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ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

URBAN WATER RESOURCES MANAGEMENT

WATER RESOURCES SERIES
No. 72

UNITED NATIONS
New York, 1993

ST/ESCAP/SER.F/72

UNITED NATIONS PUBLICATION

Sales No. E.93.II.F.17

ISBN 92-1-119621-3

ISSN 0082-8130

FOREWORD

This publication contains the proceedings of the Regional Seminar on Water Management in Urban Areas held at Bangkok from 22 to 26 March 1993.

This publication is presented in three parts: part one contains the report of the Seminar, part two contains background papers presented by the ESCAP secretariat consultants, resource persons and representatives of international organizations and agencies, and part three contains the country papers submitted by participants.

Because of limitations of space and budget, it has not been possible to reproduce all the papers in full; some have been summarized or abridged.

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Part One

REPORT OF THE REGIONAL SEMINAR ON WATER MANAGEMENT IN URBAN AREAS Bangkok, 22-26 March 1993

REPORT OF THE REGIONAL SEMINAR ON WATER MANAGEMENT IN URBAN AREAS
Bangkok, 22-26 March 1993

A. Organization of the Seminar

1. The Regional Seminar on Water Management in urban Areas was held at Bangkok from 22 to 26 March 1993.

2. The Seminar was organized by the Economic and Social Commission for Asia and the Pacific (ESCAP) with generous financial support from the Governments of Japan and the Netherlands.

Attendance

3. The Seminar was attended by 20 participants from the following members and associate members of ESCAP: Bangladesh, China, Hong Kong, India, Indonesia, Iran (Islamic Republic of), Kyrgyzstan, Malaysia, Mongolia, Nepal, Singapore, Thailand and Uzbekistan. Five participants were sponsored by the World Health Organization (WHO) and two resource persons and one participant were sponsored by the United Nations Development Programme (UNDP) – World Bank Water and Sanitation Program. The following United Nations bodies, specialized agencies and intergovernmental organizations were represented: UNDP, United Nations Centre for Human Settlements (Habitat), United Nations Environment Programme (UNEP), Food and Agriculture Organization of the United Nations (FAO), WHO and the Asian Development Bank (ADB).

4. Other organizations also represented were the Association for the Development of Environmental Quality (ADEQ), the Malaysian Water Association (MWA) and the Regional Housing and Urban Development Office of the United States Agency for International Development. The Seminar was also attended by six observers.

Opening of the Seminar

5. A message from the Executive Secretary of ESCAP was read out by the Chief of the ESCAP Natural Resources Division. In his message, the Executive Secretary thanked the Governments of Japan and the Netherlands for their generous contribution in support of the Seminar. He noted with appreciation the support provided to the Seminar by the World Health Organization Regional Office for South-East Asia, the UNDP-World Bank Water and Sanitation Program and other organizations.

6. The Executive Secretary said that, in the Asian and Pacific region, the ever-increasing demand for water by a growing population and the expanding industrial and agricultural activities were placing a heavy burden on existing water resources. That strain had become critical in many urban areas in the region, where various users were competing over limited water supplies. Despite concerted efforts to meet the demand and bring adequate supplies of potable water to cities, there were still millions of urban residents throughout the region who did not have access to an affordable drinking water supply and basic sanitation services. The shortage of water was also holding back development of industry in urban areas, thus hindering national socio-economic development.

7. The Executive Secretary noted that the General Assembly had recognized the vital importance of the development of water resources for human health, social and economic activities, and had recently declared 22 March of each year as World Day for Water.[1] The first observance of the Day fortunately coincided with the opening of the Seminar, the objective of which was to assist the developing countries of the region in the formulation and implementation of policies for sustainable development and environmentally sound management of water resources in urban areas. He hoped that the exchange of experiences and expertise among Seminar participants representing the developing and developed countries as well as the international organizations and aid agencies would contribute to the strengthening of regional collaboration for sustainable development and environmentally sound management of water resources in urban areas.

[1] See General Assembly resolution 47/193 of 22 December 1992.

Election of officers

8. Mr P.S. Rajvanshy (India) was elected Chairman, Mr Md. Nurul Abedin (Bangladesh) was elected Vice-Chairman, and Mr Chan Pui Wah (Hong Kong) was elected Rapporteur.

Agenda of the Seminar

9. The Seminar adopted the following agenda:

1. Opening of the Seminar;
2. Election of officers;
3. Adoption of the agenda;
4. Problems, objectives and strategies of water development and management in urban areas;
5. Urban water supply management;
6. Urban sanitation and wastewater management;
7. Recommendations on the formulation and implementation of a national policy for sustainable development and environmentally sound management of water resources in urban areas;
8. Related international activities;
9. Other matters;
10. Adoption of the report of the Seminar.

B. Problems, objectives and strategies of water development and management in urban areas
(Item 4 of the agenda)

10. Under the above agenda item, the following documents were presented and discussed: "Urban water management issues in the ESCAP region" (NR/RSWM/4), "Water supply, sanitation, and the urban poor in Asia and the Pacific: how to serve the unserved in cities?" (NR/RSWM/1)", "Urban water management problems" (NR/RSWM/5), "Technical and management aspects of the sustainable use of groundwater resources in urban areas" (NR/RSWM/2), and "Environmental impacts of urban water management (NR/RSWM/6).

11. It was generally recognized in the discussion that while the individual countries in the ESCAP region had problems in the field of urban water resources management unique to themselves owing to different climatic and geographical conditions, and cultural and social developments, they did have common problems. There were, however, differences in scale and magnitude and the factors that needed to be considered in the formulation of objectives and strategies of water development and management in urban areas.

12. The participants agreed that the challenge of the formulation and implementation of a policy of sustainable development and environmentally sound management of water resources in urban areas of developing countries was of common concern and there was an obvious and urgent need for countries to cooperate and assist one another with a view to finding practical and economically feasible solutions to common problems confronting them.

13. Some concerns raised during the discussion were:

(a) The difficulty of managing the quality and quantity of water in a river flowing through a number of countries;

(b) The inability to control the increase in urban population owing to the migration of people from rural areas to urban areas;

(c) The inability of the urban poor to pay for the water supply and sanitation;

(d) The difficulty of correcting the deep-rooted misconception that water was a gift from nature and should be free;

(e) The dilemma of choosing between improving the rural water supply to stop people migrating to cities or expanding the urban supply to meet the demand of the new arrivals;

(f) The serious consequences of contamination of the quality of water in rivers, lakes and particularly aquifers, in terms of the prohibitively high costs and long time periods required to restore water quality;

(g) The need for care in interpreting the unaccounted for water ratios in different places owing to the use of different definitions for unaccounted for water;

(h) The need for improving the performance of the water supply system in urban areas in order to postpone the construction of new projects;

(i) The threat of ground subsidence and other problems arising from over-exploitation of groundwater due to lack of information on the capacity of the aquifers;

(j) The failure of some water supply projects in urban slums due to the absence, or inadequate involvement, of the community from the planning stage through implementation, operation and project maintenance;

(k) How to finance water supply projects in places where "full cost recovery" of water was not politically acceptable;

(l) Conflicts between various sectors of water users.

14. It was stressed that, despite the constraints and concerns mentioned above, an integrated approach was of paramount importance in the formulation of objectives and strategies to overcome problems in water management in urban areas. Such problems could not be tackled in isolation; by taking an overview of the problems together with the situation and context in which they arose, there was a good chance of finding the right solutions.

15. A representative of ADEQ briefed the Seminar participants about his organization's involvement in water conservation in Thailand.

C. Urban water supply management
(Item 5 of the agenda)

16. The introductory paper "Urban water supply management: basic issues" (NR/RSWM/7) emphasized the need for clear national policy in the urban water supply sector to provide guidance on sound management principles, taking into account the magnitude of the problems and the limitation in resources both physical and financial. The necessity of autonomous water supply agencies was a prerequisite for sector reforms leading to better investment decisions, tariff rationalization and improved management practices.

17. The presentation of the paper and subsequent discussion highlighted the importance of capacity building, especially at the local level, in support of policy implementation. The identification of training needs for planning, design, construction, operation and maintenance of urban water supply systems, and the provision of the required training as well as the creation of incentives and career development opportunities which could help to retain the trained personnel were cited as deserving priority consideration.

18. The view was put forward that for the provision of water to the urban poor, there was a need for the promotion of community participation, with emphasis on the role of women in the planning and implementation of programmes for water supply.

19. The solutions to a host of problems in the management of urban water supply were dependent on improving efficiency and reducing costs, both capital and operational; privatization of the water supply service was considered a proven means of achieving those goals. By allowing the private sector to play an active role in the financing, building, ownership, management, operation and maintenance of the water supply service, water supply projects could be put into operation more rapidly. Urban dwellers would then be provided with a reliable and good-quality service with which they would be satisfied and therefore willing to pay a slightly higher price to support. Most developing countries in the ESCAP region could not afford to invest in needed water supply projects owing to resource constraints. Private sector financing could close the gap between funding supply and demand by investing in low risk water supply services.

20. Privatization could take various forms: from complete privatization to corporatization, contract management, build-operate-transfer, contracting out, or a combination of those forms. In many successful stories of privatization, the public bodies which were privatized alleviated staff-related problems by redeploying the surplus staff in areas which had been given insufficient attention in the past. The private sector was better able than the public bodies to introduce new technologies, recruit and train the right staff, and take a critical look at the way operations and maintenance were carried out in order to improve efficiency and cut costs.

21. Participants generally agreed that while production of water was the obvious area in which privatization should start, the full benefit of privatization could be realized in the privatization of the distribution of water where, owing to high staff and energy costs, there was great scope for efficiency improvement and costs reduction. The same was also true for billing for the service.

22. Participants recognized that there was a need for setting up a regulatory mechanism to monitor the performance of the privatized body in order to ensure that the interests of the water users were adequately protected.

23. Participants from Bangladesh, China, Hong Kong, India, Kyrgyzstan, Singapore, Thailand and Uzbekistan presented brief accounts of the status of urban water supply management in their respective countries or area and highlighted the major problems facing them in that sector.

D. Urban sanitation and wastewater management
(Item 6 of the agenda)

24. Under the above item, the Seminar had before it the following documents: "Urban sanitation in Asia and the Pacific – issues and emerging trends"; "Low cost wastewater disposal system: Bangkok experience" (NR/RSWM/8); "Urbanization, sanitation and group water contamination" (NR/RSWM/3); and "Achieving compliance with wastewater standards".

25. The papers cited the shortcomings of the conventional approach to sewerage for urban sanitation. Those shortcomings resulted in low coverage, poor functioning of infrastructure and gross environmental pollution which affected the health of the urban dwellers, especially the urban poor who were unable to move to a better environment. Although low-cost alternatives had been found, the range of available technology was still limited and the traditional focus on "supply side" issues was insensitive to the users' preferences and their ability to pay for the service. The emerging trends in urban sanitation were stricter standards for effluent discharge and advances in the areas of both supply and demand, which led not only to a much wider range of supply options catering to the needs of a wider range of income groups, but also to a participatory approach in the allocation of resources which was based on users' informed choices from a number of options.

26. It was stated that the plans to use simple and cost-effective technologies in wastewater disposal in Bangkok would require careful planning to provide sanitation to urban areas, given the financial constraints, the shortage of land and the engineering capacity for ambitious solutions. A simple or improvised solution that could solve a major part of the problem would appeal more to developing countries than the conventional sewerage master plan approach.

27. Participants generally recognized that sewage contamination from on-site sanitation facilities, and leakage from faulty sewers and storm-water drainage systems were the major causes of pollution of groundwater. The control of groundwater contamination was a major aspect of groundwater management and was essential to urban areas dependent on groundwater resources for their water supply.

28. Participants also agreed that, once wastewater standards were established, there was a need to ensure compliance with those standards by proper enforcement of standards. A high rate of economic growth was seen as an essential factor in overcoming existing barriers, such as lack of adequate resources and public awareness which had so far reduced effective implementation of environmental standards in many countries in the ESCAP region.

29. The participant from Indonesia presented a paper focusing on sanitation management issues.

30. Country papers from the Islamic Republic of Iran, Malaysia and Mongolia were made available to the participants.

E. Recommendations on the formulation and implementation of a national policy for sustainable development and environmentally sound management of water resources in urban areas
(Item 7 of the agenda)

31. Participants noted that the challenge of securing a sustainable water supply for current and future needs and protecting water resources from degradation and depletion was one of the most fundamental issues related to both environment and development.

32. The Seminar stressed the urgent need for action at the national and international levels aimed at achieving adequate sustainable urban water supplies and the conservation and protection from pollution of water resources in urban areas. However, it was noted that although the need for properly managed urban water resources was recognized in the region, policies for sustainable development and environmentally sound management of water resources in urban areas had largely failed to materialize in many countries.

33. The Seminar therefore urged the countries of the region to formulate and implement national policies for sustainable development and environmentally sound management of water resources in urban areas in line with its recommendations (see the annex to the present report).

F. Related international activities
(Item 8 of the agenda)

34. The representative of the Malaysian Water Association provided detailed information about the objectives and activities of the Association with regard to water supply and sanitation. The role that MWA played in the Asia Pacific Group of the International Water Supply Association was highlighted. A briefing note was distributed among the participants.

35. The representative of the Asian Development Bank briefed the participants about the project on sustainability of

water supply for mega-cities currently carried out by ADB.

G. Other matters
(Item 9 of the agenda)

36. Field trips were made to the Central Training Centre of the National Waterworks Technology Training Institute and the Bangkhen Water Treatment Plant. Participants also visited a number of wastewater treatment plants in Bangkok.

H. Adoption of the report of the Seminar
(Item 10 of the agenda)

37. The report of the Seminar was adopted on 26 March 1993.

Annex

RECOMMENDATIONS ON THE FORMULATION AND IMPLEMENTATION OF A NATIONAL POLICY FOR SUSTAINABLE DEVELOPMENT AND ENVIRONMENTALLY SOUND MANAGEMENT OF WATER RESOURCES IN URBAN AREAS

Policy formulation

1. To achieve sustainable development and environmentally sound management of water resources in urban areas, greater attention should be paid to the formulation and implementation of a national policy, the general objectives of which are:

(a) To ensure on a sustainable basis adequate water supplies for present and future needs of urban users;

(b) To prevent water pollution and to reverse current trends of water resources degradation and depletion.

2. To fulfil these objectives, urban water development and management policies should be formulated within the context of regional water management based on a river basin approach. Urban water management should, therefore, be integrated with all aspects of regional planning processes affecting the region and the river basin in which the urban areas are situated.

3. Interregional mass water transfer is very costly and if this is required to satisfy demand for water of large urban areas located in water-scarce river basins, it should be considered thoroughly, taking fully into account potential socio-economic and environmental implications in both source basins and recipient basins.

4. At the regional level, utmost attention should be paid to reconciliation of conflicting demands for water from agriculture, industry and urban users. To this end, priorities should be set up in order to allocate water resources in an efficient and equitable manner between those users. Priorities of food security, industrial growth, water requirements of population, environmental protection, educational institutions, health services and other economic or social environmental entities should be identified, taking into consideration the availability and long-term sustainability of water resources.

5. The availability of a reliable, safe, adequate and affordable water supply and proper sanitation should be ensured to meet the basic demands of the population, particularly those of the urban poor. The involvement of women is critical in dealing with the urban poor as women bear the brunt of the consequences of poor services.

6. At the urban level, all the water use sectors, such as water supply for domestic use, municipal purposes, industry, recreational activities, navigation and power generation, should be considered together in formulating a management policy.

Upgrading of management and institutional mechanisms

7. Institutional mechanisms dealing with various aspects of water resources development, management and protection should be strengthened and water resources management should be integrated with land use planning in urban areas. There should be an integrated approach to water resources management and water pollution control in those urban areas where the responsibility of water supply is quite separate from that of water pollution control.

8. The fragmentation of responsibilities for urban water resources development and management among sectoral and administrative agencies and any obstacle to proper development and management of water resources in urban areas should be identified and alleviated through effective communication channels and closer cooperation between concerned departments and agencies. At the urban level, a mechanism for coordinating all water-related activities could be established to ensure an intersectoral approach to water resources management.

9. Clear policy directions on water supply, sanitation and wastewater management in urban areas should be prepared by national Governments for consultation with

State and/or provincial/local administrations. Full recognition should be given to the role of local authorities, bearing in mind their particular requirements.

10. Responsibilities for urban water resources management should be delegated, to the extent possible, to the lowest appropriate levels, to ensure the involvement of urban dwellers in the planning, execution and management of water projects. At the same time, a close interaction between management institutions at the lowest appropriate level and those at the regional and national levels should be enhanced, thus ensuring that adequate support is given to local institutions.

11. A participatory approach, involving users, planners and policy makers, service providers and non-governmental organizations at all levels should be encouraged. Public participation in water resources development and management activities should be an important instrument to promote a successful implementation of policies for sustainable development and environmentally sound management of water resources in urban areas. Decisions are to be taken with public consultation and involvement of users, especially women, in the planning, implementation and operations of water projects.

12. The involvement of local communities in all phases of water supply and sanitation management should be supported to foster the successful implementation, cost recovery and sustainable operation of water supply and sanitation projects.

13. The cost implications of the pollution or mismanagement of water resources, especially with regard to the cost of developing alternative supplies, have not been fully borne by the population. Intermediate solutions and appropriate technology at the community level should be encouraged. Water services and their management have to be paid for by users directly or indirectly. As Governments alone cannot afford to bear the full cost of providing water services, there has to be a progressive move to diversify funding sources, both national and multilateral, with a loan/grant mix for financing. Pricing should be recognized as an important instrument of demand management, and water tariffs designed accordingly. In this respect, the private sector should also be encouraged to play a greater role in the ownership, management and financing of these public services, through privatization of such services to relieve the Governments of the heavy financial burden they are continually faced with. Privatization of such services could either be on a project basis or through corporatization of the government departments and eventual divestiture of the corporation through flotation of shares to the public. This would then allow free accessibility to private sector capital markets to finance development programmes.

Water conservation and pollution control

14. As a part of urban water management, a strong water conservation and pollution control policy should be formulated and implemented. Protection of available water resources, water conservation and prevention of wasteful use of water would enable demands to be met more economically compared with the costs of developing new water sources. This policy should encourage: (a) efficient, non-wasteful water use; (b) pollution reduction through wastewater reuse and recovery; and (c) introduction of clean technologies and water-saving appliances in various economic sectors.

15. Proper account should be taken of the high quality, reliability and value of groundwater resources, particularly the implications of their pollution and misuse. Water conservation and reuse should be fostered by all possible means including economic incentives and legal regulations, administrative measures and public awareness.

16. More attention should be paid to reducing the generation of pollutants at source, preferably by on-site treatment of wastewater. The polluting load from the low-income urban areas could be reduced through the introduction of basic sanitary waste disposal facilities based on environmentally sound low-cost and upgradable technologies, for example, oxidation ponds and land irrigation. Municipal and industrial wastewaters should be treated to certain standards before their disposal into water bodies.

17. Compliance of discharge quality standards for municipal and industrial effluents should be enforced by legislation and pricing mechanisms. The "Polluter Pays Principle", including the levy of effluent charges adequate to achieve the desired reduction of pollutants, should be adopted.

18. The effective utilization of existing water resources in urban areas should be mainly achieved through demand management in the domestic, municipal and industrial sectors. Water demand reduction methods and strategies should be formulated within the framework of a policy for sustainable and environmentally sound development and management of water resources in urban areas and vigorously promoted using economic incentives and legal instruments. This should be supplemented by reduction in leakage and unaccounted for water losses.

19. Attention should be paid to the promotion of strategies for pursuing the broader goal of providing sustainable expansion of sanitation services that are adequate in terms of coverage and effectiveness in services quality and environmental pollution abatement.

20. Attention should also be paid to the promotion, development and production of a wider range of sanitation technologies and lower-cost sewerage systems so that the range of options and costs would enable a wider group to enjoy the benefits of improved sanitation services.

International cooperation

21. There is a need for enhanced regional cooperation for sustainable development and environmentally sound management of urban water resources. Further regional cooperation should be aimed at the exchange of information and experience in such areas as formulation and implementation of relevant policies, legal and institutional aspects of promoting an integrated approach to water and wastewater management in urban areas, technology transfer, research and development. Exchange arrangements between water authorities or agencies in developing countries of the region should be supported by the United Nations and other international assistance agencies.

22. International cooperation should be promoted in cases where catchments or aquifers cross national boundaries as water use in an urban area affects the quantity and quality of water resources in other parts of the same river basin. Such cooperation could lead to the harmonization of water-related policies, strategies and programmes in river basins shared by two or more countries.

23. Regional cooperation should also be promoted to support the efforts of the countries concerned in human resources development with a view to enhancing national management capabilities in the urban water sector. The feasibility of setting up a regional training institution to be funded by international aid agencies such as JICA (Japan International Cooperation Agency) and ODA (Overseas Development Administration (United Kingdom)) to conduct courses in water resources management and wastewater treatment and disposal should be given consideration.

24. ESCAP and other international organizations and agencies should disseminate knowledge and information among national Governments and institutions on various aspects of sound water resources and sanitation development and management in urban areas by organizing regional activities such as seminars, workshops, expert group meetings and study tours, and preparing pertinent guidelines reflecting prevailing local socio-economic and environmental conditions of the countries of the region.

25. Specific activities could be organized by ESCAP at the subregional level on the particular problems critical to the subregions.

Part Two

BACKGROUND PAPERS

Chapter I. PROBLEMS, OBJECTIVES AND STRATEGIES OF WATER DEVELOPMENT AND MANAGEMENT IN URBAN AREAS

A. URBAN WATER MANAGEMENT ISSUES IN THE ESCAP REGION*

Introduction

Industrialization normally coupled with the growth of urban centres is a major driving force behind national economic development in the developing countries of Asia and the Pacific. However, industrialization and urbanization are placing an incredible strain on water resources, since industrial, domestic and municipal users in urban areas are demanding a progressively greater share of water resources and are, at the same time, degrading these resources with their wastes. This strain has become critical in the larger urban centres of many developing countries of the region, which experience severe problems with both the availability and the quality of water needed to sustain urban populations and national development. The availability of an adequate potable water supply and a clean aquatic environment have become crucial indicators of the quality of life in urban areas, while unsustainable urban water supply and contaminated water resources are considered the most important factors limiting socio-economic development.

Until quite recently, water supply and waste disposal were not regarded as serious constraints to urban development. Since many major cities in the region, such as Bangkok, Dhaka, New Delhi and Shanghai, are located on the banks of large rivers, a cheap water supply was secured and the river's self-cleansing capacities were sufficient to take care of the polluting wastewater discharges. However, with the fast growth of urban centres over the last decades, overuse of water resources stemmed from the efforts to satisfy the relentlessly increasing demand for water by urban users without due consideration to sustainability and protection of water resources has resulted in water resources depletion and degradation in a large number of river basins in Asia.

The lack of comprehensive water resources management in urban areas is very apparent. Polluted rivers, rapid eutrophication of lakes, and degraded recreational and aesthetic qualities of the aquatic environment attest strongly to the need for an integrated approach to development planning and management of water resources in the urban context.

Under the above mentioned circumstances, the formulation and implementation of policies for the environmentally sound management of water resources for use in urban areas which implies (i) a continued adequate water supply for present and future needs and (ii) the prevention of water pollution and the reversal of current trends of water resources degradation and depletion, are of vital importance to many countries of the ESCAP region.

1. Need for provision of urban water supply and sanitation at accelerated rates

The rapid growth of the urban population seems to be overwhelming the financial and technological capacities of many developing countries in Asia and the Pacific to provide water supply and sanitation services to urban residents, particularly to the poor.

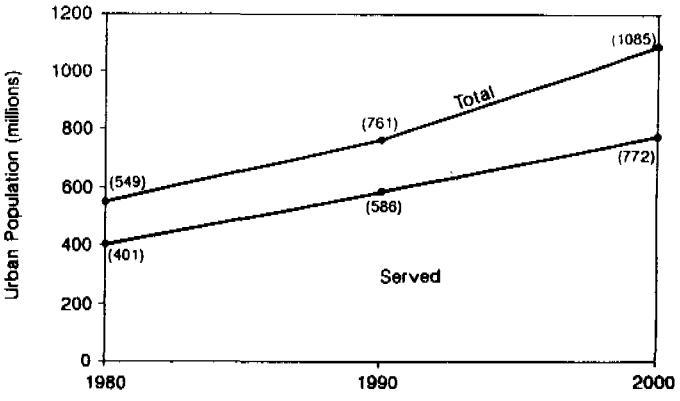
Concerted efforts during the International Drinking Water Supply and Sanitation Decade (1981-1990) brought potable water and sanitation services to millions of urban and rural residents throughout the world. The target of the Decade was to provide safe drinking water and sanitation to underserved urban and rural areas by 1990, but two major factors – high population growth in developing countries and inadequate funding of water development and protection projects – contributed significantly to preventing the full achievement of these goals. Nevertheless, impressive advances were made in providing the urban population with an adequate water supply and sanitation services in Asia and the Pacific.

(a) Water supply coverage

In Asia and the Pacific, the most dramatic increase took place in the urban water supply sector where the number of urban inhabitants provided with a water supply in 1980 had increased by 185 million or 46 per cent by

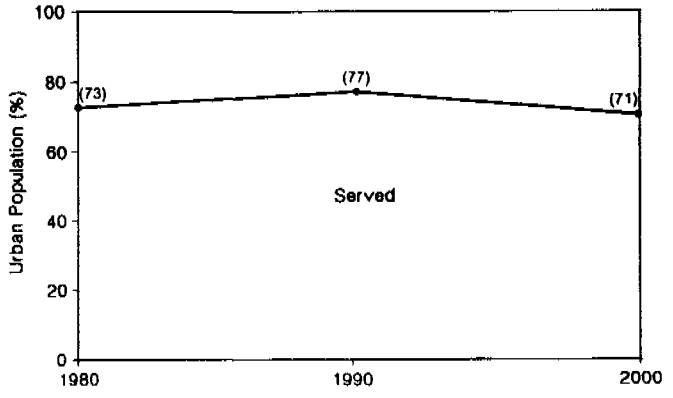
* Note by the ESCAP secretariat.

1990, i.e. from 401 million to 586 million (figure I). However, with the urban population rapidly expanding, this increase in the number of urban dwellers with reasonable access to a safe water supply did not translate into an equally significant increase in the percentage of people served relative to the total urban population, which had grown from 549 million to 761 million during the 1980s. In urban areas of Asia and the Pacific, the percentage of people served by adequate water supply services increased slightly from 73 per cent in 1980 to 77 per cent in 1990 (figure II).



Source: A/45/327, Achievements of the International Drinking Water Supply and Sanitation Decade 1981-1990, July 1990.

Figure I. Water supply coverage of urban population in Asia and the Pacific, 1980-2000



Source: A/45/327, Achievements of the International Drinking Water Supply and Sanitation Decade 1981-1990, July 1990.

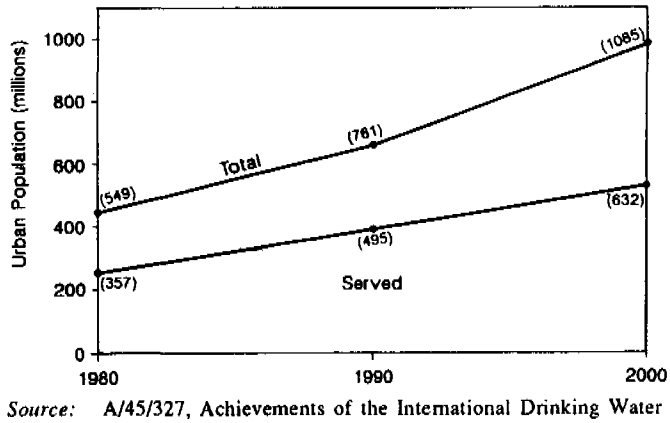
Figure II. Share of urban population in Asia and the Pacific covered with water supply, 1980-2000

Despite the achievements of the Decade, the rate of progress in providing the urban population with a water supply lagged behind the rate of population growth in urban areas. In the Asian-Pacific region, the number of urban dwellers *without* access to a proper water supply increased by 27 million or 18 per cent from 148 million in 1980 to 175 million in 1990. It is obvious that with the rate of progress achieved during the 1980s in the urban areas of the region it would not be possible to reach the ultimate goal of full access to a water supply for all urban inhabitants in the developing countries of the region by the year 2000, as it was proclaimed at the Global Consultation on Safe Water and Sanitation for the 1990s held at New Delhi in September 1990. Moreover, the gap between water supply and demand will probably be widening in many urban areas in Asia and the Pacific.

It has been estimated that if the expansion of the water supply and the population growth in urban areas continue at the current rates, the number of people in urban areas without adequate water supply will increase by 139 million or 79 per cent compared with 1990 to reach 314 million by the year 2000 and the percentage coverage will then decline to 71 per cent of the total urban population (figures I and II). Thus, the situation of the water supply in urban areas of Asia and the Pacific would be worse at the end of the century compared with the beginning of the 1980s, in spite of the persistent efforts made to increase the service levels.

(b) Sanitation coverage

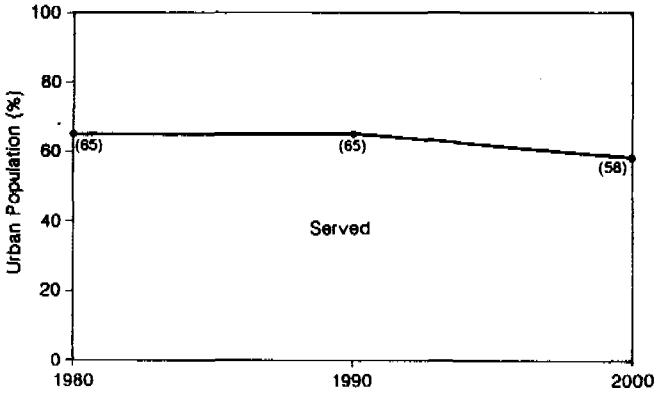
The progress in extending sanitation services in urban areas of Asia and the Pacific has also been impressive. The number of urban inhabitants provided with sanitation facilities in 1980 had increased by 138 million or 39 per cent by 1990, when the sanitation coverage reached 65 per cent of the total urban population or 495 million (figures III and IV). However, during the same period, the number of urban residents *without* adequate sanitation increased by 74 million or 38 per cent from 192 million in 1980 to 266 million in 1990. It is estimated that at the present rate of expansion of sanitation services and the even faster growth rate of the urban population, there is a real possibility that the number of urban residents without adequate sanitation services would increase by 70 per cent or 187 million by the year 2000 to reach 453 million. Thus, the expected sanitation coverage of the urban population would be reduced to 58



Source: A/45/327, Achievements of the International Drinking Water Supply and Sanitation Decade 1981-1990, July 1990.

Figure III. Sanitation coverage of urban population in Asia and the Pacific, 1980-2000

per cent, much lower than the sanitation coverage in 1980 of 65 per cent (figures III and IV).



Source: A/45/327, Achievements of the International Drinking Water Supply and Sanitation Decade 1981-1990, July 1990.

Figure IV. Share of urban population in Asia and the Pacific covered with sanitation, 1980-2000

(c) Targets

Certainly, there are significant variations from country to country in water supply coverage and provision of sanitation services in urban areas throughout the Asia and Pacific region. Nevertheless, the United Nations Conference on Environment and Development (UNCED) held in Brazil in June 1992 has called all states, according to their capacity and available resources, to have ensured by the year 2000 that all urban residents have access to at least 40 litres per capita per day of safe water and that 75 per cent of the urban population are provided with on-site or community facilities for sanitation. It is obvious that each individual country should set its own specific targets reflecting the current status of water supply and sanitation in urban areas, accessibility of water resources, availability of financial and human resources, etc.

The International Conference on Water and the Environment held at Dublin in January 1992 recommended in its report that in urban areas water supply and sanitation services should be extended with the aim of reducing the number lacking services at the end of the International Drinking Water Supply and Sanitation Decade in 1990 to half by the year 2000 and to provide coverage for all by 2015. But even for the more realistic target of universal access to water supply and sanitation, on a sustainable basis, by 2025, it is estimated that annual investments must reach at least double the current levels. However, this option, would appear not to be feasible for some developing countries of Asia and the Pacific, when taking into account their prevailing economic situations. Therefore, a practical strategy to meet present and future needs is to develop lower-cost but adequate services that can be implemented and sustained at the community level.

2. Need for protection and rehabilitation of water resources

Uncontrolled industrial development and rapid growth of the urban population without basic water-related services have led to the depletion and contamination of surface and groundwater resources due to overexploitation and pollution by wastes. In its turn, the water resources degradation has resulted in reduced urban productivity, increased cost of manufacturing, lowered quality of life and, eventually, in the undermining of sustained economic growth and social development on the national scale.

(a) Surface water

Rivers flowing through cities have traditionally been used to carry away human and industrial waste. When the amount of sewage and industrial wastewater is low in relation to the amount of water flowing in the stream, this approach seems appropriate. However, pollution load caused by the disposal of municipal and industrial wastes has exceeded a certain capacity of a large number of waterstreams to accommodate wastes, and subsequently many rivers have been ruined as potential water sources for downstream uses. This is preventing the countries concerned from adopting the strategy based on multiple water use, which has enabled industrialized nations to cope with rising domestic and industrial water demands.

(b) Groundwater

Groundwater was used extensively in urban areas for drinking and as an industrial water supply as this source was usually of high quality, free of mud and sediment and relatively cheap to develop. The attraction of groundwater for urban water supplies has led to its overexploitation, since groundwater was often pumped out at rates exceeding the rate of replenishment. Excessive withdrawals of groundwater have led to falling water tables, decreasing pressure in the aquifers and land subsidence in Bangkok, Beijing, Jakarta, Manila and other large cities in the region. In coastal areas, where a number of large cities are located, excessive exploitation of groundwater has caused high salinity levels in coastal fresh-water aquifers owing to intrusion of saline water from the sea. Saline water intrusion threatens to contaminate the drinking water supply of numerous coastal cities in Asia and the Pacific, unless urgent remedial and preventive measures are taken.

(c) Source of pollution

Water, both in surface streams and aquifers, is mostly contaminated by human waste, especially in congested low-income settlements with inadequate

sanitation and waste disposal facilities. According to some estimates, piped sewerage carries away the wastes of only 40 per cent of the developing world's urban population and only a very small portion of that is treated before disposal. The rest pollutes surface streams and groundwater. Since human waste contains dangerous pathogenic organisms, responsible for the spread of waterborne diseases, improper wastewater disposal poses an enormous health problem in urban areas, particularly for the urban poor. With a choice between heavily contaminated water from on-site sources or expensive clean water from vendors, the poor cut their consumption of clean water to the minimum and pay for it with sickness and disease.

Storm run-off also contributes heavy pollution loads as rainfall flushes out contaminants and wastes from urban areas. The water quality of this run-off is often worse than that of treated sewage. Traffic emissions, construction residue, street refuse, uncollected garbage are generating toxic contaminants and organics, washed out by run-off from urban areas to water bodies. Urban run-off has contributed to the appreciable decline of water quality in almost all of the rivers that flow through the region's cities.

Industrial wastes are also great contributors to water quality degradation, if proper disposal is not secured. Industries in developing countries commonly face few controls over wastewater discharges compared with industrialized nations. Many factories have been built without costly waste treatment and disposal systems since waste treatment expenses could increase production costs and consequently reduce a product's competitiveness on the international market. However, the impact of industrial wastes, especially containing heavy metals and chemicals, is particularly severe due to their persistence, harmful effects at low concentrations and ability to enter the food chain.

(d) Summary of water quality problems

In general, the water quality in the region has been degraded in many urban areas by the combined effects of sewage, urban run-off and industrial wastewater. The quality of water influenced by climate, geology, streamflow rates and pollution load varies considerably even along a large waterstream owing to the diversity of human influences and quantity of water resources. The severity and extent of common water quality problems in Asia and the Pacific can be summarized as shown in table 1.

