of the Straits as ships begin to cross one another. The key to solving

the problem of marine pollution lies not with a piecemeal approach but a total strategy which involves all parties carrying out their functions effectively. Countries should ratify conventions such as IMO and Marpol and all registries should be accountable to the IMO. Port and flag states should be vigilant in enforcement and monitoring enforcement. There is little the Straits States can do through unilateral or regional actions if the costs of prevention are going to be prohibitively high. Thus, unless the international community places a high value on clean seas and coastlines, littoral states of the Straits will have to depend on legislation and local enforcement to keep their seas safe and clean.

## NOTES

1 Among the recent mishaps which attracted public attention were:
   - A Singapore registered super tanker the 254 000 tonne *Maersk Navigator* with more than 200 000 tonnes of crude oil caught fire after colliding with an empty tanker, the *Sanko Honour*, resulting in an oil slick 32 km long of 25 000 tonnes.
   - In September 1992, the Japanese oil tanker *Nagasaki Spirit* and the Panamanian registered ship, *Ocean Blessing* collided resulting in an oil slick of 13 000 tonnes polluting parts of the northwestern coast of Peninsular Malaysia;
   - The sinking of the cruise ship Royal Pacific in August 1992 after colliding with a Taiwanese trawler resulting in three deaths and six missing;
   - Collision between two supertankers in July 1992, in which one man died and some oil was spilled;
   - In June 1992 the USS *Ingersoll* collided with a merchant ship.
2 *Shipping Times* 30 July 1992.
3 For reasons of commercial simplicity freight rates (and earnings) are not expressed in cash terms but rather in terms of 'Worldscale'. Established by the Worldscale Association, the rates are published annually and are based on the costs of running a standard ship with specified characteristics. Rates for virtually all ports which handle oil or oil products are set and these are then referred to as 'flat rates'. A flat rate for a voyage is established as Worldscale 100 or WS100. The final rate is set through negotiations between owners and charterers. An agreed upon Worldscale 45 means that the revenue for the voyage is 45% of the published flat rate. Thus, the going or final rate may not have any bearing on the costs of operation but rather is an outcome of the market mechanism.
4 *The Straits Times* 26 September 1992.
5 The Traffic Separation Scheme (TSS), first mooted in 1969 was aimed at reducing the risk of accidents involving vessels plying the Straits by regulating the passage of ships and minimizing collisions. East-bound traffic should keep to the western side of the Straits close to Sumatra and west-bound traffic to the eastern side closer to Malaysia. Implemented in 1981, TSS operates in three stretches (see Fig. 4):
   - One Fathom Bank of Port Klang in Malaysia (36 km stretch);
   - Singapore Straits (112 km);
   - Horsburgh Lighthouse (26 km).
6 *The Straits Times* 22 January 1993.
7 Department of Foreign Affairs, Singapore, 21 November 1971.
8 M. Daud Silalahi, ed. 1981. *Legal Aspects of the Pollution of the Marine Environment by Oil in Indonesia*. Bandung: Litera.
9 MARPOL 73/78 is an international Convention on the prevention of pollution from ships held in 1973 and subsequently modified in 1978. It deals with all forms of marine pollution including oil pollution except the disposal of land generated waste into the sea by dumping. The main Convention is short but the detailed technical measures are contained in 5 Annexes which are subject to amendments. Singapore has acceded to only Annexes I and II. Annex I consist of detailed regulations on the control of pollution. The control of chemicals is found in Annex II. MARPOL provides each country to not only control discharges by its own ships but also on all ships in its territorial waters.
10 *The Straits Times* 11 June 1993.
11 The suggestion of a passage toll was made by Dr Mahathir the Prime Minister of Malaysia at the recent ASEAN Heads of States meeting. However, the proposal itself is not new as it was first mooted by Tengku Razaleigh, the then President of the Malaysian Associated Chamber of Commerce. A Malacca Straits Authority was proposed to charge a levy of US$5000 for oil tankers, US$3000 for cargo ships and US$1000 for cargo ships calling at Malaysian or Indonesian ports. Additional levy was suggested for all Far Eastern Conference ships.
12 Major users include ships from the United States, Japan, China, Taiwan, Hong Kong, Britain, France, Liberia, Panama and Australia.
13 *Business Times* 3–4 June 1993.
14 In recent years the increase in incidents of tanker incidents have led to unilateral, regional as well as international legislation. The United States Oil Pollution Act (OPA) of 1990 include wide-ranging and strict rules on ships visiting

U.S. ports and a detail compensation scheme. In addition U.S. state legislation makes it compulsory for ships to have contingency planning and defines ship owner, charterer and cargo owner liability.

15 Talk given by Robert J.W. Walvis on Prevention of Oil Spills from Tankers, Shell International Marine Ltd. in Singapore. March 1993.

16 *The Straits Times* 3 July 1993.

17 *Far Eastern Economic Review* 19 November 1992.