In some urban areas, the degradation of water resources has reached such an alarming level that preserving the aquatic environment in its present state will not be enough to safeguard future water resources. Rivers have become open sewers. Rehabilitation of polluted and degraded water bodies is urgently needed in order to restore aquatic habitats and ecosystems, thus ensuring sustainable economic and social development. To achieve this goal, pollution has to be reduced and wastewater disposal has to be improved. In particular, the United Nations Conference on Environment and Development held in Brazil in June 1992 called all states to have established and applied by the year 2000, quantitative and qualitative discharge standards for municipal and industrial effluents. However, there is a trend in the developing world to set up relatively lenient discharge effluent standards compared with relevant standards in more developed countries. But, this situation

Table 1. Water quality issues in the ESCAP region

Quality Issues	*Indian sub-continent*	*South-East Asia*	*Pacific Islands*	*China*	*Japan, Australia and New Zealand*
Pathogenic agents	1-3	1-2	2-3	1-3	0-1
Organic matter	1-3	0-2	0-1	1-3	0-1
Salinization	0-1	0-1	0-3	0-2	0-2
Nitrate	0-1	0-1	1-2	0-2	0-1
Fluoride	0-1	0	0	0-2	0
Eutrophication	0-1	0-3	0	0-2	0-1
Heavy metals	0-1	0-2	0-1	0-2	0-2
Pesticides	0-1	0-1	0-1	0-1	0-1
Sediment load	0-2	0-2	0-1	0-3	0-1
Acidification	0	0-1	0	0-1	0-1

0 – No pollution or irrelevant
1 – Some pollution, water can be used if appropriate measures are taken
2 – Major pollution
3 – Severe pollution affecting basic water uses.

Source: "Water Quality. Progress in implementing the Mar del Plata Action Plan and Strategy for the 1990s", 1991. United Nations Publication.

is changing as more countries in Asia and the Pacific raise their standards of effluent discharge to combat the growing level of water pollution.

3. Approaches to urban water management

To meet urgent needs in the urban water sector and to manage water resources in the urban context more efficiently and in an environmentally sound and sustainable manner countries could reconsider and modify accordingly their current approaches to the formulation and implementation of water resources policies and action programmes.

(a) Management and institutional arrangements

(i) Regional approach

It is becoming increasingly apparent that many of the problems facing urban areas in the water management sector are regional in nature. Both maintaining an adequate and sustainable supply of good quality water to meet the basic water needs of the urban population and protection of the environment from pollution by wastewater generated in urban areas are problems of a regional scope which transcend the boundaries of local urban communities. Typically, water flows in and out of urban areas with no regard to jurisdictional boundaries. The principal source of surface water supply may often be located far upstream in the same river basin. However, given the depletion of water resources in river basins with large urban areas, interbasin water transfer schemes are becoming common. There are several such schemes, already in existence or planned in China, India, the Philippines, Thailand and some other countries of the region. In the cases of Hong Kong and Singapore, international arrangements have been made and expensive engineering works have been constructed to supply water from the territory of another country, namely, China and Malaysia, respectively.

Urban areas are also served by groundwater withdrawn from aquifers whose boundaries do not coincide with city boundaries. Wastewater from urban settlements is discharged, often without proper treatment, into streams leading to the degradation and pollution of fresh water, thus causing sharp decreases in the amount of water suitable for use in downstream areas. These water-related problems certainly require regional approaches for their solution.

As water scarcity increases, water resources planning has a greater impact on development planning. Urban water management should, therefore, be integrated with all aspects of national and regional planning processes affecting the region in which the city is located. Urban water supply and sanitation services need to be integrated with land use, housing development and environmental protection.

(ii) Management decentralization

To introduce an integrated approach to water resources management, most countries in the region have to upgrade their institutional frameworks dealing with the various aspects of water resources development, management and protection. Integrated water resources development and management should be delegated to the lowest appropriate levels thus ensuring the representation of those concerned or affected and the integration of sectoral demands. This approach has to be adopted, first of all, for tackling water resources issues in urban areas, where responsibility for water supply is often separate from that for pollution control.

(iii) Community involvement

Community management of water supply and sanitation is a viable option, particularly for poor urban settlements where adequate services are not provided by local municipalities. For example, there is a success story in Pakistan where local residents in the densely populated districts of Karachi have mobilized funds, planned and constructed a sewer and drainage system at a fraction of the cost of similar systems provided by the city government.

However, in general, urban communities show lower levels of participation than rural communities because community ties are weaker in the former thus preventing a proper collective definition of priority needs and the expression of demands. Nevertheless, governments should support and encourage community management of services by, in particular, setting up formal mechanisms for interaction between the community and the municipal authorities. The principle adopted in Agenda 21 of UNCED that decisions are to be taken at the lowest appropriate level, with public consultation and involvement of the users in the planning and implementation of water projects, should be widely applied. Capacity building of local institutions, therefore, is necessary to make community management effective.

(iv) Non-governmental organizations

The role of non-governmental organizations (NGOs) in urban water development and management should be given due attention. NGOs could provide an often missing link between community and local institutions. As a rule, NGOs are flexible, credible, and are ready and able to experiment with innovative approaches. They are in a suitable position to support research, development and the introduction of low-cost technology for water supply and sanitation in low-income urban areas. The contribution of NGOs to the promotion of public awareness, information dissemination and education could also be essential.

(b) Allocation of water resources

Water is a vital resource for human activities and an integral component of the environment. Finite water resources are used in agriculture, domestic and industrial supply. Water is a major resource to electricity production both for hydropower generation and for cooling thermal generators. It is also essential to the maintenance of environmental quality and proper health conditions, recreation and the protection of wildlife. Inland fisheries and navigation depend upon adequate flows of water in the rivers.

As demand for water grows in all sectors of the national economy in the countries of the region approaching the limit of feasible water supply, the competition for available water resources is intensifying.

Regionally, agriculture accounts for about 85 per cent of the volume of water withdrawn annually for all uses. Domestic and industrial water uses, concentrated in urban areas, are still a relatively minor component of total water commitments in the majority of the countries of the ESCAP region. However, the share of domestic and industrial water supplies will definitely rise, most probably at the expense of water allocated to agriculture.

Therefore, the allocation of water among uses, which are often conflicting, is a major task of governments to handle. In order to implement this task, priorities have to be established to reach a balance between water requirements for food production and urban economic development, health improvement and environmental protection. It is anticipated that top priority will always be given to adequate and affordable domestic water supply to meet the basic needs of the rural and urban population, especially during droughts. But, in any case, the availability and long-term sustainability of water resources should be taken into account when setting up priorities and planning urban development.

(c) Demand management

Limitations in the supply of water available for urban use effectively slow the pace of economic growth and social development in water-scarce urban areas, thus affecting national development as a whole. As the cost of developing new sources of water supply needed to overcome those limitations increases, the effective utilization of existing resources mainly through demand management becomes more beneficial to all concerned. The cost of saving water might be significantly lower than the cost of developing additional water resources.

Demand management is based on the following key principle – water should be considered an economic good having a value consistent with its most valuable potential use. Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources.

(i) Demand management in agriculture

In many still predominantly agricultural countries of the region, agriculture, accounting for the bulk of water use, might be considered a primary target for potential water saving. Such water saving resulting from a reduction in demand by agriculture could be reallocated to urban areas to alleviate urgent water problems there. However, the transformation of agriculture into a water efficient water user would require essential investments over a relatively long time period. Moreover, due consideration is to be given to the possible impacts of such transformation on food security and rural development.

Reduction in demand for water in agriculture, industry and in the domestic sector combined with the multiple use of water by successive downstream users could definitely lead to the sustainability of water supplies.

(ii) Demand management in industry

Efficient demand management could reduce water use in the urban industrial sector. Normally, water consuming industries are located near water bodies in order to have access to a cheap and reliable supply of water – a key input in many production processes. Although large industrial enterprises might have their own water supply systems and wastewater treatment plants, if any, small- and medium-sized industries typically scattered in a metropolitan area rely on municipal water supply systems and use high quality drinking water, which is often not needed for their production purposes. In addition, industrial

wastewater discharges contaminate the water resources downstream, which may be degraded to the point that they become unsuitable for use without prior treatment.

However, if industries were not scattered throughout metropolitan areas, but were concentrated in special zones, they could be served by lower quality water, thereby preserving limited drinking quality water for domestic consumption. Moreover, industrial wastewaters could be easily separated from municipal wastewaters and given appropriate treatment.

Demand for water in the industrial sector could also be reduced through the introduction of water-saving technologies, recycling techniques and water reuse, with the additional benefit of reduced wastewater discharge. However, in many cases, to discharge wastewater without treatment or with minimum treatment and then to intake a make up supply of fresh water would be cheaper than to introduce water conserving and saving measures. Thus, unless water prices are raised significantly, there are no economic incentives for industries to save water.

(iii) Demand management in the domestic and municipal sectors

Essential water savings may be achieved in the domestic sector by eliminating poor consumption practices. Water pricing is an important instrument for stimulating efficient use of water. A basic amount of water could be provided at a relatively low rate, while water consumption beyond that amount could be charged with progressively higher rates. On the one hand, payment for water is expected to cover the cost of water supply to the local authority. But, on the other, it should not be more than 3 or 4 per cent of the average income of a family in order not to overburden the family budget, of, particularly, that of poorer groups among the urban population.

Public water uses, such as park watering, should be paid for from the municipal budget. Water losses in distribution networks should be reduced from the present "unaccounted-for" water rate of 45-50 per cent in a number of large cities in the region to a reasonable level.

(d) Pollution control

In order to slow down the rapid deterioration of water quality and to enhance the availability of fresh water for use by future generations, the pollution load, generated in urban areas, on water resources should be drastically reduced. Controlling pollution through reduced loading is preferable because it is much more expensive to clean up polluted water than to avoid polluting it in the first place. Although efficient use and demand management are the most cost-effective and environmentally sound ways to address this problem, nevertheless some wastewater discharges are inevitable, but they could be controlled.

(i) Pollution control in the domestic sector

The polluting load from the urban domestic sector can be reduced through the introduction of sanitary waste disposal facilities, based on low-cost improvable technologies. The International Conference on Water and the Environment (Dublin, January 1992) recommended that, (a) within 10 years, programmes to provide sanitary containment or treatment for at least 50 per cent of the pollution load (biological oxygen demand) from domestic wastes should be initiated; (b) by 2015, every country should have achieved river water quality (varying from location to location) which safeguards supplies for downstream users.

These goals are not easily achieved. Although, in general, a range of low-cost sanitation technologies is now available to match the financial capacity and development level of most urban communities, more research is needed into sanitation and waste disposal technologies appropriate for high-density low-income settlements. On-site sanitation facilities and sewerage can reduce the polluting load on water resources. However, provision of sewerage alone is not enough, since it simply converts the problem from a series of scattered pollution sources to a single concentrated source. Therefore, wastewater should be treated before discharging into waterstreams. However, conventional wastewater treatment technologies, such as activated sludge plants or biological filtration, are relatively costly. In this regard, waste stabilization ponds have been used in many countries, where large areas are available for ponds near cities at low costs, as an alternative form of municipal wastewater treatment. The effluent from the ponds rich in nutrients, may be used, wherever appropriate, for crop irrigation or watering of public parks.

(ii) Control of industrial pollution

The discharge of pollutants to the aquatic environment could be drastically reduced by reuse and recycling of wastewater generated in the industrial sector. The introduction of appropriate low-waste and water-saving technologies and water pollution control installations should be supported by legal, economic, administrative and other measures.

Permits and regulations relating to industrial effluents are an important legal instrument with which to control the discharge of pollutants by industry. Control of industrial pollution sources should be enforced by economic incentives, such as effluent fees, so that companies will have an incentive to control their effluents at the source. On the other hand, subsidies could be given to polluting industries for building wastewater treatment facilities to reduce the pollution load on water bodies.

(e) Resource mobilization

(i) Financial strategies

A many fold increase in investment by central governments, city administrations, donor agencies and local communities will be needed in the near future in order to ensure a sustainable water supply to cities and to provide environmentally sound disposal of wastes from urban areas, and to reverse the present trend in aquatic environment degration. The average total global annual funding for the water and sanitation sector among developing countries is estimated at US$ 10 billion. About 65 per cent of these funds comes from national sources and the rest from the international community on grant or concessional terms.

However, a sharp increase over the current level of investments from traditional sources seems to be unlikely. Therefore, financial strategies should focus, as proposed in the New Delhi Statement (adopted at the Global Consultation on Safe Water and Sanitation for the 1990s, which was held at New Delhi from 10 to 14 September 1990), on (a) increased efficiency in utilization of available financial resources and (b) mobilization of extra funds by diversification of sources of finance.

(ii) Financial instruments

Autonomy and financial viability of urban water supply and sewerage facilities should be encouraged to the extent possible, as recommended in Agenda 21. In particular, the collection of charges should be decentralized so that revenues stay with the facility or community.

With water charges typically below costs and fines for polluting discharges absent in general, huge subsidies are required annually to sustain services vital to the urban population. However, cost recovery of urban water supply and sanitation services might be improved by more realistic pricing reflecting not only the actual costs of providing those services, but also the local socio-cultural and economic conditions. But, while consumers are generally not reluctant to pay for their water supply, they do not accept willingly the much higher costs of sewerage and wastewater treatment. As water pollution control and protection are becoming indispensable elements of urban water management, the willingness to pay for these services will have to be promoted through education and public awareness campaigns. The "polluter pays principle" should be introduced and enforced in the industrial urban sector. Penalties for polluting discharges could make a significant contribution to environmental protection measures.

Economic efficiency of urban services can also be improved by rehabilitating defective systems, reducing wastage and unaccounted-for water, recycling and reusing wastewater and improving operation and maintenance. This kind of investment will in many cases be more effective than the funding of the development of new systems.

(iii) Private sector involvement

There is a considerable role for the private sector in the provision of services in urban areas. The involvement of private companies could, first of all, reduce the heavy financial burden borne by Governments in the water supply and sanitation sector. The private ownership and management of public water supplies and sanitation could also improve the quality of services and increase efficiency and productivity. However, the transition from the government-run services to the private sector involvement is a lengthy and complicated operation, which needs to be planned and executed taking into account the prevailing socio-economic conditions in a particular country. A phased increase in private involvement seems to be more appropriate rather than a sharp transfer from Government responsibility to a lease or concession of water supply and sanitation services by private companies. But private sector operations need to be subject to the control of municipal agencies, backed by appropriate regulations and means of enforcement.

(iv) Public participation

An important resource, particularly in low-income settlements, is the capacity for self help among local communities. Poor people devote a higher proportion of their meagre incomes to obtaining basic amounts of water compared with urban residents in well-to-do areas. By involving benefiting communities in the development of water supply and pollution prevention facilities and

the subsequent maintenance and operation of new facilities, required investments can be reduced substantially. Some experience in motivating communities to take care of the development and management of water supply and sanitation projects in low-income urban areas has been gained in China, India, Pakistan and several other countries of the region.

4. International cooperation

Although water supply and sanitation programmes and aquatic environment protection activities are national responsibilities, multilateral and bilateral cooperation supported by the international community could complement national endeavours.

Regional and subregional cooperation in the field of urban water resources management and development should be intensified. Experience accumulated by some countries in the effective management of water resources in the urban context has to be made widely available to other countries. An exchange of experience could help them avoid the same mistakes made by some countries in the past.

International cooperation is particularly essential in cases where catchments or aquifers cross national boundaries as water use in an urban area affects the quantity and quality of water resources in other parts of the river basin in which the area is located. It could lead to the harmonization of water-related policies, strategies and programmes in river basins shared by two or more countries. Even institutional mechanisms at various levels might be duplicated if they are found worthwhile.

Regional cooperation could be aimed at the strengthening of the capacity of developing countries in Asia and the Pacific in the formulation and implementation of policies on various aspects of sustainable development and environmentally sound management of water resources in urban areas. Deficiencies in national training needs could be filled through exchanges of trainees, trainers and training materials. Continued support could be provided to the further promotion of technical cooperation among developing countries (TCDC) in the urban water management sector.

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B. URBAN WATER MANAGEMENT PROBLEMS*

Introduction

Given rising demand, overuse, and growing pollution, there is good reason to fear that water shortage will worsen urban health problems, undermine economic growth, and promote conflicts between urban water management and other development goals.

Municipal authorities responsible for urban water management are going to face very serious problems and challenges in the years ahead. These challenges will require radically new thinking regarding the future role of municipalities with respect to managing these essential services as well as new ideas regarding the private sector.

If there are real solutions to be had, they will probably be primarily political ones in which there are compromises between different perceptions of the problems. This means that the many groups in the political arena will wield influence according to their relative powers.

The perception of those involved, or wishing to get involved, will inevitably differ markedly. Simple remedies will not suffice. Nor should we turn too quickly to well-tried Western "solutions", which have not been shown to have a good track record (Gladwell and Bonell, 1988).

1. Setting the objectives

The luxurious standards of industrialized countries are clearly unattainable for the vast majority of the population in developing countries. Despite this clear evidence, the common approach in developing countries since colonial times has been to promote the adoption of industrialized country standards and systems to reach them.

Unfortunately, planners are continuing to adopt the solutions rather than learning from the past. With some notable exceptions, university curricula in public health engineering still tend to concentrate on conventional solutions, so that professional engineers who are responsible for planning urban systems are not in the habit of thinking about viable alternatives. Further, it is conventional wisdom that donor agencies and consultants from developed countries encourage the use of costly equipment and materials which are produced in their countries of origin (Lee, 1992).

In many urban centres in the Third World, rapid population growth means that the already large deficits in terms of the number of people lacking piped water, sanitation, garbage collection, schools, health care, and emergency services also grow rapidly.

Thus, an evaluation of the urban water management principles, that have been pursued during the last decades, clearly indicates that the traditional planning structures and planning procedures are not adequate to handle new boundary crossing problems. Only drastic administrative reorganization can solve this impasse.

There is no doubt that the management of water for domestic, industrial, and agricultural purposes will continue to dominate those for purely social or environmental purposes. But there is an obviously growing consciousness of the need for the full consideration of those "non-economic", "non-quantifiable" aspects. In fact, there is an increasing awareness that social and environmental reaction to improperly planned water management activities can often negate what might have otherwise been worthwhile objectives.

Planners have an obligation to properly consider the consequences of their water management propositions in the light of real social and cultural conditions. When the results of their efforts are tallied, the benefits should have exceeded the costs – they should have contributed to the solution, not to the problem (Hjorth, 1991).

Local government has at least three important roles to play in stimulating and supporting development of sound water management practices within its boundaries: social, economic, and political. Its social role is to ensure that people within its jurisdiction are served with the infrastructures and services essential for human health – even if other agencies provide some of these. The economic role of local government is to support a growth of productive activities within its jurisdiction. The political role is to respond to the needs and priorities of local citizens; the political role may also include

* This paper was prepared by Peder Hjorth, Asian Institute of Technology, Bangkok, at the request of the ESCAP secretariat.

representing local needs at higher levels of government.

The provision of infrastructure and urban services has become a crucial element of the management of the urban environment, both because it contributes to the social welfare and survival of urban populations and because it is vital to the economic growth or cities. Adequate water supply, sanitation, solid waste treatment and disposal, and drainage are essential to decent shelter and public health standards. They directly advance the productivity of labour and the capacity of urban markets to work effectively. The location of urban infrastructure and urban service investments has great bearing on the pattern and efficiency of urban growth, on the siting of employment centres and on the ability of the natural environs to support development (LaNier, Reeve and Young, 1989).

2. The problem of enforcement

Present problems may partly be viewed as the outcome of economic and political situations that lead to often apparently bad land-use decisions. Many developing country cities have formulated master plans that have included some prescriptions about the future land use. These master plans rarely, if ever, have been realized. The land-use controls included as part of these master plans have been mainly ineffective. There was little or no recognition of the limited power of enforcement available in planning departments in most developing country cities, where most land development has taken place outside the formal, regulated sector.

There is a growing understanding that a major reason that local administrations have not coped successfully with their tasks is because they simply do not know what is going on in their local area. Without information, many planners and policy makers have been operating on the basis of assumptions or using standards (most often inappropriate ones) from other countries (Brennan, 1992).

Thus, policies and regulations are frequently adopted without any consideration of how they can be implemented, i.e. imposed and enforced. What is actually needed is an implementation incentive system. Developing and maintaining an effective implementation programme, however, requires the responsible agencies to have a technical capability to monitor activities and measure their performance. There must also be a legal/ political capability to apply sanctions. In the early 1970s and 1980s, most nations in the Asian region established the legislative framework for environmental laws and promulgated basic regulations. However, due to environmental agencies' lack of political clout, dearth of funds for enforcement, or lack of significant penalties, the legislation often had little meaningful effect (Austin and Koontz, 1992).

Basic to the improvement of the capacity for environmental quality management in urban areas in developing countries is the elimination of the common lack of understanding of and incorrect perceptions about environmental quality management. This pertains to decision makers, technical staff, environmental groups, and users of the environment, e.g. industry, institutions, government, and individuals. The situation is endemic in developing countries and is not uncommon in so-called developed countries (Bower, Hyman and White, 1989).

It must also be realized that the environment will only be protected by outstanding organizational, technical and legal efforts. More and more development agencies have recognized that the funding they allocate to projects to improve infrastructure and services requires effective local partners; weak, ineffective, and often bankrupt local authorities make poor partners. However, it is only relatively recently that donor agencies have allocated much funding to institution building, training in urban management, local government finance, and urban planning. Most of the funding for this has come from the World Bank, starting in the late 1980s.

3. Consultations and coordination

In a developing country, a local government agency or a provincial agency will have a few individuals with adequate training and some experience. These individuals are often spread so thin that it is impossible for them to cope adequately with the wide range of tasks in which the agency is involved.

One result of this kind of situation is that decisions are made even before rough analyses are done. Another not unusual result is that decision makers succumb to the blandishments of consulting firms advocating capital intensive solutions. The capital intensive option is often stimulated by bilateral and multilateral lending programmes in which the objective is to provide work possibilities for local firms. In general, it is also much simpler to design and construct a major project, even if it cannot be operated adequately, than it is to develop long-term institutional capacity for implementing low-cost alternatives.

Weak, poorly functioning local governments are often associated with a high degree of centralization of authority and fiscal control in the national government. In addition, the power to raise substantial revenues is not

given to local government units in most cases, and disbursements to local governments from central governments are insufficient and often irregular. Thus, even where there is decentralization of authority on paper, it becomes meaningless without the power of the purse. Unfortunately, as a recent World Bank report has noted, the ability of local governments to solve urban problems is weaker than ever before (Parker, 1992). Instead, throughout the developing world, the institutional capacity of city government has declined over the past two decades in response to centralization at the national level and inadequate maintenance of critical infrastructure.

The German Agency for Technical Cooperation (GTZ) has launched programmes to improve urban environmental management in municipalities in Nepal and in Thailand. For the efforts in Thailand, a basic 10 point strategy, which well reflects current thinking among development practitioners and scholars, has been developed (GTZ, 1992):

(a) Self-reliance: Since urban environmental management is predominantly a local responsibility, municipalities should not rely on the central government to take initiatives or provide resources, but should think and act creatively to address local needs.

(b) The central government should therefore be seen as a resource for local activity, providing expertise and some finance, and not as provider of services on which the municipality must rely.

(c) In order to address increasingly serious environmental problems effectively, the municipality must have adequately trained personnel. It is therefore necessary that it should make maximum use of training opportunities for staff.

(d) Organizing local service provision is not possible without good information on what already exists and what is needed. Collecting – and using – information on local conditions and needs is an important task of the municipal staff.

(e) The community and local organizations must be involved both in determining what is to be done and in actually doing it. Municipal responsibilities in environmental management are as much about mobilizing local resources as about carrying out the work itself.

(f) Educating the community about the environment is a vital part of effective environmental management. All media should be used, and local organizations mobilized, to raise awareness and disseminate key messages.

(g) A really successful environmental initiative is where local communities solve their own problems, with the municipality as facilitator, providing information and basic resources to empower them to act on their own behalf.

(h) The key task of the municipality is coordination and integration of financial, physical, social, and organizational resources. Most environmental services and infrastructure are interdependent: for instance, good sanitation and drainage rely on good solid waste management.

(i) Municipalities need to define clear environmental policies and goals, and then to work conscientiously and consistently to achieve them. An annual, or more frequent, evaluation of achievements needs to be undertaken to see what has been achieved, and to determine how to overcome difficulties if these have arisen.

(j) Municipalities must have a solid legal framework to support the implementation of local environmental policies. Municipalities may pass local rules and regulations to enable the collection of service charges and to fine or restrain violators of environmental regulations.

A recent report from the Australian Industry Commission on Water Resources and Wastewater Disposal in Australia (Henshall, 1992) shows that the need for change is by no means confined to the community of developing nations. The report emphasizes two main principles as the preferred measures for improving the efficiency and sustainability of Australia's water resources:

(a) effective pricing of water, sewerage, and drainage services; and

(b) increased cost recovery.

The Industry Commission report states that: "Reform is urgent. The problems now confronting Australia in the water area demand an end to the political expediency which has so often thwarted worthwhile reforms in the past."

However, the diverse nature of water authorities, difficulties in implementing many theoretical concepts, and conflicting priorities and objectives result in the report only making broad recommendations. Throughout the report, however, the Industry Commission emphasizes the need for continuing and increased reform of water resource services despite the political pressures which will no doubt flow from the adjustment proposed. In the Commission's words, "hard decisions must be taken now to avoid even bigger costs in the future".

4. More resources to serve basic human needs

There has been a growing political consensus in recent years to place the human being at the very centre of the economic development process. This could be achieved by putting water and sanitation at the "cutting edge" of such an approach. It is significant that the world's top leaders have already identified water and sanitation as essential elements of human development, as indicated in the Global Consultation on Safe Water and Sanitation for the 1990s, New Delhi, 1990; the World Summit for Children, New York, 1990; the International Conference on Water and the Environment, Dublin, 1992; and " Agenda 21", endorsed by many nations at the United Nations Conference on Environment and Development, Brazil, 1992.

But for the time being this alternative is still a chimera. However, a strategic planning system may serve to circumvent the limitations of an existing planning system. It will also protect us from the harshness of a free market which offers little room for future oriented planning and attaches little significance to managerial and responsible local government.

An analysis presented in the United Nations Development Programme 1991 Human Development Report shows that in many countries at present, only a small proportion of gross domestic product, on average barely two per cent, is directed to priority human expenditure. The same is true of the aid budgets of most donor counties, on average only eight per cent of total aid. Put differently, the amount of restructuring to generate the resources required for meeting priority human goals is usually not large.

5. Lessons from Africa

Financial disbursement patterns of the 1980s show that an estimated 70 per cent of the resources allocated to the water and sanitation sector in Africa went into high-cost technologies for improvement of existing services. This should not continue. A more realistic approach must be considered. The gap between the current level of baseline service coverage and the ultimate objectives of universal access is very large in many countries. Planning can only be of assistance to sector management if the goals are realistic and have some chance of being met.

Africa is probably the continent which most clearly illustrates the shortcomings of current water management efforts. However there has also been a number of innovative water management approaches. Thus, the African experience has given a number of lessons (de Rooy and Doyle, 1992) that are very likely to provide guidance for water management in other parts of the world.

The first and perhaps the most important lesson learned in the 1980s is that the sector must now focus its efforts on reaching the unserved, the poor, whose numbers are rapidly growing.

The second lesson, and opportunity, concerns the role of governments. The sector has learned that unless there is a political will, little attention will be given to this relatively politically voiceless population. The focus for national governments should be upon facilitating initiatives that lead to provision of service to those who do not have convenient access to water and sanitation facilities instead of mainly improving the supply for the relatively privileged. In this period of renewed appreciation of free market approaches, one must not lose sight of the importance of the public sector's role in promoting human development, with special emphasis on the poor.

There is an important role for the private sector, however, and this is the third lesson of the 1980s, the potential of the private sector in the delivery of water and sanitation services especially to the better-off needs to be more fully tapped. At present, this population enjoys government subsidies which they could very well do without, while the poor often pay exorbitant prices and/or a disproportionate share of their earnings, for very low levels of service.

The fourth lesson learned is that water and sanitation programmes need to build-in elements of cost recovery/sharing, based on the high level of demand for improved services.

The fifth lesson is the need to fully utilize appropriate, low-cost technologies. Africa has now at her disposal a series of models for water and sanitation, developed mainly during the 1980s, which are efficient, easy to maintain, and inexpensive. The use of these appropriate technologies must be greatly expanded if one

were to substantially accelerate the service coverage in Africa, and if one were to meet the goal of universal access by the end of this decade. Without such transitional technologies, the poor have little hope for advancement.

The sixth lesson is that the fragmentation of the water and sanitation sector has proven to be a major handicap for development and must be overcome in the 1990s.

It is impossible to "go to scale" in the absence of a clear strategy, and government leadership that serves to combine the limited and often overstretched human and financial resources.

The seventh lesson is that development is contingent upon community participation, especially the involvement of women. Sustainability will continue to be a dream instead of a reality, as long as Africa's women and girls continue to devote a disproportionate part of their time and energy to such necessary but time consuming tasks as water collection, searching for fuel wood, and food preparation.

6. Make planning more flexible and pragmatic

Considering the above lessons, we can conclude that in order to effectively meet the challenge ahead in the water and sanitation sector, a much greater synergism in terms of linkage between sector monitoring, planning, and advocacy is paramount. Planning should evolve into a more flexible and pragmatic approach. It should include all or some of the following in a sequential manner:

(a) a realistic situation analysis including an estimation of available resources and of the resource gap;

(b) an optimal policy package to breach, or minimize the resource gap;

(c) selection of optimal technology/strategy options for maximum acceleration of sustainable coverage;

(d) setting of realistic sector goals ; and

(e) establishment of a pragmatic planning/ monitoring framework.

The costs of infrastructure and services are dependent on the level of service. In most market economies, costs are largely covered by property taxes with the remainder provided by user fees and allocations from general tax revenues. Where land ownership remains with the government, land rent fees for infrastructure and services usually replace the property tax as a source of revenue. In either case, a key to the success of the fiscal capacity to finance both infrastructure and services is the recovery of more of the costs of service provision through targeted user charges and taxes.

The failure to introduce comprehensive cost recovery schemes reflects the principle that basic services, such as water supply, are social services for which users should not have to pay. This view is particularly strong in rural areas where people traditionally have had access to rivers and ponds or self-constructed wells, and where there has been little government intervention in the sector until recently (Reitveld, 1992). In towns and cities, where more complicated and costly systems were required, water and sanitation services came to be viewed as a government responsibility, again to be provided at little or no cost to the user. Within this context municipal authorities have been generally reluctant for political reasons to raise tariffs and establish realistic prices for water and sewerage services to cover their true costs (Brennan, 1992). A recent review of World Bank projects showed that the effective price charged for water amounts to only 35 per cent of the average cost of supplying it (Reitveld, 1992).

A rapid but realistic situation analysis involves the assembly and analysis of existing environmental information including:

(a) data from routine quality monitoring, where it is available;

(b) data on existing environmental infra-structure and services;

(c) demographic, epidemiological and socio-economic data; and

(d) data on the natural ecosystems within or surrounding the urban area.

This preliminary stage aims in clarifying issues to be addressed, involving and informing those whose cooperation is required, and obtaining agreement and commitment on regional priorities. It cuts across conventional partitioning of development actors' concerns and responsibilities and requires coordinated response. The technique also involves the assembly and analysis of existing information using key urban environmental indicators, and the analysis and interpretation of the information through preparation of an urban environmental profile. Finally, consensus and commitment is sought through consultations that include those whose interests are affected by environmental strategies

and action plans, those who control relevant instruments, and those who possess relevant information and expertise (Bartone, Bernstein and Lettmann, 1992).

This phase is critical not only because it results in the identification of priority problems where actions and resources should be focused in the future. Several criteria are recommended for selecting priorities:

(a) the magnitude of health impacts associated with the problem;

(b) the size of urban productivity losses caused by the problem;

(c) the relative impact of the problem borne by the urban poor;

(d) the degree to which the problem is caused by unsustainable water consumption or whether it will lead to an irreversible outcome;

(e) the extent to which local support or constituencies exist to help resolve the problem; and

(f) the existence, or likelihood of building needed capacity to manage the problem.

7. The strategic planning approach

An issue-specific water management strategy will establish the framework within which short- and medium-term sectoral action planning and investments can take place. It should also provide a decision making framework for private investments recognizing that the investments will be made primarily by private actors (by households, communities, and firms) in any city over the long term. The process of formulating a strategy, therefore, should focus on achieving the coordination of both public and private decisions and actions (Bartone, Bernstein and Lettmann, 1992).

Thus, appropriate management strategies for developing countries are those which are explicitly sustainable, reflecting a realistic assessment of resources – both human and material – available to the country and including provision for cost recovery sufficient to allow continued investment in new facilities as well as adequate operation and maintenance.

There are limits to the current understanding of the components of the urban environment and especially of the complexity of their interaction. There is, however, sufficient theoretical and factual information and professional expertise available to begin much more effective management of urban environments. Common sense judgements must be relied on, even though these judgements may be based on deficient data. Such management can start now and, if approached with respect for the systemic nature of interventions, much more will be learned, and urban management capacity will grow (LaNier, Reeve and Young, 1989).

This kind of strategic planning aims, according to van den Berg (1992), to reach a balance between objectives and their implementation. Available resources, and those which need to be mobilized, suggest the level of aspiration of the objectives, and their study is a part of the planning process. A second general characteristic is the creation of a broad basis for planning activities by means of dialogue and negotiation. Strategic planning has proved effective at a time when government resources available for planning are limited. The position and role of the public sector in town and country planning has changed; it is now less of an innovator looking after society's interests and is seen more as a middleman and catalyst for ideas and resources. Collaboration has the effect of generating ideas, means and a broad base. In the initial phase of a planning project, proposals, ideas, visions, and concepts play an important role. These are discussed during the course of the planning process and can be revised and supplemented until participants reach a consensus.

In process planning, it is the interested parties – users, resident groups, and action groups – who play an influential role. The actors selected for strategic planning are those who have an essential contribution to make in formulating objectives, using resources, and establishing the desired broad base.

Resources include land, investment, subsidies, and market process and procedural know-how. Actors can be recruited from government organizations, the business community, and advice agencies. Action orientation and results are more important than the decision making process.

Strategic planning has a profound influence on the type of planning organization used. Advice groups, task committees, steering committees, and working groups are formed which foster the dialogue and negotiation which must eventually result in agreements, contracts, or covenants. The significance of planning documents themselves in terms of process results is less dominant. Plans which are more general and more flexible, are continually changed and function more as a means than as an end.

Thus, strategic planning is a viable approach to projects which a local government is unable to implement with its own resources and with its own personnel but can carry out in various partnerships. The situation automatically leads to the selection of project oriented methods which reach out beyond the municipal organization itself. However, to promote this kind of planning, the national government should devote more time to collaboration and negotiation than to decision-making. It should also attach great significance to a careful selection of strategic plans, the strategic use of resources, and the strategic choice of the persons and institutions which will be involved in the planning process.

8. Conclusions

Governments of developing countries and external support agencies involved in the water and sanitation sector have a fundamental choice : to continue with "business as usual", with essentially a low priority for the unserved, or to shift the focus to facilitating the provision of service to the silent majority. By opting for the latter, one will substantially contribute to shaping a better future and more just social order and, at the same time, establish the foundation for more rapid and equitable human development.

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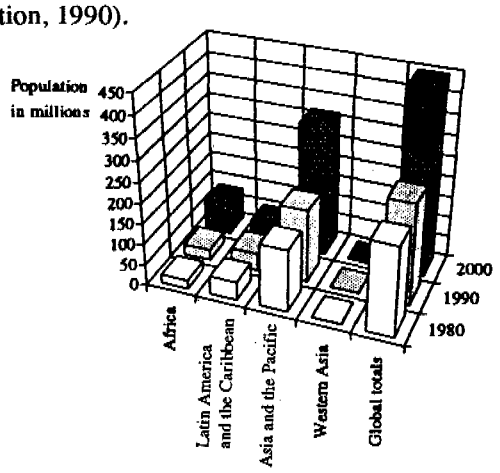
C. WATER SUPPLY, SANITATION, AND THE URBAN POOR IN ASIA AND THE PACIFIC: HOW TO SERVE THE UNSERVED IN CITIES?*

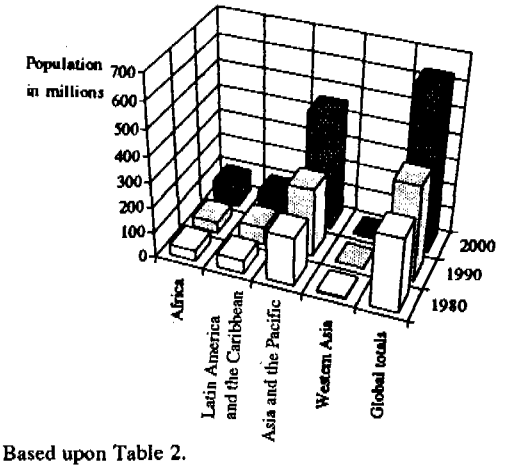
1. The challenge

In September 1990, the Global Consultation on Safe Water and Sanitation held at New Delhi concluded that the priority areas of concern are urban sanitation and water supply in Asia and the Pacific because this region makes up the bulk of the unserved projected for the year 2000 (figure V and figure VI). Moreover, low-income communities make up by far the largest part of the unserved in urban areas (Secretariat for the Global Consultation, 1990).



Source: Based upon Table 2.

Figure V. Urban population unserved by water supply in developing countries, 1980-2000



Source: Based upon Table 2.

Figure VI. Urban population unserved by sanitation in developing countries, 1980-2000

One of the concomitant features found in many rapidly expanding cities in the Asian-Pacific region is the tremendous increase in the number of the urban poor and of squatters' settlements. Most recent estimates suggest that from one-quarter to more than one-half of the population in many cities in the region live in slums and squatter settlements (Douglass, 1992). Unserved by water supply and basic sanitation facilities, the urban poor suffers the most from the lack of a healthy environment within their homes and their neighbourhoods. Infant and child mortality rates (when they are accurately known) may be three or four times higher than the city average and there is a comparable differential in all other aspects of health and social well-being (World Health Organization (WHO), 1989). The extent and gravity of this global problem (in both urban and rural areas) is manifested by the fact that the lack of safe drinking water and adequate sanitation is the cause of 900 million cases of diarrheal disease every year, which cause the deaths of more than three million children (Bulajich, 1992). More than 2 million deaths from diarrhea alone, however, could be avoided each year if all people had reasonable water and sanitation services (World Bank, 1992).

Moreover, inadequate water supply prompts people to boil water, thus consuming energy. The practice is especially prevalent in Asia. In Jakarta, more than US$ 50 million is spent each year by households for this purpose--an amount equal to one per cent of the city's gross domestic product. In Bangladesh, boiling drinking water would use up 11 per cent of the income of a family in the lowest quartile (World Bank, 1992). In addition to tremendous adverse health effects, the lack of reliable water supply thus also drains the economic welfare of the poor.

In the next four decades, urban populations in developing countries are projected to rise threefold and domestic demand for water to increase fivefold. The *World Development Report 1992* of the World Bank asserts that current approaches will not meet these demands, and there is a real possibility that the number of people unserved could rise substantially. The cause for anxiety is based upon the following financial considerations. Expenditure on water and sanitation services by government and external support agencies during the period 1981-1989 has been estimated at between US$ 100 and US$ 120 billion (1985 dollars). This amounts to approximately US$ 100 for each

* This paper was prepared by Yok-shiu F. Lee, East-West Center, Hawaii, United States of America, at the request of the ESCAP secretariat.

additional person served during the period. Investment levels of the 1980s, if not increased in the 1990s, would amount to only about US$ 20 per unserved person, given the sizable unserved population as of 1990 plus the projected population growth over the next several decades (Secretariat for the Global Consultation, 1990).

The financial situation may well be even more critical than these figures suggest. Because of a combination of factors – growing water scarcity, deteriorating water quality, limited investment in the collection, treatment, and reuse of wastewater, as well as continued rapid growth in demand for competing uses of available water – the only reasonable assumption to make for the 1990s is that the per capita unit cost of water supply and sanitation facilities will rise dramatically. In fact, in many urban areas in the developing countries, due to the quantity and quality problems, the costs of supplying water of adequate quality are rising rapidly (with the cost of a unit of water from "the next project" often two to three times the cost of a unit from "the current project") (Bhatia and Falkenmark, 1992). Thus, developing countries that wish to expand the coverage of water and sanitation services will be forced by financial pressures to radically or substantially rethink their sector strategies and re-evaluate their investment priorities. Compared to the time of Mar del Plata, it is now easier to say what is possible and what is not. Clearly, a target of clean water and sanitation for all by the year 2000 is unattainable (Secretariat for the Global Consultation, 1990).

The principal question is: Given that the trends of declining economies, rapid urban growth and rising unit costs during the past decade are likely to continue in the coming years and that the bulk of work that still needs to be done will be found in the more difficult low-income urban areas, how can limited resources and efforts be best directed towards these low-income communities in the cities in the coming decade? This will require decisions about who is to be served now, at what service level, and through what institutional mechanisms.

2. What has been done?[1]

The International Drinking Water Supply and Sanitation Decade (1981-1990) was the most notable international and national effort in seeking to improve the provision of clean water supply and adequate sanitation facilities in the developing countries. The Decade called for 100 per cent coverage of safe water and sanitary services in all rural and urban areas by 1990 (United Nations Centre for Human Settlements (UNCHS), 1987). At the time this goal was pronounced, it did not seem overly ambitious. However, the launching of the Decade coincided with the beginning of a world recession. Three years into the Decade, gloomy assessment by WHO officials pointed to "the absence of strong popular and official support, weak institutions, shortage of trained personnel, doubts about technology, and insufficient financial resources" (Urban Edge, 1983). Experience of the Decade's first half led many countries to trim their plans, so that by 1985 the proportion of countries aiming for 100 per cent urban water supply coverage fell from 48 per cent to 40 per cent and those with similar hopes for urban sanitation dropped from 33 per cent to 26 per cent[2] (WHO, 1987).

By now we all know that despite the momentum generated by the Decade, the coverage of population in developing countries with water supply and sanitation services is far from satisfactory. High rates of population growth and low or even negative growth rates in gross national product per capita are commonly cited as two major factors that have curtailed the coverage rate of water and sanitation (Christmas and de Rooy, 1991; Najlis and Edwards, 1991).

For instance, a recent WHO estimate of sector investments by governments and external support agencies (ESAs) in the 1981-1985 period indicates a total of US$ 70 billion (1985 dollars)-an average of US$ 14 billion a year. For the 1985-1989 period, the World Bank estimates sector investments by governments and ESAs at about US$ 9.3 billion (1985 dollars) a year. The estimated lower levels of investment during the last half of the Decade have been attributed to the generally lower rates of economic growth during this period in most developing countries (McGarry, 1991). But it has also

1 The bulk of discussion on the International Drinking Water Supply and Sanitation Decade is drawn upon "Rethinking Urban Water Supply and Sanitation Strategy in Developing Countries in the Humid Tropics: Lessons from the International Water Decade," a chapter manuscript prepared by the author for a forthcoming United Nations Educational, Scientific and Cultural Organization book entitled *Hydrology and Water Management in the Humid Tropics*, edited by M. Bonell, and others, Cambridge University Press (in press, 1993).

2 Estimating overall coverage of urban sanitation facilities is a very difficult task because definitions vary from country to country and private facilities usually outnumber public ones. WHO researchers tried to overcome this problem in compiling the global figures by defining access to sanitation services as being served by connections to public sewers or household systems – pit privates, pour-flush latrines, septic tanks, and communal toilets. Urban sewage disposal systems do not necessarily imply proper waste treatment. In many developing countries, the wastewater collected by central sewerage systems is often discharged into rivers, canals, and coastal water only partially treated or totally untreated. Similarly, for clarity, WHO defines access to safe drinking water in urban areas as having water piped to a housing unit or to a public standpipe within 200 metres (UNEP, 1987). In-house water connection is no guarantee of regular water supply. In Bombay, an estimated 63 per cent of urban households with in-house connections receive water for three or fewer hours each day (Unvala, 1989).

been pointed out that, in many cases, developing countries have little choice on how to spend their money. Structural adjustment loans from the International Monetary Fund often come with requirements that include stiff cuts in public spending, for example, without regard to the negative impacts of such policies on a population's welfare (Mfutakamba, 1989).

The changes in service coverage throughout the Decade in the developing world are summarized in table 2. While the Decade has made tremendous gain in terms of extending the provision of water and sanitation services to an additional number of people during the 1980s, in some parts of the developing world (notably Asia and the Pacific as well as Latin America and the Caribbean) the percentage of urban population served has only increased slightly or has remained at the same level (figure VII and figure VIII). In fact, in Africa and South Asia, the total number of residents still without safe water supply and adequate sanitation has remained the same or has actually increased. According to the report of the United Nations Secretary-General on the achievement of the Decade:

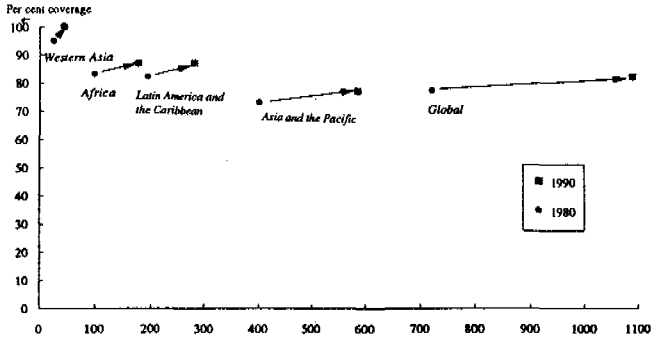
> about 1348 million more people were provided with safe drinking water supply in developing countries during the 1980s, 368 million in urban areas and 980 in rural areas. Similarly, 748 million more people, 314 million urban dwellers, and 434 million people in rural areas were provided with suitable sanitation services. Overall, the number of people without safe water decreased from 1825 million to 1232 million, while the number of people without suitable sanitation remained virtually the same (cited in Najlis and Edwards, 1991).

The most dramatic result of the Decade was recorded in the rural areas where the number of people without safe water supply decreased by 624 million, and those without adequate sanitation by 79 million (Najlis and Edwards, 1991). Urban areas, however, are still better served than rural areas with water supply and sanitation services throughout almost all of the developing world (table 2). Thus, the problem of providing water and sanitation services is at present an

Table 2. Water supply and sanitation coverage by region, 1980-1990, and coverage for 2000 at current rate of progress, for developing countries (population in millions)

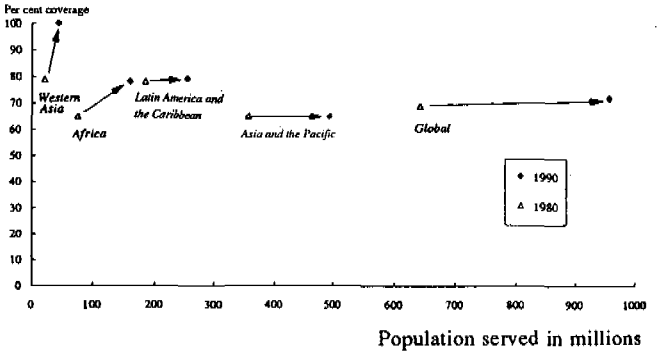
	1980				*1990*				*2000*			
Region/section	*Population*	*% coverage*	*Number served*	*Number unserved*	*Population*	*% coverage*	*Number served*	*Number unserved*	*Population*	*% coverage*	*Number served*	*Number unserved*
Africa												
Urban water	119.77	83	99.41	20.36	202.54	87	176.21	26.33	332.49	76	253.01	79.48
Rural water	332.83	33	109.83	223.00	409.64	42	172.05	237.59	496.59	47	234.27	262.32
Urban sanitation	119.77	65	77.85	41.92	202.54	79	160.01	42.53	332.49	73	242.17	90.32
Rural sanitation	332.83	18	59.91	272.92	409.64	26	106.51	303.13	496.59	31	153.11	343.48
Latin America and the Caribbean												
Urban water	236.72	82	194.11	42.61	324.08	87	281.95	42.13	416.79	89	369.79	47.00
Rural water	124.91	47	58.71	66.20	123.87	62	76.80	47.07	122.84	77	94.89	27.95
Urban sanitation	236.72	78	184.64	52.08	324.08	79	256.02	68.06	416.79	79	327.40	89.39
Rural sanitation	124.91	22	27.48	97.43	123.87	37	45.83	78.04	122.84	52	64.18	58.66
Asia and the Pacific												
Urban water	549.44	73	401.09	148.35	761.18	77	586.11	175.07	1085.56	71	771.71	314.43
Rural water	1823.30	28	510.52	1312.78	2099.40	67	1406.60	692.80	2320.79	99	2302.68	10.11
Urban sanitation	549.44	65	357.14	192.30	761.18	65	494.77	266.41	1085.56	58	632.40	453.16
Rural sanitation	1823.30	42	765.79	1057.51	2099.40	54	1133.68	965.72	2320.79	65	1501.57	819.22
Western Asia												
Urban water	27.54	95	26.16	1.38	44.42	100	44.25	0.17	67.26	100	67.26	0.00
Rural water	21.95	51	11.19	10.76	25.60	56	14.34	11.26	30.66	57	17.48	13.18
Urban sanitation	27.54	79	21.76	5.78	44.42	100	44.42	0.00	67.26	100	67.26	0.00
Rural sanitation	21.95	34	7.46	14.49	25.60	34	8.70	16.90	30.66	32	9.94	20.72
Global totals												
Urban water	933.47	77	720.77	212.70	1332.22	82	1088.52	243.70	1902.10	77	1456.27	445.83
Rural water	2302.99	30	690.25	1612.74	2658.51	63	1669.79	988.72	2970.88	89	2649.33	321.55
Urban sanitation	933.47	69	641.39	292.08	1332.22	72	955.22	377.00	1902.10	67	1269.05	633.05
Rural sanitation	2302.99	37	860.64	1442.35	2658.51	49	1294.72	1363.79	2970.88	58	1728.80	1242.88

Source: Reproduced from Christmas, J. and C. de Rooy. 1991. "The Decade and Beyond: At a Glance." *Water International*, 16(3), p. 129.



Source: Based upon Table 2

Figure VII. Urban water supply coverage in developing countries by region, 1980-1990



Source: Based upon Table 2

Figure VIII. Urban sanitation coverage in developing countries by region, 1980-1990

overwhelmingly rural rather than urban one, if one is to judge the magnitude of the problem by the number of people affected. While there is no doubt that undue priority has been given in the past to urban areas, the urban fringe where the majority of urban poor have settled in slums and shanty towns has been largely overlooked. Moreover, by the year 2000, the number of urban households living in absolute poverty is projected to increase by 76 per cent to 72 million, whereas that of the poor rural households is expected to fall by 29 per cent to 56 million (United Nations Development Programme (UNDP), 1990). As already pointed out earlier, limited information available indicates most urban infrastructure investments are directed to the well-off neighbourhoods and that residents in urban slums may have a lower level of services than their rural counterparts, who often have at least the choice of using alternative sources of water (World Bank, 1988; UNCHS, 1987).

It is by now clear that the Decade's primary goal of full access to water supply and sanitation had not been achieved by the target year of 1990. However, the Decade's experience cannot be summarized in just numbers. Despite the inability to extend 100 per cent coverage, it has succeeded in crystallizing a growing awareness of the seriousness of the health problems associated with inadequate water supply and sanitation facilities. Moreover, the Decade's activities have led to concerted efforts in establishing international collaboration concerning water supply and sanitation services and in accelerating the growing attention on the sector's institutional and sociological aspects. Furthermore, research and development work undertaken during the Decade has resulted in developing and introducing new, low-cost technologies, and in focusing attention on the user communities as active participants in the developmental process rather than merely passive recipients (Christmas and de Rooy, 1991; Grover and Howarth, 1991; Najlis and Edwards, 1991; Okun, 1991; Warner and Laugeri, 1991).

The accumulation of small events over the course of the Decade has produced a substantially new approach that has far more significance than the accumulated statistics. The approach being taken contains a new thrust which has been shaped by past evaluations of water and sanitation projects in developing countries and is directing attention to the following issues: the mobilization of communities to manage their programmes, including increased involvement of women and development of cost recovery mechanisms for sustainable, effectively used services; the development and utilization of affordable appropriate technologies, including the development of appropriate delivery, and operation and maintenance systems; the continuing need for international coordination regarding sector inputs, particularly with regard to capacity building and human resources development. In short, whereas the objectives were technology-oriented and defined in terms of "coverage" at the beginning of the Decade, the emerging approach goes beyond coverage to emphasize the "human factor" as central to achieving "sustainable, effectively used services" (Melchior-Tellier, 1991).

3. What have we learned?

(a) Technology alone is not enough

One major realization from the experience of numerous projects and programmes implemented during

the International Decade is that technology alone is not enough. Far too much emphasis was given to the construction of new facilities by national and international agencies at the expense of developing appropriate provisions for the proper operation and maintenance of existing and new installations (Warner and Laugeri, 1991). Particularly little attention was given to the institutional aspects associated with the implementation of such functions (Najlis and Edwards, 1991).

An excellent example of the serious consequences of inadequate operation and maintenance is the large volume of unaccounted-for-water in many urban centres in developing countries. In many cities in developing countries, around 50 per cent of the water that is treated and distributed at public expense is not accounted for by sales (table 3). There is no record of it having been delivered to consumers and it does not earn revenue for the water supply authorities. Often just 20 per cent of the leaks account for 80 per cent of leakage (Secretariat for the Global Consultation, 1990). World Bank research suggests that, as a rule, if more than 25 per cent of the treated water is not accounted for, a programme to control the losses may prove to be cost-effective (*Urban Edge, 1986*). Implementing a formal control policy to reduce both physical losses (through leakage detection and repair) and non-physical losses (through improved management practices) typically costs US$ 5-10 per capita. Studies have shown that savings and increased revenue will repay this cost within one or two years (Richardson, 1988). Investment to improve the performance of existing assets is thus highly cost-effective.

Table 3. Unaccounted-for-water in municipal water supply systems in developing countries

	Proportion of unaccounted-for-water to total water supply (in per cent)	*Year*
Philippines, Manila	55-65	1984
Indonesia, Jakarta	50	1976
Thailand, Bangkok	32	1990
India, Bombay	30	1988
Singapore	8	1992

Sources: Manila: Richardson, J. 1988. "Non-revenue Water-a Lost Cause?" *The Proceedings of the 14th WEDC Conference*, p.147. Jakarta: Mahta, R.S. 1982. "Problems of Shelter, Water Supply and Sanitation in Large Urban Areas" in the United Nations Environment Programme (UNEP), *Environment and Development in Asia and the Pacific*, p.242. Bangkok: Sethaputra, S. and others, 1990. *Water Shortages: Managing Demand to Expand Supply*. Bangkok: Thailand Development Research Institute, December, p. 97. Bombay: Bhattacharya, 1988. "Problems of Water Supply in Congested City Areas--Calcutta, A Case Study." in John Pickford, editor, *Developing World Water*, Hong Kong: Grosvenor Press International, p. 58. Singapore: World Bank. 1992 World Bank. 1992. *World Development Report 1992*, p. 109.

Reduction in unaccounted-for-water can allow investments in new works to be deferred or at least reduced in scope, with significant savings. In addition, by improving the system of meter reading and billing or by detecting and charging for illegal connections, revenue can be greatly increased to pay for the costs of treating and distributing the water, as well as the costs of operation and maintenance of the system. Also, if illegal connections are found and charged, willingness to pay by all may improve. For example, in urban areas in Thailand, each 10 per cent of unaccounted-for-water saved would immediately generate an additional US$ 8 million per annum from the 3.5 million people served (Richardson, 1988).

Furthermore, where the distribution systems are corroded and broken, appreciable increases in supply do not reach the consumers but result in higher leakage losses. That is, implementation of augmentation projects without controlling leakages could become counter-productive (Kumar and Abhyankar, 1988). Passive control of water loss such as repairing leaks only when they are noticed is inadequate. Active control measures are needed such as zone metering to monitor for suspected leaks and systematic leakage detection. Leakage from newly constructed systems, which can be as significant as that of old piping networks, can be minimized through careful review of design, materials and construction standards and tightened monitoring over construction (*Urban Edge, 1986*).

Minimizing leakage alone is not enough, however. Non-physical losses can account for a quarter (Bangkok) to one half (Manila) of unaccounted-for-water and they can be reduced at less cost than leakage (Richardson, 1988). Major strategies for controlling non-physical losses include: the installation, prompt servicing, and recalibration of meters; the updating and reviewing of consumer records to establish a sound basis for estimating consumption when meters are unserviceable; and the streamlining of bureaucratic procedures to make it easier for customers to make new legal connections to reduce the "theft" of water (Richardson, 1988).

Although these strategies and measures are common-sense, well-intentioned efforts to reduce high levels of unaccounted-for-water, they have met with little success, indicating the difficulty of solving this seemingly simple problem in the developing countries. This also reflects the tension between the apparent need for investment in system expansion and the requirements for routine repair and maintenance of the existing system. Whereas new investment in system expansion usually receives enthusiastic support from managers, engineers, and politicians, routine repair and maintenance work is somehow always accorded a low priority. This highlights

the fact that high rates of unaccounted-for-water are linked not only to technical problems, but to broader managerial, organizational, and social issues that must also be taken into consideration in designing efficient water supply systems.

(b) Appropriate technology maximizes the value of investments

The availability and quality of urban water supply and sanitation services depend to a great extent on the standards of physical infrastructure systems such as water piping and sewer networks. In many developing countries, there is a tendency to insist on standards higher than necessary, sometimes doubling the cost of service delivery. The result is poor access to water supply and sanitation services (UNEP, 1982; Ridgley, 1989; Gakenheimer and Brando, 1987). Per capita unit costs of providing services have generally continued to increase despite the development of less expensive technologies (table 4). Only a drastic revision of design standards to sharply reduce construction costs is likely to offer hope of providing even minimal levels of public water services to extensive low income urban neighbourhoods.

Table 4. Per Capita unit costs (median) of construction of water supply and sanitation systems in the Asian-Pacific region

Unit: US$(in current dollars)

	Urban water supply				*Urban sanitation*			
	Home connections		*Standposts*		*Sewer connections*		*Individual household systems*	
	1980	*1985*	*1980*	*1985*	*1980*	*1985*	*1980*	*1985*
South-East Asia	55	60	–	35	63	81	15	20
Western Pacific	80	96	20	42	220	444	50	73

– Not available.

Source: World Health Organization. 1987. *The International Drinking Water Supply and Sanitation Decade, 1981-1990.*

With few exceptions the technologies currently in use in developing countries are the same as those employed in the developed countries: piped water, full internal plumbing, and conventional water-borne sewerage (Ridgley, 1989). Services tend to be provided to those sectors of the population with developed country incomes. Even here there are problems because these systems require expensive equipment and materials, often imported, and trained manpower to operate them, neither of which is easily available in the resource-poor developing world.

A full-scale attack on urban sanitation problems in developing countries would require huge increases in investment only if governments insist upon adopting water-borne sewerage which is the conventional form of urban sanitation. However, conventional sewerage is inappropriate for use in low-income communities because of its high costs which are in turn the result of the use of inappropriate construction standards (Pickford, 1990; Taylor, 1990). World Bank research has demonstrated that a wide range of household and community systems could greatly improve the sanitation conditions at affordable costs to the urban poor (Sinnatamby, 1990). The key to move forward is to give people choices. This means switching from a supply-driven mentality to a demand-driven approach in which households, particularly the poor, are offered a menu of levels of services with associated price tags (Briscoe, 1992).

The solutions involve low-cost, locally manufactured hardware (plumbing, sanitary sheds, concrete caps for pit latrines) that can be installed using labour-intensive techniques. The central technologies range from improved ventilated pit latrines to simple modifications of standard sewerage designs that reduce diameters, excavation, inspection chambers, and other standard specifications (Campbell, 1989). The total annual cost per household of several of these options is only one-tenth to one-twentieth that of the conventional sewerage systems. Most demand far less water to allow for their efficient operations, and it is possible to install one of the lowest cost systems initially and then upgrade it gradually (Hardoy and Satterthwaite, 1989).

Estimates indicate that the current distribution of sector investments in developing countries to high-cost and low-cost technology is in the order of 80 per cent and 20 per cent, respectively (Christmas and de Rooy, 1991; Kalbermatten, 1991). This essentially means that 70-80 per cent of funds go to serve 20-30 per cent of the population, mostly the higher income groups. Experience gathered from Decade programmes, however, informs us that measures designed to make more effective use of existing resources play an important role in maximizing the impact of investments. Considerable progress has been made in the development of low-cost appropriate technologies with increased operational reliability. The major problem of the Decade, one which will remain for years to come, is to extend low-cost appropriate technologies to low-income communities hitherto unserved.

Conventional wisdom suggests that aid-giving agencies and consultants from developed countries encourage the use of costly imported equipment and materials which are produced in their lands of origin. Gakenheimer and Brando (1987) argue, however, that there are strong influences within the developing countries themselves – an "unintentional conspiracy" – that insist on unnecessarily high standards. These

include: engineers who are most familiar with modern solutions, government agencies who pursue failure-proof and maintenance-free construction, and politicians who wish to avoid being accused of "demodernizing" services. Taken together, these actions and inactions result in an unfortunate tendency toward high and unrealistic standards.

Appropriate technologies, and the methods of selecting them, are therefore more institutional than technological. Because the tension between financial constraint and the adoption of high cost infrastructure is caused by numerous actors with different motivations, an overall restructuring of the major institutional relationships may be necessary to yield an effective solution. One of the future challenges for research in the sector is to delineate specific incentive programmes that could be effectively implemented in different cities in the developing world to make feasible such a rearrangement.

(c) Innovative cost recovery programmes are essential to sustainable water and sanitation projects

The problem of cost recovery is to some extent linked to the difficulty in attracting skilled staff because it is cost recovery that makes it possible to pay salaries which attract and retain trained personnel from a secure revenue base. Therefore, in many ways, the key to improving the performance of urban water supply and sanitation services over the short- and medium-term lies in the ability of these public utilities to recover an increasing percentage of the cost of providing services from their customers. Nonetheless, of the 26 countries included in a 1990 United Nations regional assessment of progress on water management issues in Asia and the Pacific, only nine countries were found to have achieved full cost recovery in water supply operations (Lee, 1992). The most recent data from WHO indicate that with the exception of Singapore and the Philippines, the average water tariffs in countries in the region do not cover the average operating costs of water production (table 5).

At the beginning of the Decade in 1981, cost recovery issues were given little attention. Then, by 1985, "an inadequate cost recovery framework" was cited by WHO as the second most serious constraint facing the Decade (WHO, 1987). By the late 1980s, many ESAs and governments in developing countries had reconsidered their cost recovery policies and had started looking seriously for means of implementing cost recovery programmes (Franceys, 1990; Katko, 1990). By now the question is no longer whether to charge but how much (Melchior-Tellier, 1991). The debate is taking shape over whether water supply tariffs should cover only operation and maintenance costs or whether they should also generate resources for future investment. A closely related conflict is arising between the increasing demand for sector financial viability through full cost recovery and the long-standing commitment by most urban governments to provide subsidized services to their constituencies (Warner and Laugeri, 1991). So far very little attention has been paid to cost recovery from sewerage services.

Table 5. Unit costs of water production (operation only) and water tariffs in the Asian-Pacific region, circa 1985

Country	*Average cost of water production (US$/m³)*	*Average water tariff (US$/m³)*
India	0.08	0.05
Bangladesh	0.09	0.08
Thailand	0.21	0.21
Burma	0.25	0.20
Nepal	0.09	0.07
Sri Lanka	0.25	0.20
China	0.02	0.03
Philippines	0.05	0.15
Republic of Korea	0.19	---
Papua New Guinea	0.55	0.55
Singapore	0.24	0.29
Afghanistan	0.30	0.15
Samoa	0.09	0.03

--- Not available

Source: World Health Organization. 1987. *The International Drinking Water Supply and Sanitation Decade, 1981-1990.*

In most developing countries, the conventional wisdom is that the poverty of the vast majority of the citizens may make cost recovery very difficult. In Bombay, for example, the provision of water is still viewed as a social service and water was distributed free to nearly all categories of users until January 1986, when water fees were introduced as the insistence of the World Bank for relatively affluent domestic consumers. As a result, out of nearly 150,000 households with water connections, only about 35,000 (23 per cent) pay water fees (Bhattacharya, 1988).

Yet the supposition that the poor in developing countries cannot afford or will not pay for water services is belied by the widespread practice of water vending at market prices, indicating a high level of affordability and willingness to pay for water by the poor. Although water vending is an old tradition all over the world, little attention has been paid to it in studies of water supply. Recent studies show that, in the absence of access to a public water supply system, people spend substantial amounts of money on vended water (Katko, 1990; Okun, 1988). The evidence clearly shows that service from water vendors costs substantially more than is paid by customers served by a piped water system in the same

area (table 6). The poor may pay as much as 30 per cent of their income for water whereas the well-to-do pay less than 2 per cent (Okun, 1988). Supplying free or almost free water therefore often produces very inequitable results where only the better-off consumers with house connections reap the benefits.

Table 6. Prices charged by water vendors, mid-1970s-1980s

	Multiples of price charged by public water utility
Pakistan, Karachi	28-83
Indonesia, Surabaya	20-60
Bangladesh, Dacca	12-15
Turkey, Istanbul	10

Source: World Resources Institute. 1990. *World Resources 1990-1991.* New York: Oxford University Press, p. 77.

Instances accumulated over the Decade indicate that the success of a revenue recovery programme depends to a great extent on how the revenue is collected. Very often, the major barrier to securing financial involvement of low-income groups lies not with their absolute inability to contribute but with the lack of innovative cost recovery programmes (Najlis and Edwards, 1991). There is an understandable reluctance of many low-income people in developing countries to pay money to a government department which they suspect of corruption or in which they have little or no confidence. With increasing demand to increase the rate of cost recovery, there is a greater need to understand not only how much the user is willing to pay for service but also, from the user's perspective, how the money is to be collected and managed (McGarry, 1987). The need to implement cost recovery programmes thus leads to a fundamental, but as yet unanswered, question: What roles should each party in urban water supply development and planning play? The major actors are the central government, the municipal administration, the water agencies, the consumers (household and institutional), and the private supply sector.

(d) Community management is key to successful overall system performance

The first half of the Decade was marked by the development of new, low-cost, technologies appropriate to the needs of the developing countries. Yet both the urban and rural landscapes of the developing world are littered with inoperative pumps that may have been well conceived at the office of a donor agency and a country ministry but have fallen into disrepair because of the lack of commitment and participation of the local populations who were purportedly the beneficiaries of such projects (Okun, 1988). The need now is not so much for further technological innovation, but for the rethinking of the institutional framework to draw forth improved performance through alternative approaches to management and maintenance. For the full benefits of water supply and sanitation to be realized, more is required than the installation of the structures, pumps, and pipes.

One major reason for failure in water supply and sanitation projects has been that in the minds of international and national planners in this sector, health improvements were the greatest, if not the only, benefits of water supply and sanitation. But the population receiving these services, whether rural villagers or urban squatters, have additional concerns. For them, the reduction in labour spent in collecting water, the prestige of having water in or near the home, or privacy and comfort of a water closet, could be the primary reasons in demanding improvements in water supply and sanitation. Improved health is often a distant third or fourth priority for many users (McGarry, 1987). Well-meaning low-tech alternatives such as ventilated improved pit (VIP) latrines are unlikely to be accepted, for example, because they brand the recipient as socially inferior or their design does not provide a certain minimum degree of privacy for women. The success of introducing appropriate technologies requires a thorough understanding of the perceived needs of the user communities. In particular, the participation of women, who are the major system users, in the design, construction, and sustained effective use and management of projects has been increasingly recognized as critical to the success of sector initiatives (Ellis, 1990; Najlis and Edwards, 1991).

Benefits of community/user participation in all stages of water supply and sanitation projects could include lower costs, greater likelihood of acceptance of technology, and greater user maintenance of the facilities. Studies have shown that those projects with strong community input are the most successful in terms of reaching the greatest number of the poor with long-lasting services (McGarry, 1987).

Reorienting project design and implementation methods to incorporate meaningful users' participation is not an easy task, however. Twenty years ago, "community development" was used to refer simply to the generation of local contributions. At the beginning of the Decade, the emphasis had shifted to the concept of "community participation," which calls for varying degrees of local involvement (Melchior-Tellier, 1991). Current terminology now centres around "community management," which "goes beyond simple participation. It aims to empower and equip communities to control their own systems" (Warner and Laugeri, 1991). It thus requires substantial structural and attitudinal changes within the implementing agencies.

Community-based management on a large scale will require not only new approaches but an array of community-oriented professionals trained and committed to implement them. Where will they come from? How is this new cadre of human resources to be created? Where will they get their experience, especially in countries which have few or no community-based development projects? There are several major possibilities to address this critical need, none of which involves hiring new staff: train the existing extension workers in participatory techniques; identify and link with other government agencies that have a stronger field presence and whose extension workers have community-level experience; and identify and link with non-governmental organizations (NGOs) that have grassroots experience (Melchior-Tellier, 1992).

There are a number of community-based, and to a large extent NGO-driven, programmes succeeding at the full-project levels. However, the methodologies tend to be very site specific. Moreover, the major parameters that need to be in place to enable low-income communities to improve their own environment are only now becoming known and a major effort in documenting and disseminating the wide variety of community experiences is urgently required. One major question is how these experiences and methodologies can be best adapted and transferred to other situations in a way that they can be scaled up in rapidly expanded programmes. This is particularly important with respect to the role of NGOs. Most countries have literally thousands of NGOs with unparalleled experience in community participation. They are potentially very helpful, particularly in developing methodologies at the pilot or test level, but most of them do not have the capacity for large-scale action at the subnational and national levels.

An introduction of a community-based approach at a large scale will point immediately to the tension between the bias of many managers and administrators to adhere to conventional municipal systems in urban centres and the need to design and implement innovative, decentralized, low-cost communal systems for low-income settlements. Research is clearly needed to help address the question of how to motivate the centralized urban water and sanitation agencies to undertake effective outreach measures to attend to low-income communities where the needs for their services are the most acute but largely unmet.

4. Access to land and the urban poor

Many governments have narrowly viewed the problem of providing clean water and basic sanitation services to the urban poor as infrastructure questions rather than as land or locational ones. In the cities of almost all the developing countries in the region, one of the major problems underlying the crowding of the urban poor into unsanitary conditions is limited access to land. Urban land markets, which have been created in most Asian countries through legalization of rights to private property and the commodification of land over the past century, are vastly more competitive and much more subject to speculative investments than in the rural areas, and are invariably too expensive for most low-income households to enter (Douglass, 1992). The formation of slums and squatter settlements and the environmental problems found in them are not due to the low income levels of the urban poor alone. They are also closely linked to the lack of access to suitable land as well as the lack of incentives to invest in community infrastructure due to the insecurity of land tenure.

First, the urban poor usually occupy land that is unsuitable to settle: on steep hillsides, in flood-prone areas, near factories and garbage dumps. The lack of access to an adequate supply of land often limits the scale of provision of infrastructure. The components in a good physical environment require physical space for their installation: neither piped-water systems nor latrines can be provided without land being made available. The cleaning of drains and the collection of garbage is greatly facilitated if pathways have been built.

Second, because much of the land occupied by the urban poor is deemed by governments to be illegally captured, such settlements are characterized by high levels of insecurity of tenure. The lack of secure tenure in turn has led to low levels of investment by the community in neighbourhood infrastructure outside of the household itself. Illegality also leads to the denial of infrastructure and other basic services needed to improve the living conditions. Governments are often reluctant to provide these services lest such assistance should be taken as *de facto* legitimization of squatter areas.