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INSTITUTIONAL PROFILE

# Thailand Environment Institute

In this age of environmental awareness, with environmental problems on the rise, coupled with the greenhouse effects and the alarming depletion of Thailand's natural resources, Thailand Environment Institute (TEI) was recently established as a non-profit, non-governmental and non-partisan organization, striving to promote environmentally sound development, eradicate pollution, preserve the country's precious natural resources, advocate for national and global sustainable development and encourage close cooperation between the public and private sectors, the NGOs, the media and academia.

TEI has a two-tier governing body: a Council of Trustees, headed by H.E. Mr Anand Panyarachun, former Prime Minister of Thailand, and a Board of Directors chaired by Dr Phaichitr Uathavikul, former Minister of Science, Technology and Environment, with Dr Dhira Phantumvanit, former Director of the Natural Resources and Environment Program at Thailand Development Research Institute, as the President.

TEI's main objective is to serve as a catalyst in solving Thailand's key environmental problems, leading to the formulation of appropriate policy strategies and field activities at the grassroots level. The Institute is determined to supply professional, unbiased and reliable information to facilitate the country's decision-making process. It intends to work to link the government, business and NGOs in undertaking activities and projects related to the environment by engaging in research and policy analysis, conducting grassroots programs and collaborating with regional and international organizations.

The Environmental Information Center will serve as a training and resource information center, utilizing the latest information technologies, such as Geographic Information Systems (GIS) and Global Positioning Systems (GPS). The Center will also engage in database development and research into decision support systems and provide 'The State of Thailand's Environment', a concise yet comprehensive report designed to provide accurate information on some of the most pressing environmental issues of our time, produce up-to-date reports of conditions and trends in Thailand's natural resources base and disseminate its findings to interested parties.

## BUSINESS AND ENVIRONMENT PROGRAM

This program aims at encouraging the private sector to take a leading role in environmental quality management and to participate in solving Thailand's environmental problems. TEI is in the process of formulating a 'Thailand Business Council for Sustainable Development', consisting of leading businessmen from various corporations and companies in the private sector cooperating in an effort to design and implement activities to tackle environmental problems.

## NGOs GRASSROOTS ACTIVITIES

As far as grassroots activities are concerned, TEI plans to team up with other national and international NGOs in conducting field activities directed at protecting and conserving Thailand's environment. The Institute is working to link NGOs' grassroots activities with the formulation of appropriate environmental policies at the national level to create environmental awareness among target groups of people in Thai society.

## LONG-TERM STUDY ON MANAGEMENT OF NATURAL RESOURCES AND THE ENVIRONMENT

This program is devoted to understanding and managing the country's land, forests and water. Intensive research, studies and analyses are being conducted concurrently to explore ways to restore and to manage these natural resources. In addition,

apart from natural resources management, the relationship between energy and environment, industry and environment and urbanization and environment are also important issues to which the Institute gives special attention.

TEI receives support, donations and project sponsors from various establishments: public, private and international, in carrying out its research studies, technological and grassroots activities as well as its day-to-day operations.

Current and on-going projects of the Institute include: Policy to Promote Business and Environment in Thailand, Environmental Pollution Control Information System, Mineral Resources Management Planning, Preparation of the National Strategy on Global Climate Change and an Environmental Fare Exposition'93. Future projects which are in the process of preparation include a Geographic Information System for the Department of Mineral Resources, a study on energy conservation and environmental sustainability, and Information System for Environmental Quality Promotion and Land Policy: Management and Administration Study. TEI has also launched a quarterly, thematic journal covering issues concerning 'environment and development' in Thailand.

Obviously, the road to achieving environmentally sound development is long and challenging. The work ahead of us will undeniably be difficult. Nonetheless, the anticipated consequences will be valuable and very rewarding.

For further information, please contact the Institute at:

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INSTITUTION PROFILE

# Centre for Resource Management and Environmental Studies, The University of Hanoi

## BACKGROUND

The Centre for Resource Management and Environmental Studies (CRES) of the University of Hanoi was established in 1985 to conduct research and field activities and to train young scientists in environmental and related social sciences. Among its initial activities were those to help to promote and implement Vietnam's National Conservation Strategy (NCS), which includes a long-term research programme in such areas as the rational use and protection of forest, marine and estuarine ecosystems, the control of air and water pollution, environmental education and awareness. As a non-profit, non-governmental organisation (NGO), CRES provides a flexible vehicle for conducting activities in a wide variety of environmental fields (both within and outside the NCS) and under a range of funding arrangements.

## STAFF AND AFFILIATES

CRES has 25 members, 15 of whom are paid staff and the remainder volunteers. In addition, CRES has a network of about 100 scientists working in different institutions throughout the country. This network is formed by graduates of CRES's annual six-month postgraduate course.

## ACTIVITIES

CRES's major activities are in the areas of (i) professional development in environmental studies and management, (ii) carrying-out small projects to help local people use sustainable natural resources, and (iii) educational awareness and information development.

## PROFESSIONAL DEVELOPMENT

Each year CRES runs a six-month postgraduate training programme in natural resources management and environmental protection with about 30 participants. Participants are drawn from a variety of undergraduate backgrounds and all are working professionals who come to the Centre for intensive training in environmental science and related areas (e.g., evaluation and assessment methodologies). Participants are also encouraged and assisted in furthering their skills in the use of computers and in working in English as means of enhancing their ability to cooperate with environmental professionals from around the world.