With few exceptions, most developing country governments have largely avoided formulating any urban land policy aimed at increasing the access of low-income households to land. Given that the overall task of extending urban water supply and sanitation services is going to be exacerbated by the shift of the burden of poverty from rural areas to the urban centres as major population movements to cities in the developing countries continue in the coming years, it is important that the fundamental question of access to basic household assets such as urban land be reinstated at the top of the agenda of national governments.

Government actions are needed to greatly increase the supply and reduce the cost of all the components of a livable habitat, including land sites that are within easy reach of employment opportunities for the poor. Governments can also adopt urban land reform policies and programmes that provide encouragement to the poor to invest in their own neighbourhoods and communities. Such policies and programmes include land inheritance and transfer laws to counter trends toward land accumulation by large land holding families through generations; limits on the size of land holdings; land banking and land-pooling schemes that allow the state to increase its pool of land to exchange for low-cost housing sites in the city; land readjustment projects that include low-cost land and housing sites; land sharing schemes and, of course, tenancy reforms establishing clear rights of tenants (Douglass, 1992).

5. What might be accomplished?

The Decade has made tremendous gain in extending water and sanitation services to more than 1.3 billion people, but roughly one person in three in developing countries still did not have a reliable supply of safe drinking water in 1990. And about 44 per cent of the population lacked access to sanitation. United Nations estimates indicate that population in these countries will increase by almost 900 million in the 1990s (table 7). That is, by the year 2000, combining those who are not yet served and the expected population increase in the coming decade, more than two billion additional persons will require sector services.

Recent estimates conducted by the United Nations Children's Fund in consultation with the World Bank and UNDP indicate that if sector services were to be provided to 90 per cent of the population in developing countries, "the average annual level of investment required for new services alone, excluding operation and maintenance and rehabilitation costs, would need to be nearly three times higher than the average achieved during the 1980s" (Najlis and Edwards, 1991). This formidable task is then compounded by the challenge of sustaining existing facilities which require substantial maintenance and repair expenses as well as the prospect of rising per capita cost of water provision and its environmentally safe collection and disposal (Grover and Howarth, 1991; McGarry, 1991).

Table 7. Developing country needs for sector services, 1990-2000

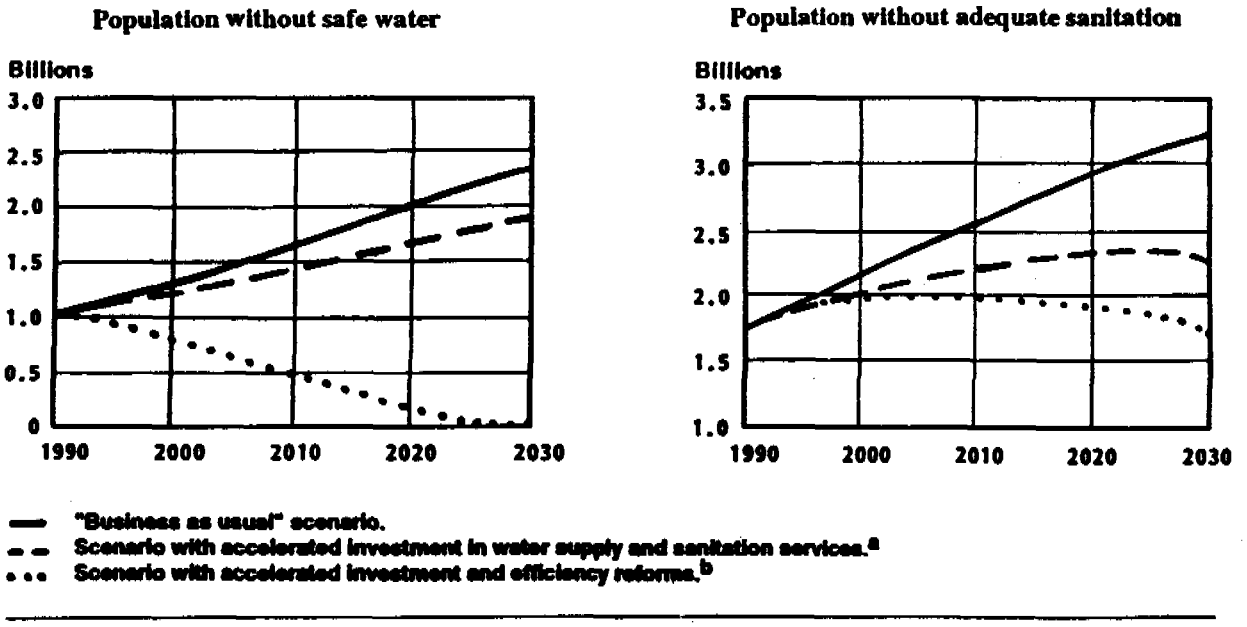
	Population Not Served in 1990	*Expected Population Increase 1990-2000*	*Total Additional Population Requiring Service by 2000*
		(in millions)	
Water Supply			
Urban	243	570	813
Rural	989	312	1,301
Total	1,232	882	2,114
Sanitation			
Urban	377	570	947
Rural	1,364	312	1,676
Total	1,741	882	2,623

Source: Report A/45/327 of the Secretary-General of the Economic and Social Council to the United Nations General Assembly, July 1990.

Although one might expect the level of sector assistance from ESAs would increase in the coming decade, the ESAs collectively have provided only a small portion of the roughly US$ 10 billion invested annually in the sector and will in all likelihood finance a declining share of overall future investments (Grover and Howarth, 1991). The common outlook for the sector is that the bulk of resources for future initiatives will have to be generated within the developing countries themselves, but it is doubtful even under optimistic assumptions about economic growth that the share of national development financing in many developing countries allocated to water supply and sanitation could be dramatically increased (Najlis and Edwards, 1991).

World Bank estimates (World Bank, 1992) suggest that an "unchanged practices" or "business as usual" approach on the part of governments in the developing countries would lead to an increase in the number of unserved in the coming decades (the top curves in figure IX). This is a result of rising unit costs, as well as unprecedented increases in population. If the shares of investment allocated to sanitation (currently 0.6 per cent of gross investment) and to water supply (currently 1.7 per cent) were raised by, say, 50 and 30 per cent, respectively, the numbers unserved might still increase, although not as much (the middle curves in figure IX). The most effective and important approach is the combination of policy reforms and accelerated investment. This new approach, already in practice in some countries, could lead to substantial gain in the number of population served (as shown by the bottom curves).

In conclusion, given that the proportion of unserved population will remain sizable by the end of the century, public financing of water and sanitation sector activities will continue to be limited, and the per capita cost of provision of conventional sector facilities will rise dramatically, the major challenge facing governments in the coming years is to develop appropriate institutional mechanisms in urban centres in developing countries whereby municipal and local resources could be mobilized



a. Investment in water supply increases 30 per cent, and investment in sanitation services increases 50 per cent over the period.

b. To realize this scenario in low-income countries, efficiency reforms – and the resulting increase in investment shares – would need to be greater than average.

Source: Reproduced from the *World Development Report, 1992* World Bank, Washington, D.C., 1992, p. 112.

Figure IX. Safe water and adequate sanitation: three scenarios, 1990-2030

and utilized in a sustainable, efficient and equitable fashion. The principal courses of actions to approach the sector's future will have to include increasing attention to efficient operation and maintenance of existing systems, further development and installation of appropriate and low-cost alternative technologies, development of innovative cost-recovery programmes, and reorienting project design and implementation methods to support meaningful community management. Major government actions are also needed to address one of the fundamental constraints – access to land by the urban poor – that greatly limits the extent of self-help schemes in basic infrastructure provision.

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D. ENVIRONMENTAL IMPACTS OF URBAN WATER MANAGEMENT*

Introduction

In the context of supply of natural resources, there is a characteristic common to all urban regions which relates directly to supply and demand. The land and resource base required to support an urban region is usually at least one order of magnitude larger than that contained within its administrative boundaries, or even within its associated built-up area (Rees, 1992).

This relationship may be established by consideration of the concept of carrying capacity, which for a particular area is defined as " the population of a given species that can be supported indefinitely in a defined habitat without permanently damaging the ecosystem upon which it is dependent " (ibid). For the human species, carrying capacity can be described as the maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a defined area without progressively impairing the functional integrity and productivity of the ecosystems essential for its permanent maintenance.

There are many reasons to believe that the environment frequently is overburdened by human development efforts. Thus, there is a need for environmental management, namely, a conscious and informed effort by people and agencies to maintain and sustain the carrying capacity of any given physical area.

1. The role of the city in a growing economy

Cities have become an important driving force for economic growth and development. They stimulate and support economic output, investment, and income and provide a wide range of employment opportunities to a growing workforce. However, as cities grow, diseconomies may become significant e.g. congestion of the urban area and deterioration of environmental systems and of natural resources, in the city itself and in its hinterland.

As sustainable economic growth and development widely depends on healthy, growing cities, sound urban environmental management is vital to sustainable development. Thus, the goals of urban governance should be to protect the environment and maintain adequate levels of urban environmental quality to prevent diseconomies and to conserve the resources necessary for sustained development.

The environmental problems associated with urbanization encompass three types of environmental degradation: critical urban spillovers, loss or destruction of resources, and environmental hazards. Although the extent of these problems in specific cities will differ according to the unique conditions in each region, the following summarizes the critical environmental challenges confronting most developing countries (Bartone, Bernstein and Lettman, 1992):

(a) Critical urban spillovers include pollution from urban wastes and urban transportation externalities. Pollution from urban wastes encompasses inadequate basic sanitation and hygiene, domestic sewage, industrial wastewater, stormwater run-off, municipal and industrial solid waste, ambient air pollution, and indoor air pollution.

(b) There are regional environmental problems that are linked to the overuse and degradation of natural resources and systems. This includes water resource problems, land degradation, urban energy issues, and loss of natural as well as cultural heritage.

(c) Many urban regions are increasingly vulnerable to both man-made and natural hazards. When such events occur in or near densely populated areas, they may constitute major environmental disasters in terms of human suffering and economic losses.

The regional ecosystem in which a city is located is often a critical determinant of the severity of environmental conditions within and around cities as well as the complexity of potential intervention strategies. Further, certain natural features of an urban area such as topology, elevation, atmospheric stability, altitude, and temperature are key determinants of how the regional ecosystem will respond to environmental pollution (ibid.).

* This paper was prepared by Peder Hjorth, Asian Institute of Technology, Bangkok, at the request of the ESCAP secretariat.

The focus of this paper is on the impacts of current urban water management practices on the urban environment itself and on the carrying capacity of the drainage basin in which the city is located. Basically, the paper aims at pointing out some problem areas where an increased awareness is needed in policy making and decision making on various water functions and phenomena in urban areas.

2. The city and its environs

The unmanaged environment cannot receive society's unregulated wastes indefinitely without serious harm. We must develop better means of reducing the environmental impact of a highly technological urban society without causing a major social displacement (Cairns, 1980), or as Whipple (1978) put it:

> "In order for water supply not to be a limiting factor in urban revitalization and growth, or, in order for such growth to occur without seriously damaging essential hydrologic systems, we must reformulate the premises on which urban policy rests."

A basic idea is that many problems related to natural resources can be seen as communication problems. The contemporary society depends heavily on specialization and concentration of people and activities. To this end, sophisticated communication networks and logistics have been developed. In the natural ecosystems, however, there have been no corresponding developments. Therefore, man has had to develop systems that transport resources to places where they would not normally occur. This, in turn, means that the resources do not appear in places or in quantities that they used to. The affected ecosystems suffer from this change in the course of events (Hjorth, 1992).

For the discussion of the impacts of urban water management, the drainage basin is a fundamental concept. The basin, together with the precipitation pattern of the area, uniquely determines the water potential of the area in which a city is located. How much of that potential that can be brought to serve the common good of the basin and its inhabitants depends largely on the land use and the water consumption practices in the basin.

At this point it may be argued that a groundwater aquifer may be common to two or more drainage basins or, that there are many examples of man-made interbasin transfers. The groundwater case offers an opportunity for human interaction to divert to one of the basins more water than would naturally flow in that basin. The surface water interbasin transfer constitutes a *de facto* human intervention in the natural flow of events. However, such interventions preserve the cause-effect relationship and only affect the location of the associated environmental impacts. Thus we may take the drainage basin as the geographical basis for the subsequent discussion.

Cities act like focal points to which flows of rural resources are concentrated. In return for the rural contribution, cities provide rural areas with other resources needed for rural life and production. However, the massive flow of resources also generates a massive production of waste in the cities. This waste has to be exported from the city areas to be harboured and recycled in the rural area.

If cities draw on too much rural input, the rural environment will suffer from environmental degradation due to the resource deficiencies incurred. If the city forces too much waste on the rural environment, the latter will again suffer. If cities are unable to rid themselves rapidly enough of the waste produced, there will be a build-up of waste, which will have serious impacts on the urban environmental quality.

In the present era of extensive global transportation networks, the input needed by a city may come from all over the Globe. However, air and water would be too costly to transport. Thus, for these resources, the city is wholly dependent on what is naturally available in the region. Even the long-distance input to a city contributes to waste production. However, with very few exceptions, it is not deemed economically feasible to transport the associated waste back to the region from which the input originated. Thus, even this waste has to be absorbed by the regional environment.

3. The changing drainage basin

This far, the discussion points at two essential facts to be considered in the environmental management related to urban water supply and sanitation:

(a) It must be secured that the drainage basin is clean enough to secure the kind of water supply necessary for, as well the urban as the rural activities.

(b) The waste loading on the drainage basin must be confined to what the area can provide in terms of air, land, or water resources capable of decomposition and regeneration of the effluent and waste.

In developing countries, large-scale industrial development near rivers and bays is seriously threatening living aquatic resources. Untreated domestic and

industrial sewage reduce the oxygen supply killing fish and contaminating shellfish – an important source of food for residents of many cities.

Rapid industrialization and population growth on ecologically fragile land also creates serious physical problems. For example, the Valley of Mexico, in which Mexico City is located has undergone serious adverse transformations as the result of industrialization and overdevelopment. The valley has lost almost all of its lakes, which have turned into large salt basins (Schteingart, 1989).

In Arizona, the United States of America, the Arizona Water Commission, in its Sixth Annual Report for 1975-1976, described some of the assumptions underlying its planning. The Commission indicated that:

> "in projecting future levels of development of each of these activities, it was assumed that non-agricultural uses of water would generally grow without being constrained by lack of water supply. This assumption recognized that these uses have an economic advantage over agriculture, when it comes to the amount that can be paid for an acre-foot of water, and if necessary, can buy out farmland solely for the purpose of obtaining a water supply".

Welch (1985) cites a 1971 study by the Arizona Department of Planning and Economic Development which suggests that, if all water use in the state was diverted to municipal and industrial purposes, the state could support a population of 20 million. Of course, such a diversion would bring to an end the present rural lifestyle, the communities that depend on agriculture, and would also totally neglect values of water that are non-economic (e.g. the importance of water in particular cultural contexts).

4. Impacts in upstream areas

When surface water is developed for municipal water supply, this is frequently associated with the construction of a dam. The environmental consequences of a dam are, *inter alia*, flooding of farmland, forests, and/or land of specific cultural or natural value. Dams further change the aquatic environment from riverine to lakustrine, meaning that the flora and fauna in the reservoir will be quite different from what originally was present in the river stretch dammed. The annual water level fluctuations in reservoirs are frequently much larger than and out of phase with those in natural rivers and lakes. Consequently, the shoreline ecology is disrupted, leading to a change of the chemical characteristics of the shallow water zone and to a barren shoreline, the extent of which depends on the slope of the shore and on the amplitude of the water level fluctuation. The change from flowing to stagnant water may also provide formidable habitats for parasitic and water-borne diseases such as schistosomiasis, malaria, filariasis, and liver fluke.

A frequent measure to increase the inflow of water to the reservoir is to improve the drainage of the upstream reaches. This measure reduces the upstream wetland acreage and reduces the evaporation losses. There are examples from Europe and other places, that if well planned and well managed, reservoirs can become highly appreciated recreational assets (Schultz, 1991).

There are two ways that water may be transported to the city where it is supposed to be used; either in a man-made conduit or along a natural water course. In both cases, the downstream reach will be subject to a change in flow regime. In the first case, it is reasonable to expect a decrease of the low flow and an increase in the length of the period of low flow. In the second case, the low flow is normally increased to sustain the downstream municipal abstraction. The length of the low flow period will be extended considerably. In both cases, floods will tend to become less frequent, but there is a substantial risk that the severity of the floods will increase.

5. Deterioration of groundwater resources

If groundwater is used as a source for municipal water supply, this causes a lowering of the groundwater table, which apart from impacts on existing wells also may have significant ecological consequences. Some authors point out such circumstances as a possible cause of desertification processes. All over the world, ecologists are generally very interested in wetland management. In many cases, the control of groundwater hydraulics appears to be a necessary condition to protect and manage the surface ecosystems.

Other problems related to groundwater use include overexploitation, drop of groundwater table and water deficit as well as land subsidence and effects of changes of subsurface pressure distribution. In coastal areas, problems of saltwater intrusion are encountered (shifts in the underground saltwater/freshwater interface, intrusion due to groundwater use) (Herrmann, Hubert and Kobus, 1991).

The provision of potable water is a continuing problem in large parts of Australia. The drought/flood cycle is erratic and makes the farmer's life exceptionally difficult. In the cities, it makes the provision of potable

water an expensive business. Adelaide, South Australia is an interesting case in point. The capital of Australia's driest state gets some of its water from catchments in the Mount Lofty ranges east of the city, while farmers and market gardeners north of the city draw irrigation water from an aquifer on the coastal plain. Local water must be supplemented by water piped 100 km or more from the River Murray. In a dry year, this could amount to 90 per cent of the city's water supply, with every drop requiring treatment before it is potable (*Bangkok Post*, 26 January 1993).

6. Downstream effects

In the downstream areas, less water will be available for agricultural use, which means that farmland may have to be taken out of production or that the cropping pattern has to be changed.

There are a number of possible impacts on the downstream river reach itself. The ecology of a river strongly depends on the gradient of physical conditions. The flow of water, the transport of organic matter, and the energy fluxes are the driving forces of the ecosystem. Biotic communities which can be described by the producer and consumer communities reflect as a biological analogue of the hydraulic system and its way of using kinetic energy. As a consequence of this idea, a river system in dynamic equilibrium exhibits an adapted biological system without any succession processes in any given river reach (Nachtnebel, Saeijs and van der Zwardt, 1991).

7. Impacts on the urban environment

According to Chinese planners, the urban rivers and lakes can be classified into three categories on the basis of their function and quality: the first is the water source canals carrying water to the city. These require high water quality. The second category is the water bodies crossing the city which beautify the city environment. These water bodies can use low quality water. The third category is the rivers and canals downstream of the city which drain the sewage and transport the water for agricultural use. It is necessary to improve the water quality in these rivers and canals because of serious pollution at present (Hong and Ting, 1990).

In New Delhi, sanitation is an area of serious concern. The monsoons of Delhi are identified with outbreaks of gastroenteritis, typhoid, and infectious hepatitis, all of which are endemic to the city and threaten to take the form of epidemics from time to time. The problem of sanitation is not only confined to the urban poor living in the growing slum pockets but has become a challenge for the city as a whole. The need is not only to provide basic amenities like supply of safe drinking water, improved waste disposal systems, and latrines in the fast growing slums, but also to improve health education and awareness for the masses regarding sanitation and hygiene practices (Mahapatra. 1992).

The breakdown of services, due to the war of the past 15 years in Lebanon, resulted in epidemics of water-borne diseases amongst the population, especially in rural areas. A national survey conducted in 1990 revealed an average incidence rate of diarrhoeal diseases among children under five of 3.6 episodes per year. The survey also revealed contamination in 66 per cent of urban and 78 per cent of rural household water supplies (Latham, 1992).

8. Flood protection and drainage

Despite the billions of dollars devoted to flood control, the annual losses from floods in the United States of America seem to show little decline. This is not because the dams are totally ineffective, or because man in trying to control nature has been overpresumptuous. Flood losses are still high because the very modifications we make in natural systems encourage people to use land that was formerly seen as much too hazardous for the location of homes and factories (Abler, Adams and Gould, 1972).

Apart from the flooding problem, these developments create an increased drainage of the city and the surrounding land due to the man-made drainage systems, that are an integral part of urban development. In a study of the water budget of the city of Lund, Sweden, (Hogland and Niemczynowicz, 1979), it was found that the average inflow from surrounding land to the urban drainage system was 191 l/s. Thus, the urban development has caused a decline of the elevation of the groundwater table in the area.

The opposite problem may be studied in Riyadh, Saudi Arabia. Here, the urban growth has given rise to a daily water consumption of about 800,000 m^3. Of these 600,000 m^3 are transferred 400 from the Persian Gulf. After consumption, the water is led into the desert surrounding the city. As the permeability of the desert sand is rather low, the water stays in the area and as a result, the groundwater table is rising (Nilsson, 1988). The situation is becoming rather serious and the groundwater table has now reached the ground level of the lowest portions of the city.

9. The case of Hanoi

How an adverse environment and poorly-managed infrastructure can make city life unhealthy, is a point well-illustrated by the current situation in Hanoi (Nguyen, 1992).

The city is located in the Hong river delta about 100 km from the sea. The urban area is bordered by two main rivers, the Hong river to the north-east, and the Nhue river to the south-west. The mean water level in the Hong river varies between +2.18 m in the dry season to +10.8 m in the rainy season.

The topography of Hanoi is flat and low-lying. The elevation ranges from +11.0 m in the north-east to +4.0 m in the south-east with an average slope of 0.003.

Presently, the sole source of municipal water supply is a confined groundwater aquifer, the hydraulics of which are not very well known. According to the regular sampling undertaken by the Hanoi Water Supply Company, the raw water from some of the well-fields contains significant amounts of contamination such as ammonium, phosphate, and a high number of thermotolerant coliforms. The rising trend of such contamination indicates pollution of the source from wastewater and industrial effluent. For 25 per cent of the raw water, the water treatment is insufficient to make the treated water meet the required quality for potable water.

The Hong river has a considerable and dependable flow of water. Unfortunately, it also has a very high concentration of suspended sediment, which effectively rules out the river as a raw water source for Hanoi.

Due to leaks and bursts in the reticulation system, *inter alia*, due to land subsidence, only 25 per cent of the population served get water from pipes where the service pressure is maintained. In the remaining 75 per cent of the network, the inadequate pressure makes the water supplied highly susceptible to pollution.

In many areas, people have to scoop water from tanks in the street owing to the low pressure in the distribution pipes. Even in the central areas, people have been observed to wash dishes or clothes near such tanks, which further increases the pollution risks.

Owing to the flat topography and the low elevation relative to the Hong river, it is very difficult to provide adequate drainage. Sewers have to be installed with a very low hydraulic gradient. The low gradient leads to low flow velocities and, thus, to inadequate self-rinsing of the drainage pipes. Due to the unfavourable elevation, drainage pipes have to be laid at very shallow depths, frequently only 0.2-0.3 m below the ground surface. Consequently, they frequently break due to traffic loads.

In principle, the drainage situation in the city could be improved by means of installation of pumping stations and/or lowering of the water table of the receiving water body. However, such measures would impose a flooding and/or pollution threat on downstream agricultural areas and have, therefore, been ruled out.

There are three major types of sanitation facilities: pour-flush toilets, double-vault latrines, and bucket latrines. The pour-flush waste normally flows to septic tanks, from where it enters the drainage network. The sludge from the septic tanks is, if at all, collected by the Urban Environmental Company. A common practice is to sell the sludge to be used as fish feed in aquaculture. The double-vault latrines are inadequate to meet the demand. Thus, the vaults are prematurely emptied, which means that the anticipated composting has not taken place. The bucket latrines are mainly collected by farmers, who use the raw contents as fertilizer on their fields. Thus, when flooding occurs, there is a wealth of excreta on the land surface contributing to the pollution of the overland flow. The health statistics consequently show very high intestinal infestation rates, over 95 per cent of which 50 per cent are multiparasitic.

The low coverage and inadequacy of the municipal solid waste collection has led to an uncontrolled dumping of garbage in lakes, ponds, and canals in the city. Most of the controlled garbage dumps or composting sites are located on hydrologically unsuitable sites and contribute to the pollution of surface and groundwater.

10. The flows of water in urban areas

Let us make a simple mental picture of the circulation of matter in a city. This picture will show how matter is imported into the city, transformed in the productive processes, used, and evacuated from the city. The picture should also show the recycling of matter within the city. This recycling may be either planned or accidental. The latter phenomenon is often the cause of epidemic outbursts or other health or productive problems.

The first thing that such a simple model makes perfectly clear is that if we want our system to be sustainable, we must make sure that the amount of matter leaving the system equals the amount entering it. If these quantities do not match, we will either have an

accumulation or a depletion of matter in the system. Neither case represents a sustainable situation.

It is important to take into consideration that we have two kinds of flows, a natural and a man-made. This point will now be illustrated by means of some practical examples:

As a city grows, there are two tendencies that have a profound influence upon the in- and outflows of water; the first one is quite self-evident: the more the population grows, the higher the water consumption. The second effect is that as the city grows, the land prices rise, which creates an incentive to develop marginal land i.e. land near the valley bottoms, that are floodprone and poorly drained. In cities on the coast, there is a similar problem with development of land that is much too close to the seashore and thus susceptible to inundation and erosion problems. If the future rise in the sea level will be as dramatic as predicted by Thomas (1985), there is an urgent need to reconsider the land-use policy in coastal cities in order to avoid the enormous costs that will otherwise be incurred either by damages or by construction of sea walls and other protective structures.

11. Recycling and reuse

In Beijing, the strategies to soften the water resources crisis are interbasin water transfers and wastewater reuse. It is very difficult to direct water from other river basins. Thus, it becomes an imperative to reuse urban wastewater. Urban sewage has been used to irrigate farm fields for thirty years in Beijing. Currently, 260 million m^3 of wastewater accounting for 35 per cent of the urban sewage is used every year. The sewage irrigation areas which directly receive the wastewater use 15 per cent of the sewage. The other areas which are irrigated with a mixture of clean water and sewage, use the remaining 85 per cent of sewage. (Hong and Ting, 1990).

During 30 years of sewage irrigation practice the urban sewage has become the most reliable water source for irrigation in Beijing. However, planners are becoming more aware of some emerging difficulties:

In the 1950s, the urban sewage was mainly domestic. Its fertility increased the yields. With the development of urban industry, the proportion of industrial potentially harmful waste in the sewage has increased gradually and the groundwater quality has deteriorated in the west suburban sewage irrigation areas.

It has also been observed that the increasing industrial pollution makes water treatment costly. As a consequence, one thermal power plant in Beijing has reduced its production by 20 million kWh and one treatment plant has become unable to meet the water quality needs of industrial water users. Its water production has been reduced by more than half. This has led to increased demand on urban waterworks and to groundwater overdraft (Hong and Ting, 1990).

Internal recycling is mainly used in industrial settings, but the great potential for urban use must not be neglected. In arid areas, where lawn- and garden watering stand for a large portion of the water consumption, there is an obvious opportunity to reduce the water needs of the urban environment by means of using some of the drainage water for irrigation. In some arid areas, there have even evolved markets for sewage water, e.g. in Mexico (Hjorth, 1985).

The mindless reuse may constitute a significant hazard to the urban dwellers. There are many ways that such reuse may take place. The first one is contamination of the water source with sewage. This risk is present as soon as the wastewater is discharged into a water body serving as a water source. Even if hydrological surveys have shown that the wastewater discharge point is located downstream of the water intake, there may be extreme situations where the normal flow pattern is reversed. In Sweden, such events have been observed during winters when ice covers have disturbed the water circulation in lakes (Andersson, 1987) or during dry summer periods when river flow has been reversed. Improper design, operation, or maintenance of water distribution or water collection networks may also allow sewage to enter into supply pipes.

For a semi-arid climate, we have to consider that if sewage treatment plants are located downstream of the city, many rivers crossing the city will go periodically dry due to the lack of a reliable water source. Thus, the sewage treatment plants should be built on the upper or middle reaches and treated water should be used as sources for these rivers.

12. The impact on downstream areas

The impact of urban water management on areas downstream of the city is related to pollution and to changes in the flow regimes of the rivers passing through the urban area or to which the urban effluents are diverted.

The flashy and rapid run-off processes in urban areas create environmental problems as the self-purification ability of the water courses is reduced. Not only does this create environmental problems, but it means a mismanagement of resources as a substantial portion of the plant nourishment in the sewage is taken away from the terrestrial environment and lost into the sea where it creates great problems, the extent of which has only recently been realized.

Tourism is nowadays a very important export income earner, especially so in some developing countries. Coastal cities polluting their sea water find it increasingly difficult to attract tourists. Thus, sea-resort cities are generally among the first cities in a country to introduce some kind of sewage treatment facilities. Tunisia is one such example. Thailand is another, where sea-resort cities like Pattaya and Rayong were among the first Thai cities to install sewage treatment plants.

At an early stage of the development process, the urban waste is mainly from organic matter. The effects of the waste on the receiving water body are mainly an accelerated eutrophication process and oxygen depletion causing fish kills and odour problems. When industrial activities develop, the waste tends to become significantly more hazardous to human and environmental health. For example, Japan was one of the first Asian nations to industrialize after World War II, and among the first to face the environmental consequences of its push towards economic growth. In the mid-1950s, for example, health officials acknowledged that the causes of the infamous Minamata mercury poisoning and the "Itai-Itai" cadmium poisoning were industrial wastes (Austin and Koontz, 1992).

In Sweden, many municipalities chose to discharge their effluent into nearby lakes assuming the lake to be well mixed. Thus, the capacity of the ecosystem of the lake to digest the pollution was overestimated. The result is an accumulation of pollution in the lake. In many lakes, such accumulation has been allowed to take place for considerable periods of time. The remedy is to try to improve the mixing conditions in the problematic areas. However, experience shows that often one has to mechanically remove the contaminated sediment layers in order to achieve the desired lake rehabilitation. Thus, when the associated problems had reached a stage, where they became visible, the damage to the lake ecosystem was very severe and the rehabilitation costs for the lake were very high indeed.

13. Conclusions

The problems outlined in this paper indicate that the environment, in fact, frequently is overburdened by urban development efforts. The unmanaged environment can no longer sustain the water consumption and waste discharges associated with urban development in developing countries. Thus, there is a need for rapid, radical, and informed efforts to adapt the management of urban water supply, sanitation, and drainage to the carrying capacity of the surrounding environment.

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E. TECHNICAL AND MANAGEMENT ASPECTS OF THE SUSTAINABLE USE OF GROUNDWATER RESOURCES IN URBAN AREAS*

Introduction

(a) Population and urban growth in region

The phenomenon of rapidly increasing urban population is one that has become progressively more obvious in recent decades, all over the world but particularly in the developing countries. On the global scale the urban population is reported to have been about 1,350 million in 1990 of which about 1100 were served with water (Bhatia and Falkenmark, 1992). At the years 2000 and 2020, the total urban populations numbers are expected to rise to 2,000 and 3,600 million, respectively, but at present rates of supply extension the proportion of these populations served will decline from 81 per cent (1990) to 59 per cent (2020). During the 1980s the efforts of the International Drinking Water Supply and Sanitation Decade (1981-1990) enabled development of supplies to an additional 360 million urban residents while the urban population rose by 400 million; a continuation of this trend will mean that in spite of increased services and water supply development, the urban population without a proper water supply will increase by about 600 million people by the year 2000. By 2025 the predictions are that more than 5 billion or 60 per cent of the population, will be urban (United Nations, 1992).

In the Asian and Pacific region, the increases in urban population follow in general the same pattern as indicated in table 8. There are also particular problems in the region for the development and contamination of groundwater in the numerous oceanic islands and island nations, where population densities are sometimes inappropriately high and the latitude for the mis-management of groundwater is minimal.

(b) Demography of new urban areas

Most of the population increases outlined above are currently taking place within the "low-income" slum and squatter sector; in Jakarta, 70 per cent of the increase is attributed to this category (WASH,1989). It has been estimated that by the year 2000 about one third of the population of the countries of South and South-East Asia will live in urban areas; of these almost one half will be living in low income housing areas (Reed, 1990). Some data for the region are shown in table 9, which are incomplete but give a general profile for some of the major cities.

Table 8. Urban population and groundwater use data for selected cities-Asian Pacific region

Country	Urban population (millions) 1985	Urban population (millions) 2000	Urban population % of total 1985	Urban population % of total 2000	1 Groundwater % of supply	2 Legislation Available? Drilled	3 Legislation Available? Dug
Australia					16	*	*
Bangladesh	18	27	13	18	22	*	*
China		320	25		18	*	*
India	197	330	25	34			
Indonesia	59	77	25	37		?	?
Japan					26.5		
Malaysia					25		
Myanmar	9	17	24	28	30	*	
Nepal	1	3	7	14	35		
Pakistan	27	53	29	37			
Philippines	22	36	39	49	4	*	*
Republic of Korea					?10		
Sri Lanka	3	5	21	24		?	?
Thailand	13	19	18	29	50	*	

Sources: Economic and Social Commission for Asia and the Pacific (ESCAP), 1991; United Nations 1992; United Nations Centre for Human Settlements (UNCHS), 1991; Water and Sanitation for Health (WASH) Project of the United States Agency for International Development, 1989

Notes 1 - Percentage of public supply comprising groundwater

Notes 2,3 - Laws already in place to control drilling and groundwater pumping of drilled and/or hand-dug wells

Table 9. Water supply and sanitation data for selected cities of the Asian-Pacific region

City	Population 1990	Population 2000	1 Growth Rate ( ) %	2 Groundwater produced (Mm3/a) 1990	3 Ground-water % 1990	4 Piped supply % 1990	5 Con-sumption l/c/d	6 Slum Area ( ) %
Bandung	1.5		5			75		
Bangkok	7.3	11.9	2.1	1814	~50	86.1		25
Beijing	10.8	14		2600	56.5		248	
Calcutta	11.8	15.7	8					
Dhaka	6.6	12.2				60		
Jakarta	8.9	16.6	3	310	59	28		35
Madras		12.9						30
Manila	8.5	11.8				70		~25
Shanghai	13.4	17					204	
Tianjin	9.4	12.7					137	
Tokyo	18.1	19				94.2	380	

Sources: Bhatia and Falkenmark 1992, ESCAP 1991, United Nations 1992, UNCHS 1991, WASH 1989

Notes: 1-Population growth rate

4-Piped supply includes surface and groundwater

5-Average per capita consumption

6-Per cent of population (WASH 1989)

* This paper was prepared by K.J. Edworthy, Groundwater and Environmental Consultant, United Kingdom of Great Britian and Northern Ireland, at the request of the ESCAP secretariat.

(c) Water supply and sanitation

Water supplies without proper disposal of wastewater can be a serious health hazard. Sanitation to carry away the increased volumes of wastewater is essential.

At present sewerage systems carry away the wastewater from only 40 per cent of the worlds urban population and 95 per cent of this is totally untreated and discharged into surface watercourses. It is no surprise that human wastes represent the largest threat to surface and groundwater supplies and resources worldwide. Approximately one billion people in urban areas of the world have to be supplied with sanitation during the 1990s to achieve full coverage. Between 3 and 4 times as many people will remain unserved by sanitation in the Asian-Pacific region compared with the total for the remainder of the world. Meantime the pollution of water supplies will continue.

1. Groundwater use for urban water supply

(a) Groundwater use in region

Some of the salient features of groundwater use in selected cities of the region are shown in table 9 and these are referred to in this section. Groundwater is clearly an important source of domestic water supply particularly in urban areas. Reference will also be made to examples of urban problems in cities and towns outside the region which are considered relevant, and the effects of high population densities on the many oceanic islands and their groundwater resources should also be included as highly relevant types of urbanization as outlined briefly below for Maldives (Edworthy, Heard and Ibrahim, 1990)

(b) Public supply

The high microbiological quality of groundwater, the stability of chemical quality and temperature and the absence (in properly constructed wells) of suspended solids, are attractive attributes for all uses, particularly public drinking supply. Reserves available in aquifers are normally many hundreds of times greater than annual replenishment so reliability is also high. The combination of high reliability and minimal treatment costs (usually limited to precautionary chlorination) make groundwater highly desirable from an operational and an economic point of view.

(c) Industrial and other uses

The above attributes make groundwater extremely valuable for many industrial uses and, for example, in Thailand 60-80 per cent of industrial groundwater supply is used for cooling. Quality does not have to be of the highest for many uses but many companies prefer to develop their own supplies for the extra security it affords, over a piped supply. Industrial pumping is often fairly concentrated geographically and in most countries, is growing rapidly; in Bangkok the rate of increase is about 10 per cent per annum (ESCAP, 1991), and there is competition with public supply for the remaining limited groundwater resources. Agricultural use in peri-urban areas is normally relatively small because farming is displaced outward during urbanization. In the early stages of urban growth however there may be considerable interference where the same aquifer is exploited. Agricultural consumption of groundwater overall tends to be extremely high by comparison with other uses.

2. Effects of urbanization on aquifers

(a) Increasing demand and inter-sectoral conflicts

Groundwater is a high value resource for public supply. Exploitation is simple and inexpensive and the costs of treatment and distribution are almost always small by comparison with the surface alternatives. Increments of demand can be satisfied with small progressive increases in investment, unlike surface water schemes which need fewer but comparatively high capital investment to make overall costs acceptable. Furthermore, surface water requires substantial investment in treatment and distribution. The tendency in most cases is for cities to continue to use groundwater as the low-cost water supply option for as long as possible, provided no deleterious effects are evident. If groundwater is easily accessible and inexpensive to develop then private and industrial users will also tend to make use of the same source as occurs in Bangkok, Thailand. Here, excessive groundwater exploitation for public supply, private use and for industry, beyond the natural resources of the aquifers has led to significant decline in groundwater levels. Other serious subsidence problems have also occurred which demand a reduction in abstraction; these are discussed briefly below. The reduction of groundwater abstraction for public supply clearly involves costs for the development of alternative surface water supplies; it also involves an implicit curb on industrial and other private development and competition for the limited long-term yield available. The resolution of inter-sectoral competition makes it necessary to consider many complex economic and political factors.

In Sana'a, Republic of Yemen, traditional use of groundwater from dug wells in the city was compatible with the use of cess-pits while the amount of water use was small and the flux of contamination from surface to water table was small. The use of mechanical pumping

led to depletion of the resources and the start of contamination breaking through to the water table. Continued exploitation of groundwater was only possible by drilling wells in the suburbs, where there was direct competition between public supply and irrigated agriculture, for the limited groundwater resources.

Intensive abstraction of industrial supplies from the alluvial aquifer in the vicinity of Guangzhou, Hebei Province, China, drawdown of more than 60 m has been caused over 100 km^2 and 38 per cent of the irrigation wells within this area have been abandoned (Chen Mengxiong, 1982)

(b) Effects upon recharge

The spread of urban areas involves many changes to the land surface including removal of vegetation, increase in paved areas, and the installation and operation of a range of services. These changes can clearly cause significant accompanying changes to the rates and amount of rainfall-derived recharge. Cities are also large areas of environmental disturbance which can have an effect on the local climate. The main aspects are reviewed below.

(i) Effects of paved areas and housing

The prevention of infiltration is the most obvious effect of paving, and the direct effect is to reduce direct rainfall recharge of groundwater resources. In terms of water quality this may be a beneficial factor in protecting groundwater from urban contamination. However, the increased run-off caused is an important side-effect presenting an increasing flood danger and place a greater strain on drainage in general. This situation is increasingly evident in Karachi, Madras and Manila, for example but is a more widespread problem which exists in all urban areas to lesser degrees (the problem is always exacerbated by partial clogging of drains with deposited wastes). Recovery of some of these resources may be possible by diversion to either bare or vegetated infiltration areas under some rainfall/superficial geological conditions but there may also be a danger of dissolved contaminants causing pollution to groundwater; however, the main contaminants in urban storm drainage are particulate matter and possibly microbes which do not generally present a serious threat to groundwater quality.

(ii) Leaking services

The construction of piped water supplies from outside a city to augment the *in situ* sources is normally a later stage of urban evolution when local resources have been largely used or possibly contaminated. The losses from water services worldwide are now known to be significant even in developed countries (Khadam and others, 1991); rates of loss of less than 10 per cent from public water supplies are rare and are more commonly in the range 25 to 35 per cent, at which level the infiltration can form a major element of the water balance (Lerner, 1990). In Birmingham, Liverpool and London in the United Kingdom of Great Britain and Northern Ireland, the historical overuse of groundwater led to the development of outside resources which are now piped into the urban areas. The "losses" from services combined with natural recovery of groundwater level is now causing problems due to rapidly rising water levels; subsurface structures and underground services constructed when groundwater was deeper are now below the water table (Arthur, 1990; Hurst and Wilkinson, 1986). Similar problems are also reported from Kuwait City (Al-Sanad and others, 1990) Doha, Qatar (Pencol/J. Taylor and Sons, 1985), Jeddah (Abu-Raiza, Saraika and Ali Khan, 1989) and Cairo (Shahin, 1990). The causes of the above problems are closely linked with aspects of groundwater management which are touched upon below. Infiltration from cesspools and septic tanks was also shown to augment recharge significantly in Cairo and Jeddah and can clearly cause serious groundwater pollution.

(iii) Effect on microclimate

Agricultural land is assimilated by the growing urban areas with the essential hydrological effects related above. There are additional and equally important changes to the environment above the city caused by emanated heat energy or simply altered thermal properties of the city area including the albedo of the surface. Particulate matter in the air exerts a potential effect on precipitation and in the catchment in which St Louis, Missouri, United States of America, is situated, a 10 - 30 per cent increase in precipitation has been reported by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 1989). In this instance the benefits of larger resources was off-set by increased flux of contaminants from the surface causing groundwater pollution.

(iv) Infiltration from watercourses

River and canal infiltration may be a significant mode of groundwater recharge or discharge and an important element of the hydrological balance beneath cities where a phreatic aquifer exists. Urbanization often involves the sealing of the banks and possibly the

bed of urban watercourses, and also possibly considerable straightening. Bed sealing may occur in any event due to accumulation of silt/clay matter. These modifications can clearly reduce infiltration and recharge substantially. Urban watercourses are in most instances of a low sanitary quality and any infiltration can equally be the source of serious groundwater contamination in addition to those described below.

(c) Contamination of groundwater

Contamination of groundwater resources is rarely identified because monitoring systems are not established in most developing countries (ESCAP, 1991), and are inadequate even in the industrialized countries. Inevitably contamination eventually becomes pollution and groundwater resources may become effectively sterilized either by introduced matter from the surface or in a coastal setting, by induced salinity intrusion. Salinity intrusion affects many of the cities listed in table 8 above notably Bangkok (Buapeng, 1987), Jakarta (Schmidt, Soefnes and Soekardi, 1990) and Manila (Binnie and Partners, 1986). Leakage of sewage, leachate from solid waste accumulations, or ill-managed disposal of industrial wastes are the commonest sources of contamination.

(d) Public health

At low population density and low per capita consumption on-site sanitation may be appropriate and compatible with groundwater use. Urban population densities of more than 50,000 per km^2 are reported in the slum and squatter areas of Jakarta (WASH 1989), and even at low per capita consumption, the health hazard of sewage and wastewater discharges to the low-cost housing areas is obvious, and the danger of pollution of any shallow groundwater is also evident. There are several factors other than water supply which contribute to health hazards in slums but water supply is clearly important (Listorti, 1990). The prevalence of many diseases in slum areas such as worm infections, are reported to be twice the normal flat-dweller rate in Singapore and Kuala Lumpur (UNCHS, 1990). The costs to a nation of allowing poor standards of public health in the slum areas may be high if we take Lima, Peru, as an example; the costs of the cholera epidemic which arose initially in the squatter areas, was US$ 460 million, more than was spent on water and sanitation in Lima during the 1980s. The problems of groundwater pollution are dealt with in an accompanying paper.

(e) Overabstraction of groundwater resources

Declining groundwater levels are the most immediate result of abstracting groundwater at a rate greater than it is being replenished, either locally or regionally. Local problems arise when the density of abstraction is too high; better distribution of abstraction may solve the problem and allow gradual recovery of levels. In most of the cases where levels are declining however, the problem is due to both high densities of abstraction and to the use of too many wells; in this situation the abstraction is greater than the recharge to the aquifer regionally, and the implications for operators are increased pumping costs and possibly quality deterioration. Serious drawdown problems are reported from Bangkok, Jakarta, Manila, and in many cities in both China and Japan. In China it is reported that 20,000 km^2 are severely affected with drawdowns of up to 60m (Li Xizeng, 1990; Ji Chuanmao, 1982). Large drawdown in coastal urban areas can cause saline intrusion by inducing inland flow of sea water as occurs in many parts of the Philippines (Binnie and Partners, 1986) and in the well documented case of Bangkok (Buapeng, 1989); this phenomenon is also evident in most of the cases listed above and must be viewed seriously as its effects prevent the use of groundwater and are difficult to reverse.

The secondary effect of severe drawdown may be subsidence of the land surface where the dewatered succession is significantly compressible. The deep alluvial aquifers exploited by many major coastal cities commonly contain extensive compressible strata. As water level declines and these strata drain, subsidence develops to the extent that land surface may fall by several metres. In Japan, excessive drawdown has developed since the end of the 1950s and many of the major cities were affected even by the mid-1970s (Yamamoto, 1976). Bangkok suffers increasingly serious subsidence problems to the extent that several hundred km^2 of the central and eastern parts of the city have subsided by more than 1.0 m and are at, or below, sea level. Subsidence in Tianjin reaches 1.5 m within an area of 2,300 km^2, and at Shanghai subsidence in 1982 was up to 2.4 m (Chen Mengxiong, 1982).

In Maldives the fresh groundwater resources on Male, the capital island, encouraged increasingly dense settlement, until demand exceeded annual recharge and reserves within the thin aquifer were rapidly used. Since 1975, almost the entire freshwater resources have been used and now, in spite of abundant monitoring information and prediction of serious problems, the situation has been allowed to develop to the point at which desalination, and limited roof run-off are now the only alternative sources for low salinity water (Edworthy, Heard and Ibrahim, 1990).

3. Management of groundwater resources

(a) Assessment of resources and monitoring

Any sensible and practically useful planning must start with an adequate knowledge of the aquifer system in

use, the ambient groundwater quality, and the effects of existing use. These data should ideally be acquired before the start of development but in practice, enough information can never be known at the outset and development can always be considered a long-term test. A complete assessment should logically extend, where suitable hydrological conditions apply, to the possibility of conjunctive use of groundwater with surface water, a strategy which is capable of optimizing overall resource use. The geology of the aquifer, its relationship with contiguous strata and continuity are basic data which must be collected as part of a properly planned drilling programme jointly with sampling, analysis and testing in advance of development. Increasingly, digital modelling of groundwater systems are feasible and useful aids to management but only if the data concerning the system are reliable and properly validated.

Phreatic or water-table aquifers are particularly vulnerable in cities, where the recharge area is the urban area. Many cities such as Jakarta and Bangkok exploit mainly confined aquifers which, within the city areas, are largely protected by thick overlying clays. The chalk-limestone aquifer which has been used for industrial and public supply in London, United Kingdon, is also effectively protected by clay strata in the same way. Natural recharge to each of the above confined aquifers occurs remotely, possibly more than 50 km distant, so that the effects of urban contamination are relatively unimportant or only occur slowly if at all. A good knowledge of the vulnerability of the aquifer is however of highest importance in planning of land use in and around the urban area.

The rate of recharge, which will determine the safe yield of the aquifer system is difficult to measure without regular monitoring of operation to assess and extend the value of initial test data. Regular water level measurements indicate the volume of groundwater reserves; the rate and distribution of pumping can be modified to avoid the undesired effects of subsidence, saline intrusion, and the costs of pumping from increasingly great depth.

(b) Planning and resources development

Groundwater abstraction is ideally suited to staged development as the demand expands. The rate of investment can be minimized in this way and clearly offers economic advantages over, for example, the construction of a large reservoir to satisfy the same demand. Also supply can be organized readily into a number of zones fed by single, or groups of, wells providing a high degree of operational flexibility. There is further potential for optimization of development and supply if abstraction and its effects on levels and quality are carefully monitored in parallel with development. These advantages are not often realized because of inadequate planning at the outset, problems of coordination between concerned agencies, and lack of control over competing industrial and private abstractors.

(i) Evaluation of trends in sectoral demands

Existing trends in demand for any given developing urban area must be expected to differ in the future over those which prevailed in the past. One reason is the latent demand from the vast "informal:" fringes of urban areas which must be addressed in the immediate future if the work-force upon which economic growth depends, is to be stabilized and remain healthy (WASH, 1989) and there are compelling economic reasons to divert as much water as possible to urban domestic supply. A second reason is the increasing rate of urban industrial growth. Demand increase is offset by increasing amounts of reuse and recycling, but taking the example of Bangkok, industrial demand will nevertherless take a 40 per cent share of supply by the year 2000 against the current 35 per cent. A third factor to take into account is the increase in per capita consumption which accompanies economic growth and improvement in average standard of living. The average domestic consumption is expected to rise in Bangkok, for example, from 220 to 270 litres/per capita/day (l/c/d) during the 1990s. The average domestic consumption in Mexico City reflects a range from 350 l/c/d for higher income users (15 per cent) to less than 140 l/c/d for 60 per cent. A final factor is the probable decline in the proportion of distribution losses as old services are repaired and new lower loss systems are constructed.

(ii) Allocation of resources

In terms of financial resources, it is interesting and informative to note that in India, while only one fifth of the population lives in towns, almost two thirds of expenditure on water supply and sanitation is for urban use (Mankodi, 1990). Management of the use of groundwater resources in terms of allocation to different groups of users is comparatively complex. An example of the misuse of groundwater is in Bangkok where 60 - 80 per cent of industrial groundwater is used for cooling, a purpose for which recycled or alternative sources could equally well be used. An underlying and guiding principle, wherever possible, should be give water its full economic value which would always mean the retention of high quality groundwater for public supply and other high value uses. The maintenance of

groundwater quality can be assisted by control of abstraction but measures to assist pollution prevention are essential also. In a situation where agricultural demand competes with urban demand for the same groundwater supply, the value of urban water is almost always considerably greater, bearing in mind also that most agricultural use is only 30 per cent efficient (United Nations, 1990); this statistic is an important one as it reveals how considerable resources might be released by improving agricultural efficiency. In the Republic of Yemen, the agricultural use of groundwater around the capital Sana'a has seriously depleted the limited resources of the aquifer which all users exploit; the city will soon face a crisis in both agricultural and urban supply, and much higher costs for water (Edworthy, 1990)

(c) Protection of resources

Licensing of abstraction is the best method of control, which is capable of limiting and managing groundwater abstraction, possibly in connection with a charging system. In practice, there is legislation in only a few of the countries of the region (table 8) and then it is not necessarily comprehensive or fully policed and hence tends to be ineffective. Protection of groundwater from pollution is agreed to be far preferable to the treatment of pollution after it occurs; this really implies that comprehensive legislative controls have to be enacted to deal with the many potential sources of pollution including industrial wastes, solid domestic and hazardous wastes, sewage in all of its forms, influent polluted surface water, etc., framed against the basic premise that the "polluter pays".

(d) Charging for groundwater

Because of its many advantages including its apparent low cost, groundwater tends to be used as long as possible. In practice this means until serious quality or excessive drawdown problems occur which force traumatic review and replacement. The low-cost of groundwater development leads to undervaluation of its strategic importance and the costs of alternative supplies is always higher. The overabstraction of groundwater for Mexico City, for example, forced development of surface water resource costing over 50 per cent more; in Amman, Jordan, Shenyang in China and in Lima, Peru, the additional costs of alternative sources when groundwater had been over-used or contaminated, was 2 - 3 times higher (Bhatia and Falkenmark 1992; United Nations, 1992). In Maldives, the costs of groundwater taken from private hand wells was virtually nil; the effects of aquifer overexploitation and contamination has been to force the development of replacement desalinated supplies the reported costs of which during 1989-1990 were about US$ 3.50 per m^3.

Control of consumption by cost is well exemplified by the sale of water by vendors in most slum areas of developing countries cities, the unit costs of which might be up to 80 times that from the municipal supply. This is another illustration of the unfortunate situation of low income families who may have to spend up to 20 per cent of their income on a water supply, for which the higher income family may spend only 2 - 3 per cent of its income (Bhatia and Falkenmark, 1992).

The value of groundwater is high and users are correct in seeking to extend its use as much as possible. The short-sightedness of the way in which groundwater is conventionally misused however, is evident from all of the experiences related above. All the situations in which resources have been exhausted or polluted could have been avoided by adequate monitoring information and management on the basis of these data. The costs of setting up a suitable system would have been minimal and are seldom the reason for a lack of such systems; the absence of monitoring in developing countries is always due to the lack of the institutional organization to administer and make use of it, not to cost. If monitoring is done, there is often no interest in the data on the part of the decision makers whose management criteria are shorter-term or non-technical.

(e) Setting of equitable tariff

Even the notion of charging for water is a puzzling one in some societies, though fortunately, this is changing gradually. It is not however, difficult to see why there may be resistance to the charging of an economic rate. Urban supply pressures are now becoming such that charges are increasingly being introduced in the knowledge that dramatic reductions in consumption can be encouraged (Arlosoroff, 1989), but these measures require the introduction of metering, some form of allocation, a controlling authority to monitor and to enforce payment. The "poor" stand to lose from such a system unless the tariff is carefully designed to allow basic requirements to be supplied at minimum or no cost, and to charge progressively higher rates for higher consumption. In Bogor, Indonesia, the cost of domestic water was raised from US$ 0.15 to US$ 0.42 per m^3 and this encouraged a 30 per cent reduction in consumption, and significant reductions in industrial consumption are also reported elsewhere (Bhatia and Falkenmark, 1992).

4. Management and institutional arrangements

(a) National level

Appropriate legislation is needed to set up hydrological areas or other planning units to facilitate the regular collection and organization of surface, groundwater and climatic data as background information for all management. Support for research should also be readily forthcoming to underpin basic technical support and to explore such topics as conjunctive use and artificial recharge, logical stages in extending the efficiency of water supply development.

Legislation to enable licencing of both groundwater abstraction and pollutant discharges is another essential early step. An inventory of all existing users and polluters should also be established, and realistic standards set to aim for which can be attained within the framework of laws which can be implemented. The point has been made by the World Bank (1992) that some governments have set tight standards copied from developed countries, which have had the effect of encouraging corruption and undermining the credibility of all environmental policies.

The control of water resources development and management of use by the various sectors of the economy who need water as an essential prerequisite, has to be backed by policy decisions at a national level. These decisions can only sensibly be made on the basis of measurements and monitoring data. The difference in the value of the same volume of water used by industry and by agriculture for example, is widely distorted by subsidies, usually to agriculture. In China, for example, it has been estimated that water use for industry generates 60 times the economic value than the same volume used for agriculture (United Nations, 1990). With 70 - 90 per cent of water being used for agriculture, the effects of mismanagement are relatively rapid and the other sectors are forced to pay relatively higher charges for alternative supplies or do without water. Equally, small reductions in irrigation use by removal of subsidy or improved efficiency, can release relatively large amounts of water in terms of public supply or industry, which jointly consume, on average, only 20 -30 per cent of resources.

The strategy followed by government on allocation of water has to take many factors into account, including both internal and external factors. In the present context of urban groundwater, the resource is doubly valuable on account of high quality and its high economic and social value. It is predicted that 80 per cent of future national economic growth will be generated in urban centres so the maintenance of public and industrial water supply must be seen as a high priority (UNCHS, 1991).

Efficiency of use will inevitably become more important; there is much scope for leakage reduction as described in this paper and in industry, there is great scope for conservation and reuse. Substantial public education projects using the media should be mounted to explain the implications of abuse of water and other services, and of sanitation. More important still, it should be a high priority to encourage public participation, especially the participation of women who are most directly involved in dealing with the effects on living conditions and health, in improvement in water services.

(b) Municipal level

The number of agencies and ministries involved to a greater or lesser extent in water matters is wide and overlapping. Water is a major element within the basic urban infrastructure, possibly the most important, and an important potential constraint on economic growth. The availability and quality of the water supply affects the sanitation, health and housing sectors. The industrial sector needs water and generates considerable amounts of pollution, and in some cases there remains an important interface with the agricultural sector.

The complexity of the interaction between these many separate sectors in the urban area imply a clear need for an effective form of coordination. This could be asserted through a municipal planning body, the head of which would be held responsible for the management of all water and waste disposal services in the urban area. To be effective, any body must be empowered adequately to coordinate and manage services through the application of the national laws and standards possibly augmented by special local conditions. It would be important that the body is allocated, and allowed to manage, an adequate budget and furthermore has powers to raise money from its services so that it can develop, administer and maintain the water and sanitation system.

To set up and run such coordinating authorities, and to enable the various water/waste contribution agencies to act together effectively, properly trained and qualified staff are essential to carry out the technical tasks and to apply and police any abstraction or pollution control legislation.

5. Conclusions

(a) Urban groundwater resources face crisis across the region, due to increasing population, increasing per capita consumption, and lack of management.

(b) Aquifer systems, many of which are heavily over-used and under considerable threat of contamination,

are inadequately understood and there is an urgent demand for proper investigation, backed with applied research.

(c) The most urgent need is for the emplacement of appropriate legislation to allow abstraction licencing, pollution discharges, and for the regular measurement and organization of groundwater, surface and climatic data.

(d) Coordination of national policies relating to all the sectors using, and affected by, water and rationalization of management need to be enhanced as early as possible, and on the urban- or municipal-scale suitably *staffed*, *financed* and *empowered* bodies are needed.

(e) Demand management by charging and licensing, taking account of the special demands of the urban poor, some degree of central allocation, and application of conservation measures, and possibly conjunctive use, can extend the life of existing resources substantially.

(f) Participation of the public by seeking their involvement at the planning stage, and by regularly shown and well produced public information in the media. The opinions of women are particularly important in assisting in the water/sanitation/health sectors.

(g) The economic value of groundwater resources for public supply and industry is not appreciated. Subsidies for agriculture should be removed progressivly for example and the allocation of resources considered on the basis of proper economic comparison. The costs of alternative supplies should be evaluated at an early stage in groundwater resources development.

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Chapter II. URBAN WATER SUPPLY MANAGEMENT

A. URBAN WATER SUPPLY MANAGEMENT: BASIC ISSUES*

Introduction

At the end of the International Drinking Water Supply and Sanitation Decade (IDWSSD) in 1990 the goal was set for "Safe Water 2000"[1]. It was recognized that whatever the country's stage of development and its state of economic and social conditions, all people have the right to have access to safe drinking water in quantities and quality basic to their needs.[2] With this end in view it was decided that we should aim for "some for all rather than all for some". However, when we see this in the perspective of what has been achieved in the Decade and what remains to be achieved, the task is indeed a formidable one. As per the *World Development Report 1992* published by the World Bank, there are more than one billion people who are still without access to safe water.[3] Similarly, the World Health Organization (WHO) report, International Drinking Water Supply and Sanitation Decade – End of Decade Review, has mentioned that the population increase in the developing countries over the Decade was 23 per cent, of which 42 per cent was in urban and 15 per cent in rural areas. In South-East Asia alone, the increase in coverage over the past decade was 256.79 million, the largest being in urban areas to the extent of 49 per cent. Fifteen per cent of the urban population still remained without access to safe drinking water in developing countries representating 205 million people. With an expected increase of 570 million by the year 2000, the total urban population to be reached with extended water supply services to attain universal coverage by the end of the century would be 775 million. This is in spite of the fact that US$ 45,520 million has been invested in the urban water supply sector during the decade in developing countries. Against this grim scenario it is clear that we cannot proceed with the "business as usual" strategies and there is a need for reorientating the sector policies towards more realistic and achievable goals.

Provision of water supply in urban areas is becoming more and more expensive in developing countries facing severe resources constraints, both in terms of financial outlays and shrinkages in safe water sources. There is, therefore, the need to optimize investments both in physical and financial terms. It is imperative that it is recognized that provision of water supply and sanitation in urban areas is not merely an engineering exercise but has to be guided by modern management principles. Decisions should, therefore, be on provision of sustainable services through far-reaching institutional changes and development of absorptive capacity in the institutions which are expected to deliver. Aspirations of the community to be served, especially the women who bear the brunt of inefficient water supply, have to be appreciated for any meaningful reforms in the sector. Greater community participation and movement towards cost recovery would also ensure accountability of the water supply agency on the one hand and improve the efficiency in the delivery mechanism on the other.

The lack of political will for sector reforms is faced in many of the countries of this region. It is, therefore, all the more necessary for greater community participation to generate the requisite political will for sector reforms. In a situation as it exists in a country like India where water supply is treated as a statutory service totally unrelated to the cost of supply, hard decisions will necessarily have to be taken. However, we are still a long way from stipulating total cost recovery due to the limited paying capacity of the urban population as the cost of the delivery has no relation to the income levels.

Despite these limitations, there is a need for an accepted sector policy which should be endorsed at the highest political level. The sector policy should ensure optimizing investments with a clear emphasis on reaching the unserved, especially the poor, who have remained outside the pale of most services. Statistics regarding

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* This paper was prepared by Indrany Sen, Ministry of Urban Development of India, at the request of the ESCAP secretariat.

1 New Delhi Declaration – The Global Consultation on Safe Water and Sanitation for the 1990s New Delhi – September 1990.

2 The International Drinking Water Supply and Sanitation Decade – End of Decade Review (as on December 1990). A publication of the United Nations Development Programme, Division for Global and International Projects, – WHO/CWS 92.12.

3 *World Development Report 1992* – Development and the Environment.

coverage in the IDWSSD may also not be the correct indices as these do not take into account service levels, rate of supply and the distribution aspect.

1. Sector policy

A sector policy, endorsed at the highest political level, should recognize that provision of water supply is a utility to be governed by sound management principles taking into account the available physical and financial resources and emphasize that this is not a free service which is to be provided on extraneous considerations. Settlements have been allowed to grow without any correlation to accessibility of safe water sources and the desire for industrialization has led to pollution of the earlier available safe sources. Developing countries have, therefore, limited choices to ensure the maximization of the provision of safe water and keeping a balance between optimal supplies and an optimal size of population. The following paragraphs highlight some of the factors which are essential for a sound sector policy. While this has basically been drawn from the India experience, readings from the Evaluation Reports of the Operations Evaluation Department of the World Bank[4] and the various background papers submitted during the Global Consultation on Safe Water and Sanitation for the 1990s held at New Delhi in 1990, it is felt that the problems faced in India are common to most of the developing countries, barring a few exceptions who have managed to overcome some of the problems through clear sector policies and hard decisions:

(a) Need for autonomy

In most developing countries water supply utilities remain totally government controlled where investment decisions, choice of technology and tariff issues need government endorsement. In order to ensure that these utilities function on sound management principles, there is a need for the granting of autonomy to these organizations for improving sector performance. It would be unrealistic to expect that they would be totally severed from their umbilical cord as they would have to continue to depend on government grants for a large proportion of their expenditure for sometime to come. The government should, however, function in the role of the facilitator in enunciating clear guidelines without directly intervening in its day-to-day functions. This autonomy has to extend from State level utilities right down to the Urban Local Body (ULB). In India, most State Governments have State level utilities which execute the works and later hand over the same for operation and maintenance and recovery of user charges to the ULB. Just as it is desirable for the State utilities to be given autonomy, it is also desirable for the ULB to be given the autonomy to decide whether the projects and proposals being prepared on their behalf by the State level utilities are operable in their areas or not and whether they are in a position to take on the maintenance after execution. This should, therefore, be in the form of some agreement between State level utility and the ULB. The autonomy should, therefore, extend to the whole gamut of the urban water supply exercises, i.e. investment decisions, level of services, rate of supply, choice of design and most importantly, tariffs. Autonomy can be double-edged, consequently ground rules should be clearly laid down, backed by legislation, if necessary, so that such autonomy does not become counter-productive in a politically charged situation.

(b) Master plan

For any sector policy to be meaningful, a master plan regarding allocable water resources has to be prepared for the entire State which should be dovetailed with other water users with competing demands from agriculture, industry and the power sector. There has to be an endorsement to the overall allocation of water by the various users taking into account the availability of both surface and groundwater. The agriculture sector in most of our countries is notoriously wasteful in its use of water resources. Increased output rather than water conservation has been the guiding principle for propagation of various agronomical practices. Consequently, urban water supply can benefit greatly if it works in tandem with other users emphasizing water conservation in a coordinated manner at State level.

Water has to be treated as an environmental resource like other resources e.g. metals, fossil fuels, etc.[5] The market cannot impute property rights and prices on water, unlike the other natural resources. Consequently, non-market alternatives have to be relied upon for the allocation of resources between the competing users, especially when it involves a share from the agriculture sector towards drinking water supply. A master plan by taking into account the available resources both surface and groundwater, backed by legislation should ensure allocation between the competing users, wherever it is felt necessary to do so.

Efforts in India in this direction unfortunately have not been very successful so far. However, in water scarce States there has been some realization that there is no alternative to strict enforcement of such Legislation, as

[4] Water Supply and Sanitation Projects The Bank's Experience – 1967-1989, Report No. 10789 of the Operations Evaluation Department, June 1992.

[5] Water Conservation and Pollution Abatement in Indian Industry – A Study of Water Tariff, by D.B. Gupta, and others. A study Sponsored by the Ganga Project Directorate to the National Institute of Public Finance and Policy, New Delhi.

unchecked tapping of groundwater by agriculture and industry, have led to an alarming lowering of groundwater tables and infiltration of sea water in coastal areas. Consequently, the study of available water resources in the State and inter-sectoral coordination on water supply allocations is imperative to ensure that investment decisions are made on realistic assumptions and within acceptable parameters.

(c) Investment planning

Once such a master plan is in place, it will be possible to make realistic projections on the levels and rate of service that are achievable in the urban areas. There can be a networking of projects, as small fragmented schemes may be more costly compared to integrated schemes which involve economies of scale.[6] Piecemeal planning often leads to uneconomic designs which poor countries can ill afford both from the investment and recovery point of view. Moreover, once estimates are available on the amount of water supply for the given urban area, it would be possible to curb the tendency to over-design which has also been one of the casues for uneconomic projects. It would also be possible to ensure that optimal use is made of the physical and financial resources. Most of the countries of this region have well-developed census operations with projections regarding future growth. Planning for investments in the sector should be in conjunction with population projections and available water resources.

(d) Funding

At present perhaps the most major constraint towards universal coverage in developing countries is the funding aspect. In India alone, it is estimated that the amount required for universal coverage at 1988 level was around Rs 88,500 million. This again is a rather underestimated figure as it does not take into account the rate of supply and distribution aspects. Clearly, Government alone cannot bear the burden for financing the sector. There has, therefore, to be a move towards sharing of costs and bringing in institutional finance. In order to attract institutional finance towards this sector, there has to be a reasonable rate of return which is expected from the investments made. There is no denying that cost recovery has been one of the most contentious issues in most of the projects funded in this sector by the World Bank. However, in a situation where at the beginning of the Decade water supply continued as a free service in most parts of the country, the realization has dawned that this factor, namely, levying user charges, has to be imposed for improving the sustainability of the project and bringing about greater accountability of the water supply agency. Emphasis on full cost recovery in a country like India, could become counter- productive and is less likely to be accepted by the community taking into account the low income levels and the high federal taxes. The cost of hardware does not vary with the size or the income levels in a given city as it is largely dependent on the distance from the source, its yield, the terrain, etc. Nor can we expect a situation where the Government can dictate where people should live and where they should not. In a study conducted in India, it was revealed that the present tariffs are so low that only if the ULBs double the present tariff rates and improve the collection performance to about 70 per cent (the present being only 30 to 40 per cent with the largest defaulter being Government Departments) can we hope to meet the operation and maintenance (O and M) costs.[7]

In this scenario it would therefore be realistic to expect a loan/grant mix for financing this sector. It is here that pricing can be used as an important tool for gearing up the sector. The fact that the water is not a free commodity when it is provided at the door step has to be driven home both to the consumers as well as the political leaders. Rationalization of tariffs should therefore involve a realistic assessment of the capacity to pay of the population to be served with graded systems so that higher slabs are imposed for those with house connections and large consumers. Subsidy has to be extended for the provision of water to those below the poverty line whom sheer survival is a primary occupation. The realistic tariffs with an automatic provision for periodic increase taking into account the rate of inflation and collection performance can be used as incentives for funding projects for the urban area concerned. It is expected that with such rationalization of tariffs, there would be a reduction in the wasteful use of the water on the one hand and on the other improved financial status of the water supply agency.

Pricing of water supply should therefore be on sound management principles taking into account the paying capacity of the population to be served and subsidies, if any, should be transparent. Slab systems for higher consumption would naturally impose a higher price on larger consumers who are normally the better off sections of the population and commercial and industrial units. There is no denying that large families belonging to the lower income levels may be hit equally adversely, but a graded tariff system is perhaps the least controversial for rationalizing the systems.

(e) Metering

Any such system of tariff realization can be effective only if there is universal metering. Stand post

[6] All India Seminar on Financing and Management of Water Supply Schemes, 1990-Journal.

[7] Study on Delivery and Financing of Urban Services – Operations Research Group, Baroda, India.

supplies should also be metered to prevent wastage and neglect. In India, considerable research and development (R and D) in this direction is necessary to make meters adaptable to intermittent supply which is prevalent throughout the country. Disincentives towards tampering will also have to be resorted to and imposition of the highest slab could be considered to prevent the same. This would put the burden on the water supply utility to ensure that the meters remain in working condition despite intermittent supply. Standardization of meters and improvement in their quality is essential for any movement towards financial strengthening of the ULB through cost recovery. In the South Asia region, we have to go a long way in this direction, as in a large number of cities water supply is still provided on a ferrule rate or not charged at all as it is subsumed as part of House Tax.

(f) Budgeting and accounting

In order to bring about greater efficiency in the sector and accountability, it is necessary to separate water supply budgets from the overall municipal budgets. In most ULBs in India, accounting systems continue on a cash basis with all revenues and expenditure lumped together. Larger metropolitan cities which have had exposure to World Bank projects have shifted to commercial accrual accounting systems. In the vast majority, however, cash accounting continues especially in "one horse towns" where an engineer/overseer is expected to perform all functions from street lighting to drainage as well as keep track of the collection performance from House Tax or other sources.

(g) Operation and maintenance

This is one sphere in the water supply sector which has remained neglected despite interventions of the World Bank and other multilateral and bilateral agencies. Improved performance in this sphere alone would go a long way in improving supply levels in most cities. Unfortunately, this facet is largely neglected and least attractive to the engineering fraternity who prefer capital works and further investments for augmentation. Maps regarding distribution networks are conspicuous by their absence, consequently leakages in the systems go unchecked leading to wastes apart from increases in unaccounted-for water. The average unaccounted-for water supply is almost as high as 40 per cent in India which is largely due to leaks and pilferage.[8] In a situation of dwindling safe water sources this factor should be of the utmost concern to all engaged in the supply as it almost amounts to criminal neglect. Investments should not be made in a city unless it has demonstrated better performances in O and M and reduction in the unaccounted-for water.

There are, however, complexities in the system which must be recognized for improving O and M performance. It is often the case that State level utilities execute large projects covering a cluster of towns which are then handed over to the urban local body for O and M and cost recovery wherever possible. There is, therefore, an imperative need for these ULBs to be involved right from the execution stage so that they are aware of what they will be expected to maintain and how far they will be in a position to recover the O and M costs. Sophisticated systems may become a dead investment unless the agency entrusted with its maintenance is equipped to handle the same. Here again community participation is of the utmost importance so that they are aware of the extra financial burden they will have to bear in case they require augmentation of supply levels.