## LOCAL ACTIVITIES TO PROMOTE SUSTAINABLE USE OF NATURAL RESOURCES

There have been a number of distinct activities in this area. CRES worked closely in 1986 with local people to help in the establishment of the Tram Chim Nature Reserve for the eastern sarus crane in the Mekong Delta. In 1988 CRES helped local people to replant mangroves, establish beekeeping and manage shrimp ponds as part of environmental protection and socio-economic development programmes in connection with the Xuan Thy Reserve for migratory birds in the estuary of the Red River. In 1987 CRES began to help local people to organize the Con Daoi National Park and to be trained as park managers. Another example is in Vinh Phuy Province where, after many trials, CRES helped successfully establish working examples of ecologically balanced agro-forestry and home garden practices.

## INFORMATION GATHERING AND DISSEMINATION

CRES has been actively involved in helping improve the information base on Vietnam's ecology and in dissemination of information and promoting environmental awareness both within and outside the country. For example, CRES is conducting a survey on the wildlife trade in Vietnam and is pressing the government to sign the CITES Treaty. CRES is also cooperating with the Centre of Ecology and Biological Resources in writing the Red Data Book for Vietnam, the first volume of which included 360 species of plants and will be published by the end of 1993.

CRES has translated environmental information from overseas into Vietnamese and assisted in its distribution within Vietnam. CRES also made the first Vietnamese natural history documentary film on the Con Son Islands, and served as scientific advisor and presenter on two documentary films on Vietnam shown internationally and on Vietnamese television.

## LEGISLATION

CRES and the Steering Committee of the National Programme on Natural Resources and Environment have completed the draft of the Environmental Law for Vietnam, which was presented in 1993 to the National Assembly for approval.

## FUNDING

The government provides a moderate level of financial support to CRES, but the large majority of its financial resources come from non-governmental sources. For its activities CRES has received assistance of various types from such organizations as WWF, IUCN, SIDA, Bremh Fund, and Oro Verde, the Ford Foundation, and the East–West Center (Honolulu).

## FURTHER INFORMATION

Those wishing to obtain further information concerning CRES and its activities should contact:

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# Environment Business Group Co., Ltd., Bangkok, Thailand

The Environment Business Group (EBG) Co., Ltd., is a Bangkok-based consultancy providing environmental market intelligence and policy research services on Thailand for national and international business clients, governments, and development agencies. In addition to work for public sector agencies, EBG works with Thai and foreign businessmen to identify environmental sector market opportunities and implement cost-effective solutions to environmental problems. EBG also helps businesses to develop a clearer understanding of the impact of national and international environmental issues associated with their operations.

Among its specific information services, EBG provides: strategic environmental business advice, industry policy research, market entry strategies, and environmental investment and trade opportunity studies. EBG's periodic business bulletin, Thailand Environmental Market News, tracks Thailand's environmental industry.

EBG is a Thai-owned joint-venture partnership between IMRS Co., Ltd. which offers industrial project advisory and market research services and SEAMICO BIR Co., Ltd, a member of the SEAMICO Group which offers corporate finance, venture capital, project and investment information and research services.

For further information, please contact Paul Clements-Hunt, Director and General Manager EGB 67/11 Soi Suan Plu Sathorn Road, Bangkok 10120 Thailand, Tel (662) 213-3500, Fax (662) 213-1255.

# The Economist Intelligence Unit

The Economist Intelligence Unit (EIU), a business information company owned by The Economist Group, supplies multinational companies with information and advice about doing business across national borders. The environment is one of the issues which the EIU covers on an on-going basis.

The EIU provides information on the environment through three channels:

**Special Research Reports**, EIU offices in Hong Kong, London, and New York have each published reports on environmental issues, including: *Asia-Pacific and the Environment: Investing in the Future*; *Managing the Global Environmental Challenge: Strategies for Corporate Excellence*; and *The Greening of Global Investment.*

**Newsletters**, such as *Business Asia, Business China,* and *Business Europe* include environmental topics on a intermittent, but fairly regular basis. Regulations, government policies, and corporate environmental strategies are among the topics included.

**Country Reports and Forecasts** publications contain information about the broad strategic direction of environmental policy and regulations in specific countries.

For further information on these publications, please contact Amy Ho, EIU, Luk Kok Centre, 72 Gloucester Road, Wanchai, Hong Kong, Tel (852) 527-1096, Fax (852) 865-1544.

** Editor's note: AJEM welcomes brief, overview descriptions (up to 200 words) of commercial sources of environmental information. Descriptions of information sources which periodically deal with environmental matters as one of several topics are welcome as are those which deal primarily with the environment. Inclusion of such descriptions in this journal is provided as a service to our readers and does not constitute an endorsement by AJEM of the information service. (Descriptions of commercial sources of environmental information are provided free-of-charge and without other contributions to AJEM by the organization concerned.)*