Rehabilitation of existing systems in a large number of cities may obviate the need for further augmentation. While rehabilitation itself may be an expensive exercise but if we recognize water as a resource which is limited, the social costs may out weigh the financial costs in the rehabilitation of the existing systems accompanied with improved O and M. Once the level of service is improved the community may be willing to pay more as they are only concerned with the improved supply and not with the issue whether this augmentation is from a fresh source or through improved distribution and O and M.

(h) Technological options

While one has read a lot about "appropriate" and "low-cost" technologies the fact, however, remains that quite often what is appropriate and low-cost as an investment is high-cost in the long run due to high production and O and M costs. Long-term production costs should, therefore, also be taken into account while making investment decisions on the choice of technology. Easy availability of spareparts and repair facilities should be kept in mind before arriving at a decision on what is appropriate. This would equally apply to large projects for metropolitan cities, and prosperous urban areas. Sophisticated equipment has been imported which the utility is later unable to maintain as it may be technically ill-equipped to handle the same or need imported spareparts for maintenance. Consequently, even though technological upgrading through multilaterally assisted lending agencies is desirable, this should be accompanied by the upgrading of skills for maintenance and

[8] Seminar on Unaccounted-for Water Management, India from 7-10, November, 1991 – Sponsored by the Ministry of Urban Development, Government of India, UNDP-World Bank Water Supply and Sanitation Sector Development Team for Asia (RAS/86/160), IWSA, Foundation for Transfer of Knowledge, WHO South-East Asia Regional Office, Hyderabad Metropolitan Water Supply and Sewerage Board.

development of anciliary industries for the provision of spareparts, and replicaton.

(i) Water conservation

Taking into account the overall depletion of safe water sources, water conservation has to be accepted as a dictum. While graded pricing would be a step in this direction, large consumers of water, using municipal water in urban areas like factories, commercial establishments and hotels should be induced to bring in wastewater recycling practices to reduce the burden on municipal services. Tax concessions for wastewater recycling may provide the incentive in this direction. This, however, is easier to introduce and enforce in areas which are traditionally water scarce. In India, in a water short city Madras, industries are even willing to buy recycled water from the Madras Water Supply and Sewerage Board which also has strict legislation on groundwater exploitation. On the other hand cities in the north along the Indo-Gangetic belt have made little or no effort towards wastewater recycling. Apart from wasting precious municipal water such practices have led to an unchecked flow of effluents into the rivers. An example of this is the high pollution levels which has arisen in the River Ganges, the most sacred river of the country, along which are some of India's most ancient cities, the cradle of Indian history and civilization. A massive project has been launched under the Ganges Action Plan for the reduction of the flow of effluents from the urban conglomerates situated on its banks. Industries have mushroomed around these urban areas which have further aggravated the problem.

(j) Protection of water resources

Unchecked groundwater exploitation has led to an alarming decline in the water-tables throughout the country. Moreover, with a sudden upsurge in population flow to urban areas and increased industrialization, there has been an alarming increase in flow of effluents to the hitherto safe water sources. Towns have necessarily been forced to tap water sources from greater distances outside the natural environment. This often leads to the crossing of trans-State and transnational boundaries. Such distant tapping, apart from high costs, is highly energy intensive which our countries can ill afford. Protection of such water resources should therefore be an integral part of the National Water Policy.

Water supply schemes should necessarily be dovetailed with schemes on drainage and sanitation. By augmenting water supply we are naturally increasing the wastewater produced which, if allowed to flow untreatred to water sources, would lead to environmental degradation and contamination. Recycling of water and reuse for purposes which do not require potable water has to be ensured for water conservation and protection of sources. Pollution taxes should be imposed on industrial units which should be so designed that they induce recycling and reuse.[9]

(k) Emphasis on urban poor

Perhaps all developing countries face a major problem of burgeoning population in metropolitan cities more so due to migration of the poor from peri-urban and rural areas. Economic necessity is the basic driving force behind this large-scale migration which has led to mushrooming of slums and squatter settlements. Even though this segment of the population throws the urban planners out of gear, it must be recognized that they also serve a very important economic necessity of the urban area. It is estimated that more than 50 per cent of the population of the metropolitan cities in India belong to the lower income levels and 50 per cent of the urban poor are without any access to safe drinking water. It is in this sphere that success can only be achieved if greater attention is paid towards community participation especially with the involvement of women. It is the women of this lower income group that bear the brunt of water shortages, spend hours in bringing water from sources which may be at a considerable distance from their homes. While free stand-posts supplies have been provided in some cities there is a need for the introduction of minimal user charges for bringing about a greater sense of involvement. Any service which is provided free is least likely to be appreciated and maintained by the community as it remains the responsibility of the supply agency. Facilitators and voluntary agencies have necessarily to be involved for bridging the gap between community and the water supply agencies.[10] The priorities of these communities which exist barely at the subsistence level, have to be appreciated since provision of a safe water supply may not be a felt need initially for which they are ready to pay for. Unilateral imposition of charges may lead to the community reverting back to their polluted sources if hygiene education, the need for maintenance of the stand-posts and other related issues are not fully appreciated by the community. It is especially important to recognize while dealing at this level that water supply cannot be treated as an engineering exercise and needs a gigantic effort to mobilize the community towards self help and self reliance. In order to ensure sustainability, it is necessary that the community is involved right from the design stage and the location of the stand-posts. The system of "Pani Panchayats" or Water Councils in the State of

[9] Water Conservation and Pollution Abatement in Indian Industry – A Study on Water Tariff, National Institute of Public Finance and Policy, New Delhi.

[10] SEARO Regional Health Paper No. 9 – Achieving Success in Community Water Supply and Sanitation Projects. WHO Regional Office for South-East Asia, New Delhi, 1985.

Maharashtra, in India, have shown that the community, if properly motivated can take over the O and M of the stand-posts and recover the user charges from the consumer. Women in particular have necessarily to be involved as unsuitable locations and inappropriate designs would affect them the most. The feeling of ownership and the necessity of training for day-to-day maintenance has to be inculcated. Numerous pilot projects throughout the developing world have shown that the participation of women in such community-based projects has paid the greatest dividends. However, back-up support of the urban water agency should be easily accessible so that the credibility of the water supply "managers" is not undermined nor are the poor led to believe that the water supply agency exists for the benefit of only better-off sections of the society and the poor are left to fend for themselves.

2. Human resources development

Any sector policy and sectoral reforms will be meaningful only if the institutions which are expected to deliver are suitably strengthened. The provision of water supply no longer remains an engineering exercise and the engineer planner must work in tandem with the engineer who executes and the engineer who maintains, who in turn has to work in tandem with the accounts branch which will be expected to recover the user charges. This will only be possible if the decision making functions are re-oriented by making it more responsive to the community it is expected to serve. In other words, the basic principles of proper management have to be inculcated amongst the personnel expected to deliver.

Maintenance factors have to be given the primacy they deserve. No State level agency should undertake projects which are to be operated and maintained at the local level unless they have taken the local authorities along with them. The engineer, the plumber, the accountant should be involved right from the initial stages and imparted the requisite training.

Induction of new technologies should be accompanied with training in O and M. We need to go back to the training curriculum right at the college level so that the training of engineers in this sector does not merely concentrate on the engineering exposition but has a strong sociological backing as this is one sector whose success or failure affects every man on the street.

Along with the engineering branch there has to be re-training of the accounts branches of all the ULBs. A strong emphasis on maintenance of proper accounts with regular audit is integral for improvement in sector performance. Separation of accounts for the water supply sector and accounting on sound commercial lines would involve a vast training network for the urban local body. This can be easily organized at the State level as there is no shortage of expertise for the same in the countries of this region. Software has been developed for proper billing and collection and with minimal training this function can be easily computerized. Once an incentive environment is created for improved billing and collection, only then can any marked improvement be expected in performance.

In general, unless we provide motivation and better training for the man who is expected to deliver it would be difficult to expect changes in sector performance no matter how sound the policy.

3. Private sector participation

In a situation beset by inefficiencies right from the planning, execution to the delivery stage, there is little likelihood of the private sector being attracted to the provision of drinking water supply at the present juncture. The private sector will obviously not enter the field for charitable purposes and systems would have to be developed to ensure that even in a green field situation for development of new townships, where the private sector may be involved, the poor do not remain unserved and that the lucrative areas get primacy in supplies. In India, the private sector has been involved in isolated spheres to function as mere contractors in areas like billing and collection on a commission basis, maintenance of treatment plants, etc. There is obviously a long road ahead before we can visualize private sector participation in this sector which may need changes in the legal framework since provision of water supply remains at present a statutory service of the local body.

4. Need for regional and internationl cooperation and external support

While each country in the developing world has learnt its own lessons from IDWSSD, there is a greater need for cooperation at the regional level extended to an international network so that those countries with similar problems of rapid urbanization and depletion of safe water sources can benefit from greater sharing of experiences. This networking would be possible only with External Support Agencies (ESAs) assistance. Workshops for such experience-sharing and documentation of success stories by multilateral agencies for circulation to all developing countries would be a major step in such experience sharing. Technology transfer between developing countries would be of utmost importance so that we are in a position to share from the experiences of those placed in a similar situation. ESAs

should, therefore, encourage regional and interregional exchange of technology. The use of expatriate consultants from the developed countries should be highly selectively inducted in the sector. Apart from such consultants being high cost, despite the need for upgrading of technology, they have often been known to bring in inappropriate designs which the country is not equipped to handle and becomes counter-productive in the long run.

The ESAs can also play a greater role in the sphere of human resources development. The training need of our countries is immense. While we may not need further induction of personnel, upgrading of skills and methodologies for improving the incentive environment would go a long way in improving sector performance.

Moreover, with the resources constraints faced by most countries there should be a greater step up in financial resources being provided to this sector. In India, barely 3 per cent of the investments made in this sector are from ESAs and is only confined to the assistance from the World Bank. For some reasons, bilateral agencies have shied away from the urban sector and have concentrated on rural and poverty related programmes only. Considering the magnitude of the problem, there has to be a recognition that greater assistance is needed to the national governments for fulfilling the objective of Safe Water 2000.

5. Conclusions

There is no denying the fact that the problem as it exists is alarming and with future increase in urban populations, unless hard decisions are taken at this juncture, we may reach a point of no return. Rise in urban violence, crime, drug abuse, etc. are only manifestations of rapid urbanization without correlation with improved infrastructure. The provision of safe water is one of the basic human needs for the development of any healthy society. Efforts, therefore, have to be made for developing sustainable services which will be possible only if hard decisions are taken at this juncture. Funding and finances remain the greatest constraints and, while recognizing the need for greater resources generation through cost recovery, it must be appreciated that the capacity to pay is limited. There has been an emphasis from the World Bank and other funding agencies on projects being taken up only in areas where the population has the "willingness to pay". While we endorse the view point that water supply should not be provided as a free service, however, the ground realities about the paying capacity should not be ignored. The higher income groups which hardly form 5 per cent of the total population in India can hardly be expected to pay for the entire service. The middle income groups form about 30-35 per cent and are the ones which bear the burden of high federal taxes, rising inflation and inelastic incomes. There is a cushion which can be tapped for raising the resources for the water supply agencies but this cushion is not sufficient to meet the entire cost of the investment and delivery.

Lastly, the acid test would remain the man at the grassroot level. Unless we can create an incentive environment for better performance through upgrading of skills leading to improved O and M, billing and collection, no amount of efforts in providing appropriate technologies and adequate supplies would lead to provision of sustainable services.

B. PRIVATIZATION OF WATER SUPPLIES - MALAYSIAN EXPERIENCE*

Introduction

The Government of Malaysia introduced the privatization policy in this country in 1985. This policy is aimed at privatizing, completely or partially, selected Government owned services and enterprises. The Economic Planning Unit of the Prime Minister's Department, which is the Government agency responsible for spearheading privatization, also drew up various guidelines on privatization for the reference of both the Government agencies and the private sector. Among others, water supply has been identified as one of the services suitable for privatization. The guidelines set out the Government's objectives of privatization, the various forms of privatization, the identification and selection of canditates for privatization, specific issues relating to privatization in Malaysia and the institutional machinery for privatization. Since then the country's achievement in the implementation of this policy is quite credible. However, there are still many areas which need to be understood more clearly by all the parties concerned and also where improvements can be made in order to strengthen the privatization programme and to ensure a greater success in the implementation of the privatization policy.

This paper outlines the progress made so far in the privatization of water supplies in Malaysia and the extent the policy objectives have been realized along with some of the problems and obstacles experienced. The paper also highlights some approaches, which in the view of the author, may be adopted for smoother implementation of the privatization of water supply.

1. Objectives of privatization

The main objectives as set out in the Government's guidelines are as follows:

(a) Relieving the financial and administrative burden of the Government

Public water supply in most developing countries like Malaysia is undertaken by the Government because it is an essential service. It also involves large capital investment and is quite often uneconomical to operate. However, as countries develop living standards increase, thereby increasing the per capita demand for adequate and safe water supplies. People also expect a higher quality of service. Governments are therefore continually faced with a heavy financial and administrative burden to meet this demand. One of the ways to overcome this problem would be to bring in the private sector to play a greater and active role in the ownership, management and financing of public water supplies, i.e. to privatize the water supply services. It would also allow free access to private sector capital markets through equity and joint venture participations for the building of new facilities as well as upgrading and improvement of existing facilities.

(b) Promoting competition, raising efficiency and productivity

Privatization would remove the restrictive rules and cumbersome procedures inherent in a Government department which stifles decision-making. The removal of formalities and exposure to the competitive forces of the open market would provide the spur towards raising efficiency and productivity. This is true in all sectors including the water supply sector.

(c) Accelerating the growth of the economy

Increased role of the private sector in development thereby increasing private investment in the economy through privatization would contribute towards higher growth. The commercial and profit orientation of private enterprises would also mean additional revenue for the Government to finance its development plans.

(d) Reducing the size of the public sector

The water supply industry in the public sector domain is continually plagued with the problem of staff shortage either in numbers or by way of the necessary trained professionals and skilled workers. This is further aggravated by the Government's policy on the cut-back on staff recruitments over its concern on the increasing size of the Government service. Staff salaries now constitute the single largest expenditure in the Government's budget. Privatizing water supplies would not only contribute towards achieving this objective but also allow flexibility in staff recruitment.

* This paper was prepared by V. Subramaniam, Selangor Water Supply Department, Malaysia, at the request of the ESCAP secretariat.

2. Present administrative and financial arrangement of public water supplies

Malaysia comprises 13 States and 2 Federal Territories. Constitutionally, water supply is a State Government matter. Each State Government finances the construction of new water supply projects and operates the supplies through either the State Public Works Department or the State Water Departments with the exception of five areas where there are Water Boards.

The Water Supplies Branch at the Federal Headquarters of the Public Works Department (PWD) functions as a Federal agency responsible for the planning and design of water supplies and for giving technical guidance and advice to the State PWDs and the State Water Departments. It coordinates all water supply projects funded by the Federal Government by way of Federal loans or grants. Water supply in the Federal Territory of Labuan also comes directly under the Federal Headquarters.

Most water supplies are operated on a small deficit and are subsidized by the State Governments. The Federal Government assists the State Governments by way of grants or low interest loans for capital works. Some big projects are also financed by the Asian Development Bank or the World Bank. In recent years, owing to budget constraints, the Federal Government has been gradually reducing its financial assistance to the State Governments for the development of water supplies and gradually increasing its promotion of privatization of the public water supplies.

3. Developments in the privatization of water supplies

Apart from the six or seven forms of privatization envisaged by the Economic Planning Unit in its guidelines to the Government Agencies and the private sector, all possible forms of privatization applicable to water supply and their peculiarities as distinct from privatization of other services have been discussed in several seminars and forums participated in by local and foreign professionals. While private sector participation in the water supply industry may eventually cover many areas, privatization of water supplies in Malaysia at the present time is mainly confined to the following three forms:

(a) Management or Service Contracts,

(b) Build - Operate - Transfer (BOT) Contracts, and

(c) Mixed Management and BOT Contracts.

To date, the following water supply projects/ schemes that have been privatized are of the following forms:

(a) Management or service contracts

This form of privatization involves transfer of the management, operation and maintenance of existing water treatment plants or those newly constructed by the Government to the private sector.

The operation of 10 water treatment plants and a groundwater abstraction tubewell system has been privatized in this form. The privatization of the operation of the 545 million l/d Sg.Semenyih water treatment plant in the State of Selangor supplying water to the Klang Valley some seven years ago is an example of this form of privatization. The private company awarded this contract is now entirely responsible for the operation and proper maintenance of the plant. It also assures all the risks involved in the normal operation of the plant including the repair and/or replacement of the facilities. However the contract allows for adjustments due to fluctuations in the price of chemicals and electricity. In return the Government pays the company a fixed rate for the supply of water in bulk during the concession period. The contract also envisages a penalty if the company fails to supply water in accordance with the specified quantity and quality. The contract was initially for a period of five years but has been extended for a further period of five years. At the end of the contract period the company has to hand back the plant to the Government in good working condition.

There are also two other contracts given solely for the supply of management staff and labour for the operation of water treatment plants. In these cases, the Government pays for all the chemicals and electricity consumed as well as for the maintenance of the facilities. The Government also bears all the associated risks in the operation and maintenance of these plants.

(b) Build - Operate - Transfer (BOT) contracts

In the BOT form, the private company finances the complete construction, operation and maintenance of the water supply project over a fixed concession period.

Only one project, i.e. the Labuan Water Supply Project has so far been privatized in this form. Under the terms of this privatization contract the company is fully responsible for the design and financing of the construction of the project as well as the subsequent operation and maintenance of the project over a concession period which is of 13 years inclusive of the construction period. Upon completion of the project, the

Government purchases water in bulk from the company according to scheduled quantities. The Government pays the company in two parts for the purchase of water. The first part consists of a guaranteed monthly payment to cover the company's investment costs, financing costs and overheads. The second part consists of a variable monthly payment dependent upon the quantity of water delivered. This payment is for the chemicals and electricity consumed and also takes into account fluctuations in the prices of chemicals and electricity. The contract also carries a penalty for failing to supply water in accordance with the specified quality or the minimum scheduled quantity. At the end of the concession period the company hands over the entire facility to the Government free of charge in good working condition.

A significant feature of the contract is that the company bears all the risks associated with fluctuating construction costs, financing costs, foreign currency exchange rates and technical problems resulting in additional variations or any delays during construction.

(c) Mixed management and BOT contracts

This form of privatization is really a combination of the two forms described earlier. In this case, the private company takes over the operation of existing water treatment plants and undertakes the financing and construction of new facilities to meet additional water demands over a fixed concession period. Revenue to the company is still through the bulk sale of water to the Government during the concession period.

Four such contracts have been awarded, two in the State of Perak, one in the State of Johore and one in the State of Sabah. The concession period for all four contracts is 20 years. The price of water changes with the phasing in of the new facilities in the Johore project. In the case of the contracts in Perak and Sabah, these prices together with the phasing of the works have been fixed at the time of awarding the contracts which means that the company bears the risk of inflation over the 20 years but has the benefit of timing the construction of the new facilities depending on actual water demand. However, in Johore's case, the company is paid the new price for water only when the investment for the construction of the new facilities takes place which also takes into account inflation at that material time. To date existing water treatment plants of a total production capacity of 2,150 million l/day have been privatized in the above forms. This represents approximately 30 per cent of the total supply capacity in the country. New water supply projects costing about $M 1.5 billion have also been privatized in the BOT and mixed management and BOT forms providing an additional water supply capacity of 1,100 million l/day.

4. Success/benefits of privatization

The success of the implementation of the privatization policy can be judged from the extent of achievement of the objectives set out in the policy. As mentioned earlier, the main objectives of privatization are to raise efficiency and productivity, relieve Government's financial and administrative burden and reduce the size of the public sector.

(a) Efficiency and productivity

Despite the limited time and experience in privatization, it is clear that in all the projects so far privatized, privatization has led to increased efficiency. For example, all the privatized water treatment plants have been operating very efficiently. It is imperative that the private operators keep their production costs low by cutting down on wastage, improving on the treatment process in order to save chemicals and electricity and optimizing labour so as to maintain profit levels as high as possible since the price of water is fixed. Further, the standard of operation and maintenance of the facilities concerned has vastly improved due to the higher level of staff employed in the plant. There has also been little or no breakdown of the facilities due to the fault of the operators. In the case of the Labuan Water Supply project which included the laying of some 45 km of submarine steel pipeline through swamp and across the sea, the project was completed 6 months ahead of its original schedule of 18 months. The Government and the consumers benefitted by having the crucial additional water supply in Labuan early. The company in turn benefitted from the earlier completion of construction in terms of better returns on its investments.

(b) Financial and administrative burden

Privatizing services may not necessarily result in the service being cheaper. Even taking into account increased efficiency and productivity the net effect of a privatized service is usually more expensive than a Government operated one. This is because there are a lot of "hidden" costs such as insurance and corporate costs which now have to be borne by the private sector. Further, the private sector has to allow for higher financing costs and all the associated risks, taxes and profit. Hence it is a question of whether these additional costs should be passed on to the consumers, hopefully with higher level of service in return, or it should be borne by the Government. So far in practically all the cases except in the case of the Labuan Water Supply Project, the Government has succeeded in relieving itself of the financial burden. In the Labuan case, however, the

Government has decided to carry the financial burden and subsidized the Project without increasing the water tariff to the consumer.

In the case of the privatized operation of the treatment plants, the additional cost of the privatized service is simply passed on to the consumers or it comes out of the Government's revenue from the sale of water. Hence the Government is not burdened further for providing an improved level of service. However, the impact of this additional cost on the Government's revenue should be studied carefully in order to avoid the Government still having to ultimately subsidize the privatized services in this case as well.

In all these cases, it is also evident that the Government is relieved of its administrative burden as its role in the privatized projects is confined to that of supervision and regulation which only require minimal manpower.

(c) Size of public sector

Privatization has overcome the problem of having to recruit additional staff into Government service to operate and maintain both the new and existing facilities. It has also helped to overcome staff shortages in that existing personnel can now be deployed to look after other facilities which are not privatized and which are also expanding. Generally, the level and quality of staff operating the privatized facilities are seen to have improved vastly due to the flexibility in staff recruitment in the private sector. This is important to ensure that the facilities are operating well and supplying good quality water in the long term at minimum cost.

5. Problems of privatization and suggested new approaches

Eight years of implementation of privatization of water supply have brought to light several problems that have to be overcome to ensure a greater success. Some of these problems are summarized as follows:

(a) Economic viability of project for privatization

There has been a tendency among some Water Supply Authorities to privatize water supply projects for which they have no budget, irrespective of whether or not the project is viable. They seem to work on their erroneous assumption that once they privatize these projects, the private sector with its better efficiency will be able to solve their problems including those of financing. This is not always true for everything has its cost. The private sector has to raise funds to execute their project and sometimes the private sector's cost may require the pricing of the sale of water to be much higher than the current State water tariff in which case the State may not have the cashflow to pay for the project even on a BOT basis. To avoid inexperienced privatization operators spending time and money to analyse the suitation, it may be better for the Water Authority to assess the economic viability of any project and the State's affordability to pay before deciding to privatize it.

(b) Criteria for invitation of privatization proposals

Two very important criteria that have to be satisfied before any Water Supply Authority embarks on the invitation to the private sector to submit privatization proposals are:

(i) there is an urgent need to implement the project;

(ii) there is exclusivity provided to the company invited to study and submit proposals.

If these criteria are not met it can result in the private sector wasting a lot of time and money putting up proposals. If a Water Authority has a genuine need to privatize a project it should invite the private sector to apply for prequalification. After prequalification, only one company should be invited to carry out a detailed study and submit a proposal so that the other companies not so well qualified need not be made to spend time and money on the project.

(c) Financing of water supply infrastructure

Relatively, the local banking circle is still quite inexperienced in providing financing for Government infrastructure projects as compared to international lending agencies like the World Bank and the Asian Development Bank. Because of this lack of experience local banks tend to equate Government infrastructure projects with, for example, housing projects which they have been financing. Government water supply projects are low risk in terms of financing since the buyer is the Government, the business is a monopoly and the water sale is always on the increase, whereas the housing and other similar development projects is subject to the ups and downs of the market trend resulting in high risk of financing. Yet the current trend among most bankers is to assign the same risks and interest terms to water supply projects as housing and other similar development projects. Further, the financier requires the whole works including pipelines which make up the greater part of the project cost to be insured against all risks. Hence the cost of financing of water supply projects has been unnecessarily increased. A review of the financing policy for water supply projects among local bankers is necessary.

(d) Impact of existing taxation laws on privatization

The current tax laws do not take into account their effects on privatization. Under the current tax laws, income from BOT projects are not tax deductible even for the loan repayment component. Also depreciation of assets is also not permitted for tax deduction. Hence BOT projects have to be priced higher to include the 35 per cent corporate tax payable. This tax is invariably passed on to the consumer. The tax laws should be reviewed so that the consumers need not bear the burden of additional taxes upon transfer of management and operation from the Government to the private sector.

6. Conclusions

Privatization of water supply in Malaysia has been confined mainly to management contracts, BOT contracts and a combination of these two. To a great extent privatization has been successful because consumers are able to enjoy a higher level of service without very high increase in cost to them. The Government has also benefitted in being able to keep within limits the size of its staff despite increase in the number of facilities constructed. The Government has also been able to cut down its development budget on water supply.

The next area of privatization of water supply is the distribution system which so far does not appear to be attractive to the private sector. Serious thought has to be given to this as the distribution system with its high non-revenue water levels urgently needs the participation of the private sector which is acknowledged to be more efficient.

Even in similar projects which have been successfully privatized there is room for improvement and problems to be resolved such as the need to check on the economic viability of the project prior to privatization, setting the right criteria for the invitation of privatization proposals, review of financing terms and policies by local bankers and review of the tax laws by the Authorities to encourage privatization and to lower the cost of the privatized services to the consumer.

Chapter III. URBAN SANITATION AND WASTEWATER MANAGEMENT

A. URBAN SANITATION IN ASIA AND THE PACIFIC – ISSUES AND EMERGING TRENDS*

Introduction: The urban development challenge

Demographic projections indicate that by the year 2000, Asia will have 13 of the world's 25 mega-cities, with populations of 10 million or more. During the period 1950 to 1980, cities like Bombay, Dhaka, and Jakarta tripled or quadrupled their population. Moreover, cities are increasingly serving as centres of industrial growth and as catalysts for economic activities. Due to the massive increases in population, capital, information and technology, the mega-cities have a profound impact on development in the region. The trends are expected to increase the extent, complexity and cost of sanitation service provision in the region. Increasing discharges of industrial wastewater and the need to better protect available water resources point to the need to seriously appraise sewerage, drainage and solid waste disposal. As all these impact on one another, there is a need to address these issues in a comprehensive manner, within a longer-term national, regional and city planning framework.

While economic growth has been impressive in Asia, it has not lessened the plight of the poor. It has been estimated that there are more than one billion people in the developing world living in poverty.[1] Nearly half of the world's poor live in South Asia, a region that accounts for roughly 30 per cent of the world's population. In urban areas, many of the poor live in slums and squatter settlements. These areas often do not have the basic necessities of proper water supply and sanitation facilities. These informal settlements are growing at an alarming rate. In some countries, 25 to 50 per cent of the population is believed to be living in informal settlements. It is often this group that suffers most from the consequences of pollution and environmental degradation.

The World Health Organization (WHO) defines "sanitation" to embrace water supply, excreta and sullage disposal, solid waste disposal, food hygiene, vector control, and the hygiene of housing. However, during the two-year World Bank research on appropriate sanitation technologies, it was decided to use the term in a narrower sense to embrace only "the collection and disposal of excreta and wastewater from private and public places". In this definition, we include domestic, commercial and industrial sources in "private places". For the purpose of this paper, the narrower definition is used.

The growth in sanitation coverage has generally lagged behind that of water supply. The unit cost of providing sanitation facilities and services is also much higher than that for water supply. The need for large investments by governments continues to put a severe strain on resources. The last decade has been a difficult period for domestic resource mobilization. It has also been an unfavourable time for increasing external resources. Estimates for all governments and external support agencies' investment in the water and sanitation sector indicate an average of US$ 14 billion per year for the period 1981-1985 (WHO) and an average of US$ 9.3 billion a year for the 1985-1989 period. Sector costs will be even higher in the 1990s. It is estimated that approximately US$ 50 billion a year would be needed to reach full coverage by the year 2000, using conventional approaches.

1. Issues in urban sanitation

(a) Conventional approach

Up to only very recently, urban sanitation has been mainly focused on the "conventional approach." This vision of urban sanitation was simple: there was one proven technology, conventional sewerage, which was used as the basis for preparing master plans to cover the entire urban area. During implementation, this technology was applied to the largest possible area until financial resources were exhausted; and the consequences were disastrous: low coverage, low connection rates, poor functioning of the physical infrastructure, and gross

* This paper was prepared by Wilfrido C. Barreiro, Mary Judd and Richard Cross, UNDP-World Bank Water and Sanitation Program, at the request of the ESCAP secretariat.

[1] *The World Development Report 1990* estimates that this is the number of people who are struggling to survive on less than US$370 a year.

environmental pollution.

The high cost of conventional sewerage, coupled with relatively low incomes in developing countries, was identified as one of the primary reasons for these consequences. On an average, the per capita capital cost of conventional sewerage is in the order of US$ 350 to US$ 500 or three to four times the capital cost of water supply. And the majority of the population in most developing countries is not in a position to pay this much; in 1985, about one-third of the developing countries population (over one billion people) lived on less than one United States dollar a day.

Consequently, only a few cities have been able to implement master sewerage plans based on conventional sewerage. Where such plans have been implemented, the poor are typically the last in line to be served; moreover, they often pay more than the rich for less satisfactory services. The heavily subsidized sewerage systems therefore often serve only a small minority of the population in the high income group (it serves only 15 per cent of the population in Bangladesh, and 16 per cent in metro Manila, the Philippines; in other places it serves even less).

In several places, the public component of sanitation lags well behind the private component, thereby resulting in gross environmental pollution. In many coastal cities, for instance, sewerage systems are designed to discharge raw sewage directly onto ocean beaches. In other places, growing water consumption has necessitated heavy usage of septic tanks under conditions of high population and housing densities, leaving inadequate space for on-site disposal of the septic tank effluent. Notable examples are Jakarta, Indonesia, and Metro Manila, the Philippines, which have 900,000 and 600,000 septic tanks, respectively. In Metro Manila the 600,000 septic tanks serve 4.8 million out of the 8 million people in the area. The septic tanks have no soil absorption systems, and they are not dislodged regularly. Consequently, their effluent are discharged, along with their sludge, into the inland waterways, typically through the existing storm drainage systems. They are therefore a major source of the pollution in the area. They contribute pollution load of an estimated 150 tons of biochemical oxygen demand (BOD) per day into the inland waterways.

(b) Impact on health

Urgent attention is required, because in terms of the health of urban dwellers, inadequate sanitation is one of the most serious environmental problems facing the region today. There are over 50 communicable diseases associated with poor sanitation and they bring untold suffering and premature death to millions of people every year. Yet a key to their control is improved sanitation, as demonstrated in a recent study by the Water and Sanitation for Health (WASH) Project of the United States Agency for International Development (USAID). They studied six diseases which are either wide-spread in the developing countries or constitute serious problems where they exist, or both; and their findings were as follows:

(i) 875 million cases of diarrheal diseases per year, of which 4.6 million, mostly children, end in death;

(ii) 900 million per year of ascariasis, of which 20,000 end in death;

(iii) 500 million cases per year of trachoma, of which 8 million end in blindness. In addition, the incidence of hookworm, schistosomiasis, and guinea worm are, respectively, 800 million, 200 million, and 4 million per year.

It was concluded from the studies that "as far as reducing the incidence and severity of these six diseases was concerned, the most effective intervention was safe excreta disposal, yet sanitation lags behind water in almost every developing country".[2]

(c) Impact on the poor

In addition to economic and health reasons, environmental improvement in urban areas has strong social justification, as it is intimately related to poverty alleviation. Pollution problems tend to affect the poor in disproportionate ways, because of their lack of means to engage in private mitigative actions. While more affluent groups can afford to move into less polluted neighbourhoods, it is generally the poor who bear the burden of living near polluted waterways, in areas without adequate sanitation facilities, and in crowded quarters which promote the spread of disease. The poor also tend not to speak up for themselves and are unable to lobby policy makers and law enforcement officials.

(d) Development of low-cost alternatives

The constraint caused by the high cost of conventional sewerage prompted a search for low-cost alternatives to conventional sewerage. The World Bank, the United Nations Development Programme (UNDP)-World Bank Programme and a number of bilateral agencies played a leading role in this effort.

[2] Esrey, S.A., and others (1990) "Health Benefits from Improvements in Water and Sanitation", Water and Sanitation for Health (WASH) Project of USAID, Arlington, Virginia, United States of America.

In 1976, the World Bank started a two-year research project to identify alternatives to conventional sewerage (Kalbermatten and others, 1982). This research showed that a wide range of lower-cost options existed between conventional sewerage and the traditional pit latrine. Out of this research has re-emerged two on-site technologies: the ventilated improved pit (VIP) latrine and the pour flush latrine. The cost of these alternative technologies was low, 4 - 10 times less than conventional sewerage; they provide good service, privacy, convenience, few odours or flies; they were simple to install and maintain; they required little or no water for their proper function.

(e) Outstanding issues

In spite of the advances made, two issues still remained. One was the limited range of available technologies. The research had produced two extremes of technologies, conventional sewerage and on-site technologies for high and low-income communities. There were situations where the on-site technologies cannot be used: high housing or population densities; high volumes of wastewater arising from improved water supplies; and soils with low permeabilities. Besides, there were no intermediate technologies to meet the demands of middle income groups.

The other problem was the traditional focus on "supply side" issues in making investment choices. Planners focused on such issues as estimation of costs of construction, definition of city terrain, current population, water consumption rates, etc. Master plans were generally prepared based on the assumption that all would eventually connect to sewerage. Little attention was paid to consumer preferences. This focus on supply orientation is, however, not limited to sanitation. In a recent World Bank study of the status of infrastructure in developing countries[3], it was concluded that the supply orientation and other measures traditionally pursued to enhance productivity of infrastructure have not proved successful; and that a new approach is needed which focuses on enhancing the demand orientation and consequently the accountability of services. This is defined in the report to mean a closer attention by operators to the nature and pattern of demand--to markets --and an increased role for clients, users, or beneficiaries in the planning and operation of the services.

3 Aturo Israel, "Issues for Infrastructure Management in the 1990s", World Bank Discussion Paper, Washington DC, 1992.

Thus, two challenges remained to be addressed:

(i) expanding the menu of supply options, with particular emphasis on lower-cost sewered options for the increasingly common urban situations where on-site systems were inappropriate; and

(ii) incorporating demand considerations (i.e., what users want and are willing to pay for) in investment decisions. For technology selection, this implies that "the final step in identifying appropriate sanitation technology must rest with the eventual beneficiaries. Those alternatives that have survived technical, health, social, and economic tests are presented to the community with their corresponding financial price tags, and the users must decide for which level of service they are willing to pay" (Kalbermatten and others, 1982).

2. Emerging trends in urban sanitation

(a) Supply-side advances

During the past decade, major advances have been made in both the supply and the demand dimensions. On the supply side, there have been breakthroughs of two kinds. The first is the development of a set of innovative "intermediate sewerage options such as amplified sewerage, solids-free sewerage, and condominial sewerage." The second development is the recognition that each supply option is uniquely defined not only by its technology, but also in terms of the nature of its provider; the provision could be by a public or private sector; alternatively, it could be through self-provision or through community-involved provision. These breakthroughs have led to a much wider range of supply options, thereby improving access to adequate services by a wider range of income groups, including the poor.

(b) Wastewater treatment

Treatment plants to date have been set up to treat wastewater to a relatively lenient discharge effluent standards when compared with that required by more developed countries. However, this situation is changing as more countries in the region raise their standards of effluent discharge to combat the rising level of pollution of their waterways. Treatment processes in common usage in the region consist of the following:

(i) Stabilization ponds;

(ii) Aerated lagoons;

(iii) Oxidation ditches;

(iv) Conventional activated sludge;

(v) Upflow Anaerobic Sludge Blanket (UASB);

(vi) Anaerobic digesters (with or without heating).

These processes are generally appropriate in their own particular applications. Stabilization ponds and aerated lagoons requiring large amounts of land are theoretically not suited for many of the congested countries in the region. However, their simplicity, and low cost of operation compensates to the extent that they are frequently selected. The stabilization pond requires little or no power compared with the aeration lagoon. The oxidation ditch requires considerable power but relatively small amounts of land. Much the same remarks apply to activated sludge. The UASB is proving appropriate in both India and Indonesia. It has the advantage of low power requirements, low sludge production, low land requirement and the production of an above average standard of effluent. The anaerobic digester has proved itself well suited to the particular conditions existing in India and China. It is also used in Pakistan, Nepal and the Philippines. The gas produced by the process is exploited in all countries as a useful source of energy.

Several countries in the region are planning comprehensive wastewater treatment facilities for the cleaning up of river systems of human and industrial water pollution. Examples are: Thailand, which is badly affected by seasonal droughts; Indonesia, which is cleaning up the large river basin upstream of Jakarta; Malaysia on the Sarawak River; China, in the vicinity of Hong Kong. Both Thailand and Indonesia are planning the sewering of certain cities to protect their tourist industries. Rawalpindi, in Pakistan, is setting up its first independent water and sanitation authority.

(c) Resource recovery

Resource recovery from excreta or polluted water is practiced in Malaysia, Thailand, Viet Nam, Indonesia, India, China and Singapore. A commonly used approach has been in aquaculture. Aquaculture involves the production of nutrients from fish or plants which feed on various forms of wastewater (sludge, fecally polluted surface water, septic tank effluent, sewage, etc.). Common approaches are overhung toilets, cartage, fecally polluted water, sewage and aquaculture. Overhung toilets are common in Malaysia, Viet Nam, Indonesia and India. However, in Indonesia, recently introduced government policies to protect the environment are tending to prohibit this approach. Cartage is commonly practised in Malaysia, Singapore and China. Fecally contaminated surface water is most commonly used in Indonesia. One example being the use of bamboo cages to contain fish which are located in the highly contaminated stream waters of Bandung, a very large inland city upstream and in the drainage basin of Jakarta. Sewage aquaculture is widely practised in India, China and to a limited extent in Indonesia (also in Bandung). Research and detailed studies into the use of aquaculture have been carried out primarily in India, Thailand and Indonesia.

Another approach to resource recovery used in Indonesia is the production of household bricks from hazardous waste sludge. This approach, still in the experimental stage, looks promising.

(d) Demand-side advances

On the demand side, the breakthrough occurred when methods that are used in developed countries for assessing demand for environmental quality were applied to the problem of assessing demand for sanitation services in developing countries. This development was based on work done by the World Bank on the "contingent valuation method" for estimating consumer willingness to pay for water supply[4] and by the UNDP-World Bank Programme in projects in Kumasi (Ghana)[5], Gujranwala (Pakistan)[6], and Ouagadougou (Burkina Faso).[7] The contingent valuation method involves asking individuals what they would do and how much they would pay if faced with a hypothetical choice.

(e) Other advances

In-country Coordination and Intercountry Cooperation. The rapid development in the region and the increased resultant pollution of all forms has placed great pressure on water resources and their protection from pollution. Countries are finding that they must coordinate such activities as environmental pollution

4 Briscoe, J., and others (1990). "Toward Equitable and Sustainable Rural Water Supplies: A Contingent Valuation Study in Brazil, "The World Bank Economic Review. Vol 4, No. 2, pp. 115-134.

5 Whittington D. and others (1992) "Household Demand for Improved Sanitation Services: A Case Study of Kumasi, Ghana". Water and Sanitation Report No. 3, UNDP-World Bank Water and Sanitation Programme, World Bank, Washington D.C.

6 Altaf, M.A. (1992) "Household Demand for Improved Water and Sanitation in a Large Secondary City: Findings from a Study in Gujranwala, Pakistan." Forthcoming, UNDP-World Bank Water and Sanitation Programme, World Bank, Washington D.C.

7 Altaf, M.A. and J.A. Hughes (1992) "Willingness to Pay for Improved Sanitation in Ouagadougou, Burkina Faso" Forthcoming, UNDP-World Bank Water and Sanitation Programme, World Bank, Washington D.C.

control, development of water resources and waste discharges. Viet Nam, with common borders with many countries is a prime example. Joint development of water resources is being carried out by Indonesia with Singapore and with Malaysia.

Environmental Pressure Groups. Several countries in the region (India, Indonesia, China and others) have been under the influence of the environmental movements both within their respective countries and from outside. This has already influenced development decisions and policies and it can be expected to increase in the future. In support of these movements the *World Development Report 1992* of the World Bank had environmental pollution as its theme and drew attention for the need for serious and concerted action by most countries in the region.

Governments (through tax receipts), with some external assistance, bear the major part of the development expenditures. This, however, is changing as communities themselves raise their standard of living through greater earning capacity. Because sanitation is a direct service, costs for the service can be made more equitable by shifting it away from the tax system and into a direct tariff system. Governments are finding that the burden of sanitation investment is greater than they can handle alone and, in many cases, the communities are capable of carrying a greater share of the burden.

3. Institutional framework and capacity building for urban sanitation

The Delhi Statement of the Global Consultation on Safe Water and Sanitation for the 1990s views institutional reforms and the full participation of women as one of the four main guiding principles in achieving sector objectives. Institution includes the full range of organizations involved in the sanitation sub-sector: municipal departments or public utilities; health and public wastes departments; local government; non-governmental organizations (NGOs); formal and informal private sectors; and community groups.

A major issue for the International Drinking Water Supply and Sanitation Decade has been the institutional one--determining the roles of the public sector, the private sector, and the community itself in the provision of water supply and sanitation services.

An overall objective for the sanitation sub-sector is achieving sustainable facilities which are used effectively by the beneficiaries. This means that the role of government has to change from that of provider to that of promotor and facilitator in order to promote a friendlier environment of appropriate policies, legislation and incentives which will enable public, private and community organizations to participate in service delivery. At the same time, the pace of decentralization has to increase to allow local bodies to assume a greater role in managing their own affairs.

The current macroeconomic crisis faced by many developing countries requires that some vertical "disintegration" in decision-making is essential. Sewerage, being a capital intensive investment will always have heavy involvement of the public sector.

First, in conventional sewerage organizations – where the public sector involvement is inevitably high – the situation can be improved by decentralizing operational decisions to the level or tier responsible for service delivery. In combined water and sanitation organizations, for example, the sewerage division could be recognized as an independent responsibility (if not a profit) centre. Second, responsibilities for service provisioning could be delegated wherever possible: through the market if incentives for private sector participation are available, and through beneficiaries assuming a more active role. Unless a demand focus is maintained, however, delegation of responsibilities to either the private sector or to the beneficiaries will not succeed.

With decentralization of responsibilities comes the need for capacity building. This is a complex process involving policies, institutions, and people. At the policy level, capacity building means improving "rules" governing the sector, as well as the regulations and practices that define the "enabling environment" within which sector development occurs. Capacity building also means enhancing the performance, variety and numbers of organizations active in the sector, and strengthening human resources throughout the sector.

(a) The role of the public sector

The role of a coordinator, regulator and facilitator become the key elements of the work description of sectoral institutions involved in either on-site or off-site sanitation infrastructure. The following lessons for institutional design can be derived from existing experience:

(i) Procedures for delegating responsibility for service provisioning need to be developed. This requires methods of sharing construction, operations and maintenance responsibilities in both on-site and off-site

systems with beneficiaries and the community.

(ii) Procedures for monitoring private sector performance (both formal and informal) are needed. These have to ensure that sanitation services are reliable and environmentally beneficial.

(iii) Regulations for improving the efficiency of household investments in the sector are required. These have to focus particularly on construction, human waste removal, conveyance and disposal.

(iv) Procedures for improving horizontal coordination between public agencies involved in sanitation provision need to be worked out.

(v) Methods of increasing accountability of public officials involved in providing sanitation services are necessary. These could be brought about by introducing performance evaluation systems that are responsive to employees needs, increasing the autonomy of sewerage units and improving accountability of staff.

(b) The role of the private sector

Formal Sector: Large private firms, organized on commercial lines collect and dispose solid and human wastes in several developing country cities. In the city of Surabaya, Indonesia, for example, ten private sector companies maintain a fleet of vacuum trucks to collect and dispose about 150 m^3 of septage daily from the city's septic tanks. In Jakarta, despite a large public sector presence, the organized private sector is active in septate collection and disposal. In both Jakarta and Surabaya, the role of the private sector is regulated closely by the city governments.

The other area of private sector involvement is the construction of off-site and on-site systems. In many countries, actual construction of facilities is done by contractors after a competitive bidding process. Subcontracts are farmed out to smaller construction units, and sometimes even to individual artisans. Private sector also has a major involvement in the construction and maintenance of package treatment facilities in high rise buildings.

Informal Sector: On-site systems are largely constructed by artisans and masons working through the informal sector. The "tukangs" of Indonesia function as micro-entrepreneurs, working outside the formal sector credit and home building institutions. Most of them lack any training, and often end up constructing defective facilities.

The informal sector is also active in the collection and disposal of septage and solid waste. In Jakarta, for example, entrepreneurs operate hand carts to clean communal toilets (MCKs) in individual septic tanks in lanes and streets of the metropolis that are too narrow for vacuum trucks to enter.

While the informal sector plays a significant role in meeting existing demand for sanitation services, these *laissez-faire* solutions also have major institutional weaknesses. First, as discussed earlier, artisans do not have proper training, and often construct non-standardized and defective facilities--a septic tank may fill up every six months instead of three to twelve years. Second, private entrepreneurs without governmental or community supervision, tend to take short cuts that maximize profits even at the expense of environmental degradation. A common occurrence in Indonesian cities, for example, is for the contractors to dump septage into the primary and secondary drains, instead of hauling it away to the distant septate treatment facility.

Private sector involvement can be increased and improved through a more supportive environment, provision of credit, access to information on technological alternatives, and training. Better regulation and monitoring of waste disposal is necessary in order to ensure protection of the environment.

(c) Community participation

Consultations with communities on broad priorities are an important first step in making technological and financing choices in strategic sanitation. Procedures for such consultation have varied across countries and communities, and have been undertaken with different levels of government participation.

(i) In Indonesia, more formal procedures to involve communities have been adopted. At the lowest level of government, the public official (lurah) is assisted by a semi-formal group (LKMD or village resilience group). Below this level, communities have been organized into small groups (known as RW and RT) to undertake local civil and social works. Construction of mosques, propagation of family planning, provision of credit for micro-enterprises have been utilizing these informal, voluntary groupings of local residents.

(ii) In Orangi, Pakistan, an NGO responded to an initial expression of need for improved sanitation by a community, and provided support to the community in strengthening its organization and building up technical capacity for effective participation in improving their sanitation services.

Obviously cultural and social factors play an important role in influencing community participation. Whatever the procedures adopted, in successful cases an institutional platform appears to have been created for communities to express their views, and usually *without* an over bureaucratic presence. The full participation of women in the planning, implementation and management is a prerequisite for any sanitation programme to be successful. Once the community priorities are expressed through consensus, the bureaucratic levels of government are able to utilize this information for effective infrastructural programming and project implementation.

Successful community participation thus involves two steps. First, consensus building within communities, so that programmes broadly reflect local as well as individual needs. Second, the recognition of this consensus by the public agencies, and taken as the building block of sectoral programming. In many cases, interest may have to be stimulated through educational and promotional campaigns. What appears particularly important are:

(i) dispelling any distrust communities have of the formal sector institutions (government officials, banks and private entrepreneurs),

(ii) providing support and encouragement for efforts to resolve local problems locally,

(iii) availability of NGOs who are an effective liaison agents between communities and bureaucracies, and teaching government to behave like a NGO.

Once a broad consensus has been reached, the delegation of responsibilities requires beneficiaries to actively participate in both a watchdog and an operational/management role. The ultimate beneficiaries of water and sanitation improvements are the communities where the systems are constructed. In order that the systems continue to provide the optimum level of service, the beneficiaries have to be responsible for their operation and maintenance.

4. Financing and cost recovery for urban sanitation

Sector financing approach should be consistent with a demand-oriented strategy and which emphasizes increasing sector incentives to enhance efficiency, sustainability and reliability, and broader coverage. The chief recommendation is to reorient sector financing from one based primarily on subsidies to one in which user charges provide the primary financial source. This can be supplemented, if necessary, by more efficient subsidy mechanisms triggered by demonstrations of local demand and the quality of project proposals. The discussion challenges the widespread use of cross-subsidization built into tariff structures and open-ended reliance on either subsidized loans or, more seriously, general grants.

Financing strategies, like strategies for technology selection and coverage targets, should be based on making use of locally derived demand for services. On these grounds, financing mechanisms at the local level, ranked in order of their desirability, are: user charges related to willingness to pay; local "benefit taxes", such as the property tax; inter-jurisdictional transfers (to account for externalities benefiting other jurisdictions); unsubsidized loans to be repaided by local users or local benefit; taxes; transparent transfers of central government tax receipts from tax sources which the central government is a more efficient collector but which originate locally (e.g., revenue sharing of income tax receipts); matching grants with local bidding for contributory shares; and lastly, unconditional grants.

The key underlying idea is that the central element in allocating scarce financial resources is the demand for such services, taking into account a full array of available technical options. The underlying rationale for this approach is that it gives the best assurance that the investment and operational choices will be responsive to user interests, a more reliable flow of revenues to sector organizations, and provide reliable and sustainable services, and provide more coverage to population groups unserved than the current approach. The current approach serves neither efficiency nor equity objectives, since it relies on unsustainable subsidy flows which end up providing service to a limited group of the population at a very high cost to the whole society.

5. Recommendations for demand-based sanitation approach

A demand-based sanitation approach is basically a participatory approach for making informed choices from a range of feasible alternatives for:

(i) supply options,

(ii) financial options, and

(iii) institutional arrangements

For the users, the choices they ultimately make should reflect their full understanding of the social and financial consequences of their decisions and their willingness to maintain the systems over time.

Allocating Financial Resources: At national and intermediate levels, it is necessary to decide how limited resources should be allocated between different urban communities. The process used is one of successive screening. Hence, the number of communities invited to compete for such funds should normally exceed the number that would receive allocations. But what should be the basis for screening communities to produce a short list of competitors for the limited resources? Demand-orientation requires that the choice of competitors be made on the basis of willingness of competitors to use local demand for the service as a key criterion for devising their technical solutions.

The next issue is how the selected communities can be screened for the allocation of investments. This may be done on the basis of the extent to which:

(i) allocation of financial resources for projects is driven by merit of locally determined sanitation plans;

(ii) choice of technical solutions is consistent with user willingness to pay, and solutions for different income groups are chosen to minimize financial gap between total system costs and revenues;

(iii) projected cash flows are sufficient to meet current financial obligations for operation and maintenance and for servicing debts;

(iv) financing proposals are based on local demand for service; and

(v) reliance is put on user charges to recover costs.

For intra-city choices, the guidelines for screening zones for investment include:

(i) user willingness to pay;

(ii) minimizing financial gap between system costs and revenues;

(iii) externalities (including environmental pollution abatement); and

(iv) equity considerations

(a) Choosing between supply options

Choices to be made in connection with supply options include:

(i) type of technology;

(ii) type of service providers (public, private, NGOs, community-involved, or self-provision);

(iii) extent of coverage (who, how much, and when); and

(iv) tariff level.

The starting point for such choices is demand, and the goal is to: minimize subsidy, subject to specific administrative constraints such as tariff level, service coverage, equity, or environmental pollution abatement.

(b) Choosing between financing options

The options for financing include the following:

(i) direct user charges and benefit taxes from user areas;

(ii) charges to cover non-user beneficiaries in service area (i.e., in situations where externalities are involved with the provision of the service);

(iii) loans repaid from user charges;

(iv) subsidized loans;

(v) grants; and

(vi) cross-subsidization (but must be kept to a minimum, because it undermines demand orientation).

The criteria for choice between these options are:

(i) efficiency and demand orientation;

(ii) expansion of service;

(iii) sustainability; and

(iv) reliability.

(c) Choosing between institutional options

The characteristics of institutional options include the following:

(i) service ownership: public or private;

(ii) service providers: public, private, NGO, community involved provision, and self provision;

(iii) competition/competition surrogates: decentralization, multiplicity of service providers; and

(iv) policy reform: separation between supply and regulatory functions; creation of enabling environment of legal, regulatory, and incentive environment as well as administrative practices to permit use of market friendly approaches.

The criteria for choice between these options include:

(i) Operational efficiency;

(ii) Service quality;

(iii) Accountability;

(iv) Reliability;

(v) Flexibility; and

(vi) Equity.

(d) Advantages and disadvantages of approach

Application of the project has several advantages and disadvantages. Its advantages include the following:

(i) It reduces government subsidies, thereby allowing available resources to be stretched further.

(ii) It provides a means of rank ordering cities or zones within cities for financial resources allocation for sanitation service provision.

(iii) It widens supply options, thereby improving access to service.

(vi) It improves reliance to users by generating revenues for service provision. This improves accountability and performance, and hence sustainability and reliability of service.

(v) It provides a mechanism for designing tariff structures to match users' indication of what they are willing to pay.

(vi) It improves prediction of coverage and revenues.

(vii) It reduces the risk of mismatch between supply and demand.

Some drawbacks have also been cited for the demand-based sanitation approach. Among them are the following:

(i) Some have expressed concern about the cost and complexity or the methodology for estimating user demand. Viewed as a means of estimating only the demand, this concern is valid; and efforts are being made to develop simpler and lower-cost methods for estimating willingness to pay. However, willingness-to-pay surveys produce more than estimates of user demand. They also provide socio-economic information which can be used in the design of the specifics of service delivery; they also provide information for designing tariff structures, and for use as a basis for demand stimulation. When these other uses of the results of willingness-to-pay surveys are taken into account, it is realized that the cost of the methodology is more reasonable than is apparent.

(ii) There is concern that there may not be adequate local capacity to implement the bottom up demand-oriented process implied in the approach. One way to overcome this would be to provide technical assistance to local communities that pre-qualify on other grounds for competing for resource allocation. Another mechanism would be to provide upfront funding to eligible communities for preparation of strategic sanitation plans which can then be used as a basis for competing for further investment funds.

Service providers, whether they be public, private, NGO or community groups, will require major reorientation of attitudes and specific training in order to be able to implement the demand-based approach.

6. Conclusions

The proceeding criteria for making choices between options are intended to serve mainly as initial guidelines to be adopted in the absence of local experience. They are intended to serve as strategies for pursuing the broader goal of providing sustainable expansion of sanitation services that are adequate in terms of coverage and effectiveness in service quality and environmental pollution abatement. The continued use of the criteria should be guided by feedback from experience on what works and what does not work.

The application of the demand-based sanitation approach has a number of policy implications. A basic requirement for this application is decentralization of delivery functions to local levels. In some instances, this would require a re-definition of local and central level functions. At the very minimum, it would require separation of regulatory functions from service delivery functions. It may also require changes in financing and cost-recovery policies. On the financing side, it may require relaxation of existing rules to allow local authorities to define local tariff structures suited to the locally desired service levels, rather than applying a uniform country-wide tariff structure. Similarly, it would require a flexible policy on cost recovery which is designed to encourage competition and cost effective solutions. Furthermore, the application of the approach may necessitate changes in technical standards to remove a bias for conventional sewerage in favour of a wider range of sanitation technologies and lower-cost sewerage systems. The range of options and costs would enable a wider group not only the more well-off segment of society, to enjoy the benefits of improved sanitation services.

Annex I

TABLES

Table 10. Population (in millions) in selected Asian cities

	1990 Population	*2000 Population*
Bangkok	7.7	10.3
Beijing	9.7	11.5
Bombay	11.1	15.4
Calcutta	11.8	15.9
Delhi	8.6	12.8
Dhaka	6.4	11.3
Jakarta	9.4	13.2
Karachi	7.7	11.6
Manila	8.4	11.5
Osaka	10.5	11.2
Seoul	11.3	13.0
Shanghai	12.5	14.7
Tokyo	20.5	21.3

Source: UNCHS Human Settlements Statistical Database, 1990.

Table 11. Effects of improved water and sanitation on sickness

Disease	*Millions of People Affected by Illness*	*Median Reduction due to Improvement, %*
Diarrhoea	900	22
Roundworm	900	28
Guinea worm	4	76
Schistosomiasis	200	73

Source: *World Development Report 1992.*

Table 12. Capital and operation and maintenance costs in Indonesia

Type of Facility	*Connection cost US$*	*Operation and Maintenance US$ cost per connection*
Pour flush toilet with twin leaching pit	120	
Pit privy	96	
Vacuum truck	126	
Septic tank	174	4
Composting toilet	185	
Small bore sewerage	330	13
Conventional sewerage	4152	23

Table 13. Aquaculture excreta reuse systems

Country	*Unintentional*	*Overhung latrine*	*Cartage*	*Ponds*	*Cage*	*Raceway*	*Lake*	*Sewage*
Bangladesh	+							
India		+						+
Indonesia		+		+	+	+		+
Malaysia		+	+					
China			+	+			+	+
Singapore		+	+					
Sri Lanka							+	
Thailand		+						
Viet Nam		+						

Source: Reuse of Human Wastes in Aquaculture, A Technical Review, Edwards P., April 1992.

Table 14. Selected effluent standards

Country	*BOD, (mg/l)*	*$NH_4^+ + NH_3$, (mg/l)*	*TSS (mg/l)*	*pH*	*Temp. (°C)*
India	30	–	100	5.5 - 9	–
Thailand	20	Kj-N < 40	30	5 - 9	40
Indonesia					
Philippines					
Class AA	30	–	50	6 - 8.5	40
Class D	50	–	75	6 - 8.5	40

Table 15. South-East Asian region sanitation investment estimates, 1981 - 1990

Country	*Estimated Costs to reach Decade targets*	*SECTOR INVESTMENTS (1981-1990) Total US$ million*	*% of Total development investment*	*External US$ million*	*%*	*Investment Acceleration Needed (fold)*
Bangladesh	–	171.9	1.2	97.2	57	–
Indonesia	439.9	161.1	2.0	49.6	31	2.73
Myanmar	332.1	316.6	–	147.9	47	1.05
Nepal	–	104.0	4.1	43.0	41	–
Sri Lanka	570.0	230.0	4.6	190.0	83	2.48

Source: World Health Organization

Table 16. External assistance profile for Indonesia (1989)

Funding Source	*Amount*	*Percentage*
Multilateral	83.1	22.1
Bilateral	271.8	72.2
NGO	21.4	5.7
Total	376.3	100.0

Table 17. Distribution of external assistance by sector for Indonesia (1989)

Sector	*Percentage*
Health	26.7
Agriculture, Foresty and Fishery	13.7
General Development	4.2
Education	12.0
Natural Resources	13.4
Others	30.0
Total	100.0

Annex II

INTERMEDIATE SEWERAGE OPTIONS

Simplified Sewerage:

This system is the product of changes in the standards for several design parameters, including the standards for: minimum depth, minimum slopes, minimum diameter, and the spacing and location of manholes.

The key impetus for its development was the realization that the application of conventional design standards was resulting in prohibitive costs that made it difficult to expand coverage to middle and lower income communities. Simplified sewerage can be used wherever conventional sewerage can be used.

Solids-Free Sewerage:

Its distinctive feature is a solids interceptor tank which is located between house connections and service laterals. The tank is designed like the septic tank, using a detention time of 12 - 24 hours. It provides on-site primary treatment, by capturing and storing the solids in the sewage coming from the house. This reduces the extent and cost of treatment needed at central treatment plants. The absence of solids in the effluent from the interceptor tanks makes it possible to use smaller diameter sewers laid at flat gradients. The tank also provides attenuation of flow, thereby evening out the outflow from the tank. This makes it possible to reduce sewer diameters still further because it makes it possible to decrease the allowance for peak flows. In one modification, the effluent does not flow out by gravity but is pumped out; this modification is known as a septic tank effluent pump (or STEP) system. In another modification, a grinder pump is installed in the tank to grind and pump out the incoming solids along with the liquid fraction; this modification is known as the grinder pump system. In view of the pumping, the two systems are also refered to as pressure pump sewer systems.

The solids interceptor tanks increase user costs, but the on-site primary treatment they produce decreases the off-site treatment costs. Overall cost savings of up to 30 per cent have been reported from the use of conservative design criteria.

A requirement of solids-free sewer systems which is different from other types of sewerage systems is the need to empty the interceptor tank periodically. The tank emptying intervals vary according to the size and loadings of the tanks. Intervals of 3-5 years are often prescribed.

Condominial Sewerage:

The system was developed in north-eastern Brazil. In this system, cost reduction is brought about through two sets of measures: (i) modifications in technology, and (ii) involvement of the community in service provision.

A distinctive feature in its technology is the way in which sewer connections are made between private property and public sewers. In conventional sewerage, each house or property is independently connected to the public sewerage system. But in the condominial system, the wastewater from an entire block is discharged into a street sewer through a single outlet.

A second technological feature of the condominial sewer system is the use of smaller, flatter sewers laid at shallower depths. Small diameter sewers (typically 100 mm in diameter) are laid at flat gradients through backyards of a block of houses to collect and transmit flows from small shallow junction boxes through which flows from individual houses pass. Typically, there is one such sewer for each block which is the organizational unit for the condominial system.

The key to the successful application of this system lies in the strength of the community organizations and the participation and cooperation of the beneficiaries during the planning and implementation phases.

B. URBANIZATION, SANITATION AND GROUNDWATER CONTAMINATION*

Introduction

Urban populations have increased more than four-fold over the last 40 years. The attraction of urban areas which underlie this massive shift of population is the result of fundamental economic changes which make cities the centres of national economic growth. It seems to be implicitly recognized by the governments of developing countries that to slow urban growth is to retard national economic growth.

On the global scale, the urban population is set to rise from the current 1,350 million to 2,000 million by the year 2000 and to 5,000 million by 2025. This incredible rate of growth has invariably outstripped that of the supporting infrastructure and the lack of water and sanitation, among other utilities, has constrained urban living standards significantly. The decline in standards has had a disproportionate effect on the urban poor who make up the bulk of the new urban populations and who typically have neither reliable water supply or sanitation (United Nations, 1992; United Nations Centre for Human Settlements (UNCHS), 1991). Considering only urban sanitation, almost 500 million had none in 1990 and most of these, 390 million, are in the Asian-Pacific region; by the year 2000, this already high number will have risen to 550 million.

This paper looks at the role of groundwater in some cities of the ESCAP region in particular, for which some data are available, and the effects of the changes which accompany urbanization on groundwater quality.

A range of 'index' statistics for selected countries of the region are shown in table 18; these data are taken from a large range of sources and while some may be inaccurate it is believed that the general picture given is fair and useful. Not appearing in the table are representatives of the many islands in the region which are partly or wholly dependent on groundwater and on which urban-type conditions often exist. Difficult conditions are often exacerbated by restricted area and water resources so that the solution of sanitation and contamination problems may be intractable and costly.

The natural salinity of groundwater and the chemistry of the dissolved solids varies widely from place to place, and also with depth in an aquifer. However, for groundwater in the region, chemical quality is generally well within drinking water limits for public supply and is of the highest microbial quality. Groundwater resources are also of high reliability even in droughts and supplies require minimal treatment. Very low turbidity and temperature stability are also important attributes, of special value for industrial users. Groundwater resources can also be developed incrementally which offers large advantages in terms of expenditure, and can be exploited close to demand centres over the area of occurrence of the aquifer. For all these important reasons groundwater resources should be accorded the highest value. Properly managed and protected groundwater can be used in perpetuity, and in a fully sustainable manner. In an urban environment, however, particularly where the aquifer underlies the urban area, vulnerability to abuse and contamination is extremely high. Many cities in the region, many of which are listed in table 18, are dependent wholly or partially on groundwater and the effects of a loss of those groundwater resources would have a wide-ranging impact on public and private users and be extremely costly. The various contamination hazards, implications for pollution and proposals for management are discussed below.

Table 18. Water supply and sanitation data for selected cities of the Asian-Pacific region

City	Population 1990 (million)	Population 2000 (million)	Groundwater production 1990 (Mm^3/a)	Groundwater as % of total	% piped 1990 (see*)	Average consumption (l/c/d)	% slum population (see*)	% population served (see*)
Bandung	1.5			y	75	120		
Bangkok	7.3	11.9	1814	50	86.1		25	2
Beijing	10.8	14	2600	56.5		248		
Dhaka	6.6	12.2		y	60			20
Jakarta	8.9	16.6	310	59		150	35	0
Karachi	7.7	11.7			40		33	30
Madras		12.9		y			30	30
Manila	8.5	11.8		y	70		~25	11
Shanghai	13.4	17		y		204		
Tianjin	9.4	12.7		y		137		
Tokyo	18.1	19		y	94.2	380		

* - refers to per cent of total population served

y - groundwater is significant component of public supply

* This paper was prepared by K.J. Edworthy, Groundwater and Environmental Consultant, United Kingdom of Great Britain and Northern Ireland, at the request of the ESCAP secretariat.

1. Water, sanitation and public health

(a) Relationship between water supply and health

Water supply is only one of several factors which impinge on health. Recent research results suggest that interpersonal contact is of dominant importance in the transmission of diarrhoeal diseases, the main urban health problem in the "informal" settlement areas (Listorti, 1991). Water availability is however a vital part of the basic environment for living, still seriously restricted for the poorer sector of the population. Basic hygiene is difficult in the densely populated slum areas where both water and privacy are rare commodities and it is not difficult to understand how the cholera epidemic in Lima, Peru, in 1991 started in the squatter areas. It is perhaps highly illustrative that the ensuing costs of the epidemic, direct and indirect (lost exports and tourism), exceeded US$ 400 million, more than was expended on water and sanitation during the 1980s in Peru (UNCHS, 1991; United Nations, 1992).

There are several ways in which water supply can be improved in such areas; the first is to improve reliability in terms of microbiological quality which can make an immediate improvement to health and living conditions. A second would be to increase the period during which water is available in the day. In Bombay, the supply to some two-thirds of the population is only operational for four hours per day or less, although they are considered to be "served". An intermittent supply can cause many quality problems which are outlined below; it can also encourage users to leave taps open and lead to much wastage. Finally, the volume of water available to each person is also an important factor in their long-term well-being, 30-40 litres per capita per day being a minimum target level for urban supply.

Improved water supply is clearly a much needed commodity for vast numbers of people and up to 50 per cent reductions in diarrhoeal morbidity is often quoted as a result of upgrading of water supplies with improved sanitation. The availability of an improved water supply without a sewerage system to carry away the greater volume of sewage and wastewater arising is however a decided disbenefit. Higher volumes of water encourages the mobilization of all kinds of contamination affecting both surface and groundwater with a profound deleterious impact on public health. The severely polluted condition of Bangkok's canals is an eloquent statement of this course of evolution, where there is is virtually no sewerage and the average per capita consumption is comparatively high; it is not difficult to envisage the implications for groundwater if there was no thick protective Bangkok clay, and it should be noted that few urban aquifers are as well protected.

2. Urbanization and groundwater contamination

The range of potential contaminants in the growing urban setting where earlier land uses are being "overwritten" by office and apartment buildings, and new industries being established both within and on the periphery of the cities. Roads and car parks, storm drains and sewers, other buried services, and motoring wastes all influence the regime and chemical quality of drainage and infiltrating water.

The degree to which surface-derived contamination affects groundwater depends upon the vulnerability of the aquifer system, an interplay of the thickness and permeability of the unsaturated zone between the surface and the water table. The protection afforded by the thick clay overlying the Bangkok alluvial aquifer system is highly effective as a very low permeability seal. This situation can be compared with the less well naturally protected aquifer system of the North China Plain beneath Beijing and Tianjin which has been seriously contaminated over large areas (Chen Mengxiong, 1982; Ji Chuanmao, 1982). Oceanic island atoll aquifers are relatively permeable and depth to water is generally very small (<<5m) so are even more highly exposed to surface-derived contamination. Many of the major urban areas in the region are coastal and most are situated on alluvial aquifers of varying vulnerability. Some of the main influences are listed in table 19 in which the nature and significance of each is given.

Table 19. Effects of features of urbanization on groundwater quality

Item	*Effect on recharge(*)*	*Contaminating Effect(**)*	*Occurrence in time*
On-site and unsewered sanitation	++	++ N, Org, Mic.	Continuous
Conventional sewerage	+	+ N, Org, Mic.	"
Contaminated surface water	(A)	Varied	Irregular
Imported water	++	Nil	Continuous
Storm drainage infiltration	+	Varied	Irregular
Municipal water use	+	+ N, Inorg	Variable
Solid waste leachate	(L)	+ Org, HM, Inorg	Continuous
Industrial liquid wastes	+(L)	+ " " "	"
Paving	--	Nil	
Surface drainage modification	-(A)	Varied	Irregular

(*)&(**) Number of symbols(+-) indicates size of effect

(L)-Local, (A)-Linear

(**) N-nitrate/ammonia, Org-organic compounds, Inorg-major inorganic ions, HM-heavy metals, Mic-microbiological contaminant

(a) Sewage contamination

Human wastes constitute the main type of contamination in the urban setting where population densities are high. About 2 litres of liquid waste and 0.3-0.4 kg of solids are produced by each person per day; on a global basis only 40 per cent of these wastes are

discharged through sewers and of this, only a small percentage is treated. Most sewage therefore finds its way into surface watercourses or into the ground directly.

(i) On-site sanitation

Cess-pits and septic tanks are the main mode of sanitation in most developing urban centres. Successful sewage disposal using these methods represents a significant local form of groundwater recharge and a potentially serious source of contamination in areas of high population density. Microbes are normally filtered out from infiltrating sewage except under special conditions of high permeability, and the main contamination hazard is posed by dissolved organic and inorganic substances.

The organics are typically readily degradable but exert a high oxygen demand during decomposition, and ammonia also requires significant oxygen resources from the unsaturated zone or from the existing groundwater. Nitrate is one of the main contaminants which reach the water table and the concentration may be high where sewage recharge is large compared with natural infiltration. Even under tropical conditions where infiltration exceeds 500 mm/year, the concentration of nitrate in infiltration might be expected to lie in the range 150-250 mg/l as N, under a population density of 250 persons/ha and per capita consumption of 50 l/c/d (Foster, 1990). In Bangkok and Jakarta, septic tanks are much less successful because the superficial strata are of low permeability, and overflow to surface water is likely to be the main direction of discharge.

On the densely populated island of Male, Maldives, extremely serious groundwater contamination existed until 1983 when sewerage was constructed. The aquifer here is a medium to coarse-grained calcareous shell and coral sand with water table at 1.5-2.0 m. Even with population densities of 400-500 person per hectare, per capita consumption of 50-100 l/c/d and rainfall infiltration of 900 mm/year, on-site sanitation resulted in maximum nitrate concentrations of the order of 100 mg/l as N. In this geological setting with a relatively coarse aquifer, microbial contamination from sewage seems to have been the cause of seasonal diarrhoeal epidemics at times of particularly heavy rainfall. The range of other contaminants, organic and otherwise, also made groundwater unusable on grounds of taste and odour (Edworthy, Heard and Ibrahim, 1990). The contamination of groundwater in Bermuda, another partly urbanized island, due to on-site sanitation has also been studied.

In a quite different situation in Sana'a, Republic of Yemen, under low rainfall conditions, cess-pit sanitation in the "old" city was a sustainable mode of sanitation which caused no detectable effect on the deep dug-well sources. The development of improved water supply for this area, without improved alternative sanitation, has led to higher rates of discharge to the cess-pits and penetration of waste products to groundwater. This has caused a distinct groundwater contamination problem in several wells and boreholes both within and peripheral to the "old" city area (Edworthy, 1991).

The penetration of fractured aquifers by sewage derived microbes is well exemplified by studies at the town of Orvietto in Italy. The town lies on a 1.0 km^2 plateau made of tuff lying about 150m above the surrounding plain. All wastewater drainage and sewer leakage plus rainfall recharge emerges from a series of springs around the periphery of the plateau at various levels. Faecal contamination has been found to occur consistently in 15 out of 20 springs which also contained high nitrate and ammonia concentrations (Martini Pialli and Sabatini, 1980). Similar serious problems with highly contaminating sewage is also reported from Merida, Mexico, a large town of 400,000 people, 40 per cent of whom were low-income inhabitants; the underlying fissured limestone aquifer is particularly ill-suited for cess-pits sanitation and continued use of groundwater. Beneath Beijing, China, the interaction of sewage with the calcareous and dolomitic aquifers is believed to be the cause of much increased calcium, magnesium and hardness concentrations (Zhu Jicheng, 1985)

(ii) Leaking sewerage and drains

The objective of sewers is to carry sewage away from the populated areas for treatment and disposal elsewhere. Most sewers leak, however, and in the more extreme cases can serve as serious linear pollution sources, particularly when full when sewers may be under some pressure. Old sewers in part of Cairo, Egypt, which are increasingly running under pressure, are causing serious shallow groundwater pollution and surface water contamination due to leakage (Shahin, 1990); in this case, as in many others, sewage is simply being transferred from one area to another to cause equally, or even more serious pollution. Elevated nitrate (up to 150 mg/l as N) and sulphate concentrations (up to 300 mg/l) are reported in Narbonne, France, beneath the central town area partly, it is thought, from sewers and septic tanks (Razack,M' Baitelem and Drogue, 1990); in the area of Milwaukee, Wisconsin, United States of America, research has shown that urbanization has induced an increase in chloride, sulphate, and ammonia (Eisen and Anderson, 1980). It is important to consider the effect of the relatively deep and permeable sewer trench infill as a separate "aquifer", through which contamination can migrate freely from any leaking joint in the sewer. There is a particular hazard to public health under some conditions, if water supply mains lie close enough to be

contaminated. High permeability and correspondingly high rates of flow can allow microbial pollution but the main long-term hazard is normally nitrate.

Increased sulphate due to seawater intrusion in groundwater on the island of Male, Maldives, used mainly for sanitation and washing, has inevitably caused increased sulphate and overall salinity in sewage. This promotes high H_2S and serious corrosion of the concrete of the sewer system. Although this is not an existing leakage it will eventually result in serious leakage losses and is a particular consequence of groundwater pollution in this island setting, and one which may occur elsewhere in the region.

(b) Water services contamination

Intermittent water supplies are the norm in most developing countries. In many Indian towns and cities, some areas which nominally benefit from a water supply service, that service may only exist for a few hours per day. For most of the time therefore the water mains are only part full or even empty and the losses of water which occur by leakage under pressure become "gains" under a reversed gradient. Water "losses" can help mobilize contaminants in the vicinity so that in many cases the "gain" is of polluted surface drainage. If there is sewage from leaking sewers or on-site services this can also find its way into an unpressurized water main. When the supply is next pressurized, the pollution occurs in the supply area as a pulse of contamination.

(c) Leakage

In addition to the major water and sewage services, there are many other smaller local services carrying industrial products and wastes, such as solvents, lubricating oils and fuels. These are generally of restricted extent individually but cumulatively may be important in the vicinity of industrial sites, garages, mines, airfields and filling stations.

(i) Services

The vast range of industrial chemicals, solvents, oils and fuels in use include compounds which are highly contaminating. Taste, odour or colour may be produced at extremely low concentrations, and additionally, some contaminants may be hazardous to humans and animals. Pipes buried at some considerable depth give rise to particular anxiety in the event of leakage, for two main reasons; a) the actual leak is not visible so continues until groundwater pollution occurs and b), the shallowest and most biologically active part of the unsaturated zone is partly or wholly by-passed so the opportunity for attenuation/breakdown of the contaminant is seriously reduced.

(ii) Storages

These facilities are often buried and the same anxieties apply as listed above. Recent surveys in Europe of motor filling station tanks showed that 20 per cent leaked, and the United States Environmental Protection Agency survey of underground tanks and pipes showed that 30 per cent leaked. In Brazil, the example of Sao Paulo city is perhaps typical of other developing countries where there is more than 1,600 petrol stations within the city area. More than half of these are over 20 years old and many are known to be leaking already and contaminating groundwater (Oliveira and others, 1991). The danger of groundwater contamination extends beyond any effects on consumers on some occasions; in Canberra, Australia, a 32 m^3 volume of petrol under 0.5 ha of the city centre area, was only identified after accumulated vapour in a building caused a fatal explosion. The source of the contamination was immediately up-gradient from tanks buried 3-4 m deep in a weathered and fractured Silurian mudstone aquifer (Jacobson and others, 1991).

(d) Accidental spillages

The range of liquids carried by tanker and pipeline is also very large. Those posing the greatest threat to groundwater are the highly contaminating organic chemicals and oils, etc. referred to above. The risk of contamination from these is greatly enhanced in the urban setting where activity is relatively intense.

(e) Solid wastes

As much as 70 per cent of the domestic wastes generated are disposed of informally; of the small proportion collected it is exceptional for sanitary landfills to be used. It is more normal for wastes to be dumped in suburban areas and for the leachate produced to pose a threat to any aquifer. Solid wastes also act as breeding grounds for vector-borne diseases. Few data are available for amounts of wastes produced across the region, but in China, one of the most populous countries in the region, the growth in the rate of solid waste generation in Shanghai and Beijing has been about 10 per cent during the early 1980s. Extrapolating from the gradient of the lines in figure X (from data given in Chen and Zhang, 1988) the current rate of generation is now estimated to be about 3.5 million tons/year.

In general terms, the amount of domestic waste is likely to increase as the average standard of living rises, so posing a potentially greater threat as that posed by sanitation declines as improvements are made. Although the composition of wastes also varies with the standard of

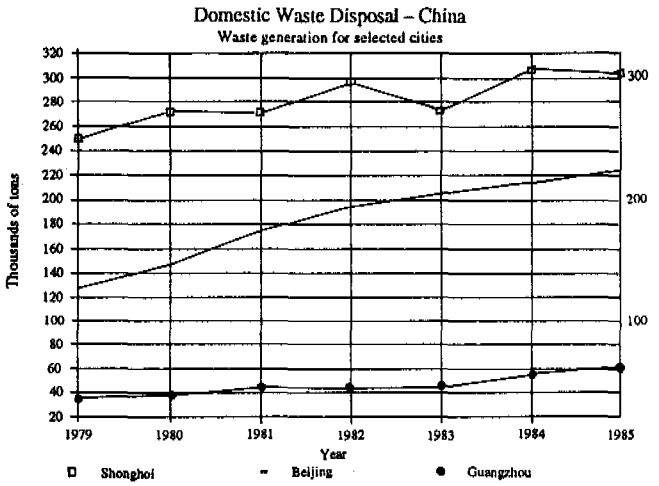

Figure X. Rise in domestic waste generation in China, 1979-1985

living the typical leachate composition is probably similar in most countries of the region and the concentrations of organics will be high, as indicated by BOD of many thousands, high ammonia, and high inorganics also. Leachate generation will be rapid in the tropical areas, but relatively less concentrated.

Hazardous waste generation from industry in cities should also be expected to increase in line with increasing economic activity but the data shown in table 20 also show that increasing industrial "maturity" allows more efficient manufacturing with considerably less waste. The amounts of waste produced per worker are particularly high for China but the total amounts produced are generally high in terms of groundwater quality hazard. The dangers are recognized by some countries of the region, and they are in the process of developing improved incineration and centralized treatment and stabilization facilities.

Table 20. Hazardous waste generation in selected countries/areas of the region

Country/ area	*1985 GNP US$ per capita*	*1985 Hw production '000 tpa (Note 1)*	*Manufacturing workforce % (Note 2)*	*HW Index (Note 3)*	*Survey Year*
China	310	40000	17	0.229	87
Hong Kong	6230	100	34	0.052	82/87
Japan	11300	1400	25	0.046	83
Malaysia	2000	380	15	0.165	87
Philippines	580	150	10	0.027	87
Republic of Korea	2150	372	23	0.038	85
Singapore	7240	13	25	0.02	
Taiwan, Province of China	3065	3020	33	0.474	86
Thailand	800	106	8	0.024	84

Note 1 - Hazardous waste production; tons per year
Note 2 - Manufacturing workers as percentage of total workforce
Note 3 - tons/person employed in manufacturing
Source: Keen and Jhaveri, 1988

(f) Industrial liquid wastes

Severe contamination is common across the region where rapid industrialization has occurred. It is exemplified by the situation at Ludhiana in India where heavy metal-rich discharges have penetrated the unsaturated zinc and heavy pollution by chromium and cyanide have been identified; other heavy metal contaminants are known to occur and are being investigated (Kakar and Bhatnagar, 1981). Severe contamination of highly valuable groundwater resources in the vicinity of Shanghai by arsenic has been attributed to industry (Hu Xiushu, 1985).

It can be argued that these contaminants are relatively easy to deal with compared with organic substances which are extremely polluting even at minute concentrations. For example, the World Health Organization Guidelines concentration for common substances such as benzene, tri- and tetrachloroethylene and diesel and light oils are 10 micrograms per litre (30 for trichloroethylene).

In the suburbs of Turin, Italy, industrial wastes have been discharged historically into disposal wells or into disused quarries. Although these offer great convenience to industry the pollution potential of these means of "disposal" is extremely high and numerous pollution incidents have been the result (Bortolami and others, 1985). Industrial wastewater causes serious chemical contamination of groundwater in Beijing, second only to the effects of sewage (Tian and Wang, 1985)

(g) Other sources of contamination

Intense abstraction of groundwater can clearly affect groundwater flow over considerable areas, and in coastal areas such as Manila and Jakarta, the intrusion of salinity from the sea may result (Binnie and Partners, 1986; Tjahjadi, 1991). The same salinity problems may occur inland where there is natural stratification of groundwater salinity and chemistry. Loehnert (1985) describes the hydrogeology of the Hamburg area, Germany, beneath which deep relatively saline groundwater is being drawn up by excessive pumping to satisfy public and industrial supply demands. The polluted state of some watercourses which run through urban areas is a further potential source of contamination, particularly so in areas where the groundwater level has been drawn down and infiltration is induced (Wang Yangquin, 1991). The polluted Hun river which replenishes the aquifer used to supply Shenyang city has now so polluted the aquifer that alternative supplies from over 50 km away are having to be obtained at great additional cost (United Nations, 1992).

One further form of pollution, which is normally unrecognized, comes from cemeteries, which often become incorporated into cities as they grow. This topic has been briefly reviewed by Bouwer (1978) and has more recently been reported from the city of Santos in Brazil (Pacheco and others, 1991). It is evident that organic and microbial pollution may frequently occur but that the greatest danger occurs in areas of high rainfall and shallow groundwater level.

3. Management and technical measures to conserve groundwater quality

There are many techniques which can be applied and alternative approaches which can be adopted, with the eventual course of action being decided ultimately either by capacity or willingness of the population to pay, the severity of the problems and the special national and local political conditions. In this section some of the main options are touched upon starting with sewage which this paper has shown to be the major urban contaminant.

(a) Comprehensive sanitation

Conventional sewerage with proper treatment is an expensive solution to sewage disposal. Urban sewerage does exist in many cities of the region but little of the sewage is treated; cesspits, septic tanks and soakage pits are by far predominant. Sewers, where built, assist considerably in the public health direction, in removing contamination from the population and focus the pollution in specific areas. This has led to severe problems in some instances where severe localized problems have been caused as in Cairo, and in Sana'a, Republic of Yemen where untreated sewage infiltrates via pools and ponds in or close to urban areas, into alluvial aquifers. The problems in Cairo are typical and due to leakage of old undersized sewers illustrating the need to ensure that sewers do not leak; any leakage seriously undermines their purpose and public confidence in the system.

The comparison of the costs of conventional sewerage with those of on-site sanitation are often difficult because it is difficult to compare "like with like"; on-site sanitation costs are usually artificially low because the standard of workmanship is very low. Nevertheless it does appear that on-site sanitation even in high density areas may be less expensive than sewerage with treatment *if the implications of contaminating groundwater are not costed.*

Cost comparisons for different solutions to the sanitation needs of Chonburi, Thailand, have been studied including on-site, conventional and small bore sewer options (Asian Institute of Technology/Cooper and Lybrand, 1988). The cost of small bore systems was found to be 15 per cent lower than conventional sewerage, and up to 25 per cent when existing on-site facilities were used as interceptor tanks. The conclusion was that a mix of sewers and septic tanks would be affordable in this city but that there would probably be severe resistance on the part of users to paying. Management responsibility passes largely to local government with the use of sewers and the crucial question appears to relate more to *willingness* rather than *ability* to pay in this case. It should be pointed out that there are probably no hydrogeological conditions under which on-site sanitation is efficient, water supply is adequate, *and* groundwater use is sustainable. This is a reiteration of the critical need to improve sanitation when water supplies are improved - the one must go with the other, particularly where groundwater is important.

(b) Management of groundwater abstraction

Once contamination of groundwater has occurred, the management of the resources becomes very much more difficult. Abstraction in the vicinity of the contamination must be either reduced or stopped to avoid inducing continued inflow of contaminated water. Pumping wells would normally be moved to areas far enough away from the contamination to avoid inducing inflow. An alternative strategy is to continue pumping from the contaminated groundwater, discharging to waste and using the abstraction as a "sink" to localize the migration of contaminated groundwater. A third short-term solution, if hydrogeological conditions permit, is for the depth of abstraction to be increased and the upper contaminated interval to be cased off.

Salinity intrusion is a special case of induced contamination and one which is amenable to the above measures of reducing or redistributing abstraction. Saline interfaces can be stabilized by scavenge pumping both in the coastal situation and inland where saline water underlies fresh. A two-level pumping solution has been used at a public supply well in the British Midlands where deep saline water underlies fresh, in this way.

(c) Groundwater protection zones

Dealing with the results of pollution is accepted to be generally much more difficult and costly than those of preventing the pollution occurring in the first instance. In the growing city setting, pollution protection is clearly extremely difficult not only because of the complexity and number of the threats but also because of the absence of appropriate legislation. European legislation is now arriving at a consensus toward the protection of groundwater sources by means of "protection zones". These are specified on the basis of bacterial survival time/

groundwater flow rate criteria in order to provide a delay time between surface and pump. Within the specified zones around the well, certain activities are prohibited, such as on-site sanitation, sewers, solid waste disposal, etc. With increasing radius, the range of proscribed activities is reduced. The range of field data needed to underpin such legislation is considerable if it is to be acceptable to users and compilation of these data should be regarded as an immediate and very desirable objective.

4. Institutional aspects of groundwater quality protection

All efforts to manage groundwater and groundwater quality in urban areas in particular are severely hampered by the lack of the institutional and legislative basis from which to act. Bearing in mind that the developed countries have only started to manage groundwater during the last few decades, this is understandable perhaps, though it is to be hoped that the new and developing urban centres can learn from their experience. The costs of water supply and sanitation lie principally with the individual for most of the population, who are the poor, of most new cities.

(a) Control of waste disposal

The need for appropriate legislation only springs from a perceived and just need. The race for increased national economic wealth leaves little enthusiasm for the impediment of this kind of restriction in most of the rapidly developing countries. In some others, regulations have been framed and enacted but there is little will, perhaps understandably, behind the policing of these laws. There seems little option, however, to the "polluter pays" principle in the longer term and little possibility that groundwater contamination can be completely avoided through enforcement of such laws where they exist. The main benefits in this direction will almost certainly spring from improvements in the technology of waste treatment.

Collection of solid wastes from low-cost housing areas will continue to be difficult but there are strong indications that the provision of basic water and sanitation facilities to the informal housing areas encourages and motivates the people to help improve their own environment. Also incentives may be given to encourage central deposition of solid wastes. The disposal of wastes once collected is a further problem and there are few examples in the region of properly managed disposal. The location and licensing of solid waste disposal sites outside areas of aquifer outcrop or the hydrological catchment can only be ensured if adequate land-use planning legislation, suitably influenced by all relevant environmental factors, is available.

(b) Control of groundwater abstraction

Groundwater use for public supply is widely affected in most urban areas by competing abstraction by private users, industry and agriculture, as outlined elsewhere. The economic value of water to industry and agriculture is clear but an economic cost for groundwater is rarely paid by either of these classes of user, partly because the value of the resource is not recognized and partly because the restraint on their consumption would affect national economic growth.

The priority should be to define the total resources available as closely and as early as possible and identify the main hazards to groundwater quality. This information then allows the managers to decide on allocation of resources between the competing sectors, based upon accepted economic valuation of the groundwater reserves, taking full account of the potential costs of being forced to the use of alternative resources if the resources are contaminated or not effectively managed. Shortage of groundwater in Tianjin and Beijing areas due to declining resources and pollution have forced conservation backed by public education and various economic and legal measures, and industrial consumption has been reduced in these areas at an average annual rate of 17 per cent during the period 1981-1988 (Bhatia and Falkenmark, 1992).

Within this framework, a system for the licensing of abstraction can be established and the locations and rates of abstraction planned to avoid causing or inducing contamination. In this way, groundwater flow can be broadly managed; this capacity needs to be accompanied by a control on the amounts, types and distribution of contamination as indicated above.

(c) Community participation

Those most affected by the lack of urban water and sanitation are those in informal housing in the peripheral areas of the cities. They are totally dependent on others for their basic services, having to endure abject squalor and to pay exorbitant prices for water from vendors in many cases. The acquisition of a stake in their own environment is cited as a major stimulus to slum dwellers in Bandung, Indonesia, to invest in sanitation facilities (World Bank, 1992); here, property titles were assigned to the slum dwellers. This same point is made by others who suggest that "enabling" the urban poor by assignment of property rights or some other security of tenure, provision of long-term credit or simply the upgrading of basic services. There appears to be evidence that the poor are keen to help themselves to improve their sanitation, if some basic help is extended to them.

Women make many of the major decisions affecting the family in the low-cost housing environment and their attitudes to waste disposal, sanitation, conservation and hygiene affect the ways in which their own children view their environment. Public education using the influence and opinions of women as much as possible, should be an increasing element of all future water and sanitation projects.

5. Conclusions

(a) Groundwater is very important natural strategic resource for many of the urban and island populations of the region. It is also widely mismanaged, undervalued and contaminated.

(b) Excessive groundwater abstraction, unrestricted domestic and industrial solid and liquid waste disposal, sewage contamination from on-site facilities and sewers are major causes of the accelerating pollution of groundwater.

(c) Sewage is the main existing and potential contaminant. On-site sanitation is a particular threat to groundwater quality where the aquifer is inadequately protected and is especially hazardous where higher per capita consumption is possible.

(d) Control of groundwater contamination is one major aspect of groundwater management and can only be accomplished on the basis of an appropriate institutional and legislative background.

(e) The needs and plans of "polluters" and water users have to be coordinated and this also has to be done against a similar background which should also include an accepted national plan according a proper economic value to groundwater and a water allocation policy. Enlisting the help of the public in improving the environment and conserving water needs special efforts in commmunication to inform and explain, using the media.

(f) The urban poor are those most disastrously affected by lack of water and sanitation. Evidence shows that "enabling" the poor, by improving security of tenure, assisting with long-term credit and special efforts to involve women in planning health, water and sanitation projects, can be highly effective and motivating, and also highly beneficial for the urban poor.

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C. LOW-COST WASTEWATER DISPOSAL SYSTEM: BANGKOK EXPERIENCE*

Introduction

The area of Thailand is 513,115 km^2. The population is about 52 million. The urbanization process of the country has been very rapid in the past few decades. Bangkok, the capital city of Thailand, is the core of economic development in the country. It is a city with a population of 5.9 million, which is about 10 per cent of the country's population.

Only 60 per cent of Bangkok's population is presently covered by the service of the Metropolitan Water Works Authority (MWWA) which is a special agency under the Ministry of the Interior. The total amount of water withdrawal from the Chaopraya River, flowing through the city, is 3,600,000 m^3/day (42 m^3/sec) which is getting close to the limit of the lowest river flow rate.

The pollution of river water is becoming very severe. The dissolved oxygen content which indicates the freshness of the river water is now at 50 per cent of the natural level, while the bacterial count is reaching the limit, thus, a double disinfection process, one before and one after the clarification process, has to be applied for providing a safe drinking water supply.

1. Present wastewater system

According to the Environmental Conservation Law of 1992, the Governor appointed from the Ministry of the Interior will have to supervise the preparation by the Provincial Mayor, of an appropriate master plan to control the pollution of the waters. The Bangkok Metropolitan Administration (BMA) has the duty of providing the sewerage service in the city as part of the drainage infrastructure. BMA established the Department of Drainage and Sewerage to take care of both the storm discharge and the sullage. The fecal wastes are expected to be stored on-site and then collected by the vacuum cars of BMA's Public Cleansing Department or allowed to seep into the ground through a system of septic tanks and cesspools installed on private premises. The final disposal plant of the BMA was commissioned in 1990. It employs an activated sludge system with nitrification, denitrification and belt-press sludge dewatering. The plant has a maximum capacity of 600 m^3 per day and operates with methanol supplement to meet the high ammonium content of the night-soil sludge. A private firm has been engaged to carry out its operation and maintenance.

The non-fecal or sullage waters have not been classified by the Building Control Law as polluting. The law requires that all the non-fecal wastewaters be discharged without obstruction into the public sewer. Only some exceptionally large buildings such as condominiums, schools, hotels, restaurants, high-rise buildings and a few other commercial buildings are required to build treatment plants on-site. This requirement will lead to a large number of on-site and community plants in the future.

The urbanization boom has turned the watercourses into sewers. The pollution has now extended to the Chaopraya River which has been carrying away sewage load from all the existing canals, known locally as klongs.

The Government realized the threat of water pollution as early as in 1950 and assumed that the most effective way to prevent water pollution was to implement a sewerage system. The Ministry of the Interior prepared a master sewerage plan for the city of Bangkok in 1967. The plan has been delayed for many years owing to budgetary constraints. Sewerage systems have been constructed in several provincial towns such as Pattaya (1985) and Phuket (1987). Pattaya has built a wastewater treatment system with rotating biological discs with a capacity of 40,000 m^3/d. The per capita investment cost was only about 3,000 Baht for both treatment and sewerage. The Phuket plant uses an oxidation ditch system. There are plans to construct oxidation ponds for the cities of Khon Khaen and Nakorn Ratchasima. BMA has to implement sewerage systems under the constraints of land shortage and various other congestion problems. The system adopted will be somewhat similar to the shallow sewer system (United Nations Centre for Human Settlements, 1986). The existing flat grade storm drains will convey sullage and septic tank effluent to central treatment plants.

The total cost of sewers is usually higher than that of the treatment plant in a sewerage system. It is uneconomical to extend the sewerage basin and the trunk

* This paper was prepared by Ksemsan Suwarnarat, Bangkok Metropolitan Administration, at the request of the ESCAP secretariat.

sewer excessively, as the specific cost per capita will increase when the optimum size is exceeded (Tabor, Shapiro and Rogers, 1980).

The second sewerage master plan completed in 1982 Japan International Cooperation Agency (JICA), 1982) followed the optimum size approach and suggested that the sewerage of Bangkok should be laid-out into 10 zones with 10 treatment plants to reduce the cost of the final interceptors and also to utilize the existing canals as useful final out-falls. This master plan was later modified because the construction sites at suggested treatment plant locations could not be obtained. Fifteen lots of land owned by BMA were tentatively proposed by the Department of Drainage and Sewerage as alternatives (table 21). Consequently, a site at Lumpini Park had to be dropped owing to the protest of park users. Therefore, the location at BMA2 was extended to take up to 350,000 m^3/d of sewage (table 22).

Table 21. Potential locations of treatment plants in the Bangkok metropolitan area

Site	*Available land* m^2	*Treatment* m^3/d	*Capacity population*
Nongkaehm	160,000	533,333	1,777,778
Lumpini	32,000	106,667	355,556
Bangkoontien	80,000	266,667	888,889
Makasan	179,200	597,333	1,991,111
Slaughter-house	40,000	133,333	444,444
Onnut	96,000	320,000	1,066,667
Ramintra	32,000	106,667	355,556
Rama 9	83,200	277,333	924,444
Toonkkru	14,400	48,000	160,000
Rangmaam	24,000	80,000	266,667
Nongbon	80,000	266,667	888,889
Nontree	32,000	106,667	355,556
BMA2	17,600	58,667	195,556
Pantom	6,400	21,333	71,111
Sripraya	1,600	5,333	17,778
Total capacity			9,760,000

Note: Estimation of population allowable for sewerage works built at the allocated sites on the assumption of a 300-litre per capita per day flow rate.

To avoid the high initial cost of the sewer, most of the existing plans propose a sewerage system consisting of a treatment plant and a trunk interceptor receiving dry-weather discharges from the existing road drains. The storm over-flows will be provided at every crossing of a road drain with a canal. The area allocated by BMA for construction sites is quite limited. In order to provide a future population estimated at 10 million with sanitary sewerage and wastewater treatment, the plants will have to be built within the limiting factor of $0.3 m^3/m^2/d$ of the flow rate (table 21). This can be achieved in a compact form such as a community plant at the Sirirat Hospital Complex in Bangkok which treats 6,900 m^3/d in a plant built under a lecture room of 1250 m^2 in area.

Table 22. Current sewerage projects of the Bangkok Metropolitan Administration

	Name of Plant		
	Sripraya	*Ratanakosin*	*Lumpini and BMA 2*
TREATMENT PLANT			
Area served km^2	2.7	4,142	37
Population	120,000	70,000	1,080,000
Density (p/ha)	444	169	309
Flow m^3/d	30,000	40,000	350,000
$m^3/km^2/d$	11,111	9,657	9,459
Year of construction	1992	1992	1995
Type	contact stabilization	2 stage activated sludge	to be proposed by contractor
Nitrate and Phosphate removal	some	yes	yes
Investment Million Baht	284	511	2,500
Baht/m^3	9,500	12,800	11,280
Baht/m^3 Operation and Maintenance	4.00	2.24	4.00
Baht/person	2,367	7,300	2,314
Plant design	BMA	BMA	to be proposed
SEWERS (interceptor only) Length km.	3	17	49
Investment Million Baht	110	348	3,500
TOTAL investment Baht/person	3,283	12,271	5,556

The Bangkok sewerage system is a combination of a combined sewer, storm-overflow to drainage canals, a dry weather sanitary interceptor, and a treatment plant in confined areas with nitrate and phosphate removal.

However, the shortcoming of this configuration is that the long detention time in the combined sewers and the existing septic tanks will turn the sewage anaerobic. The anaerobic septic sewage contains a high proportion of ammonium and sulfide content. These chemical characteristics are not favourable to the current methods of sewage treatment.

2. Stabilization ponds (oxidation ponds)

The oxidation pond process is recognized by sanitary engineers as a low-cost process. The treatment process in a simple ponding of lake water was formulated by Oswald, Hee and Gotass (1958) who described the waste stabilization process and the photosynthesis of the algae in the ponds which provides the oxygen supply for the biochemical oxidation and keeps the pond aerobic and odour free. An oxidation pond contains almost every stage of process of a standard sewerage work such as: grit and sand removal, primary sedimentation, aeration with biochemical oxidation of the BOD, flocculation and settling, and sludge digestion and stabilization.

All these processes occur to various degrees in the simple ponding of water. The process is particularly suitable for tropical areas where sunlight is abundant and the temperature of the water in a pond is relatively high and stable all year round.

The loading capacity is an important parameter of a pond. The oxidation capacity relies on the sunlight on the water surface needed to support the algal growth. The solar irradiation enhances the algal activity. For Thailand which is situated close to the equator, a BOD loading capacity of up to 400 kg/ha/d is possible (figure XI).

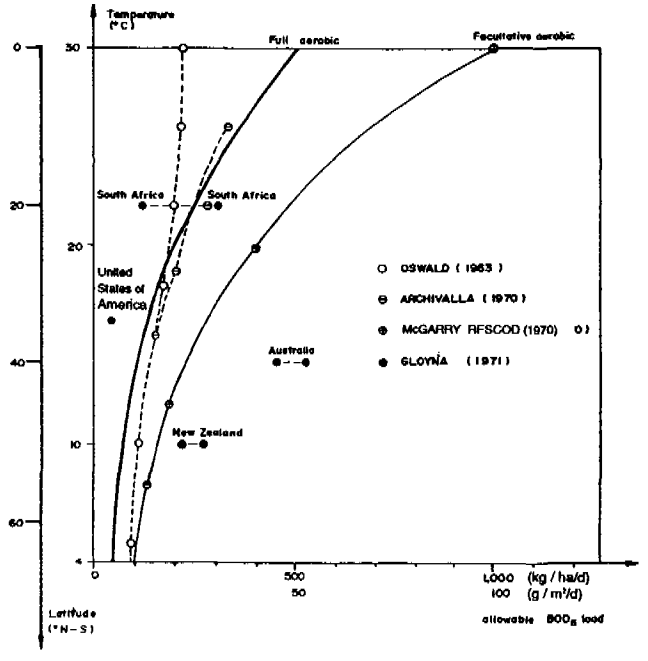

Figure XI. Allowable loadings of oxidation ponds at various latitudes.

This approach can be used for the design of low-cost wastewater treatment systems. The population may utilize canals for wastewater disposal if the load is well distributed. The canals are now serving the Bangkok metropolitan area as storm drains. The growth of algae should not interfere with such usage. The canals branch out into many tributaries, "klongs". These klongs may, in fact, provide natural treatment for sewage due to an oxidation process. Organic matter will be diluted and oxidized by natural bacteria in the water to produce soluble oxides and bacterial growth which flocculate and settle to the bottom mud as in a natural pond. In tropical areas, the strong sunlight will provide an extra oxygen supply to keep the pond "aerobic" with adequate dissolved oxygen even if there are heavy organic loads and a low dilution rate.

The estimated natural assimilation capacity of some 50 klongs in Bangkok, which are normally about 10 - 20 metres in width and together total 191,440 km in length, is quite essential. As mentioned earlier, oxidation ponds in the tropics may treat organic loads with BOD of up to 400 kg/ha/d (Mara, 1976). Klongs in Bangkok, if used as oxidation ponds, will be able to treat wastes of up to 7.9 million people based on the assumption that per capita biochemical oxygen demand (BOD) is 15 grams per day. Or if the per capita BOD is 30 grams per day, wastes of at least 1.9 million persons can be accommodated by the canals.

The prevailing pollution problems in the canals of Bangkok are owing to the lack of a balancing system to distribute the wastewater outfalls over the canal network

3. Combination of flood control and sewage treatment

A flood control master plan study (JICA, 1985) pointed out that it is inevitable that the BMA will have to maintain 13 km^2 of water retention ponds in order to reduce the storm water run-off rate to match the limited hydraulic capacity of the canal system. These ponds can be utilized to purify sewage in the dry seasons of the year. Canals will also have to be maintained to keep the discharge capacities. The strategy in this case should be the appropriate use of the natural assimilation capacity where appropriate. It seems to be unwise to go straight to sewerage at 3,000 Baht per capita and wastewater treatment at another 3,000 Baht per capita at once.

Recently, a new study was carried out by BMA with the hope that there would be some other possible approaches to stop the aggravation of the water pollution problems in Bangkok. The Klong Purification Project is the title of the study which was completed in 1990. The report of the study suggested two approaches:

(a) Fresh water intake from the Chaopraya River into the polluted canals to dilute the pollutants,

(b) Simple treatment of polluted waters, before discharging them into the canal, using surface aerators (aerated lagoons).

The study suggested that the retention treatment by aerated lagoons is feasible in the rainy season, too, by utilizing retardation ponds. Such an approach will require a per capita investment of only 100 to 200 Baht.

4. Aerated lagoons and activated sludge

The distribution of load in the urban area is not well matched to the available water surface of the canals to produce the necessary treatment. Therefore, artificial aeration may be used to provide the necessary oxygen supply to prevent the anaerobic condition. The "aerated lagoon" principle has been applied successfully by BMA in a canal in the western part of the city along the Puttamonton 2 Road. Aspirating aerators have been used

to supply oxygen and keep a certain level of active biological flock in the water to increase the treatment capacity in the road-side ditch which was too small to be aerobic in the natural condition.

The activated sludge system is superior in effluent quality and the treatment capacity per cubic metre of the tank. The maintenance of active micro-organisms is also possible by withdrawing or accumulating biological suspended solids.

5. On-site treatment

Another low-cost approach to sewage treatment in Thailand is to avoid the sewer cost associated with the conventional municipal treatment plants. The non-fecal or sullage water has not been recognized by law as polluting. The Building Control Law requires that all fecal toilet wastes be disposed of by soil seepage while non-fecal wastewater can be discharged without obstruction into the public sewer. Only large buildings are required to have treatment plants built on-site. This requirement will lead to a large number of on-site package plant installations in Bangkok and the provinces. It is estimated that about 1 million people will be served by on-site plants in Bangkok by 1994.

Under the Land Subdivision Law, there is a requirement that large housing estate projects have to install their own sewerage systems with treatment. This regulation seems to have some drawbacks in practice. For example, most of the effluent load derives from hundreds of thousands of individual houses, not from large housing estates which the standard is aimed at. If the individual houses fail to build efficient on-site treatment units, the effluent from individual houses will still be discharged into canals passing through municipal drains, or even through the underground passages provided, legally, by the cesspools. Therefore, the need for a good municipal sewerage system to collect wastewaters from individual houses is still obvious and the implementation of a sewerage still remains relevant.

The advantage of the on-site method of treatment is the independence of the system. The installation is normally done on the private premises. The word "site" relates to the private ownership of the land and also the origin of the wastewater. Construction of a treatment plant on-site results in the shortest length of collection sewer. However, a site can be very large if the owner of the premises is a housing estate or a large factory compound. The collection sewer in such cases will be long and complicated just like any municipal sewerage system. Traditionally, an on-site system is a septic tank with soil-seepage system for the effluent disposal. At present, an on-site system is a small treatment plant connected directly to a house-sewer.

An on-site system has many merits (on the ease of development) as follows: distributing cost to user, matching the capacity to the growing need, avoiding the sewer cost, and inducing commercial interests into the pollution control industry.

There are also a number of disadvantages to the on-site system: high specific cost per capita, fluctuating efficiency, high labour cost for maintenance and supervision, and relatively high operation cost per capita.

On-site treatment is the intermediate technology for urban and suburban areas in developing countries. It has been used extensively in Europe to cover areas where sanitary sewers did not prove economical. On-site treatment reduces the acute impact of pollution on rapidly growing cities. The number of on-site treatment plants in Japan in 1991 was 6,844,904 and that number is still increasing.

The application of on-site treatment of sewage in Thailand and Bangkok started in 1975 when the Department of Health of the Ministry of Public Health wrote a letter approving the efficiency of two Japanese type on-site treatment tanks. The approval served as a good incentive to a local firm which has succeeded in distributing about 45,000 on-site units which are now serving up to 450,000 people with on-site sewage treatment. The on-site technology is already comparable to conventional treatment plants in treatment efficiency (Suwarnarat, Chotchuangchatchaval and Khunpanitchkit, 1992). The current Building Control Regulation also requires that large buildings such as hotels, condominiums, market places, schools and department stores install wastewater treatment plants on-site. Therefore, the demand for such installations will continue to increase in the future.

6. Conclusions

The wastewater disposal system of a city is important and expensive. Careful planning with due consideration of the natural assimilation capacity of the environment and existing simple technologies should not be overlooked.

The introduction of on-site treatment plants is proposed as an intermediate means of alleviating the prevailing unsanitary conditions in many urban areas of the developing countries. The virtue of household and on-site treatment plants would not become significant if a city could afford to build a sewerage system to collect all the wastewaters and transport them away from the urban

vicinity. However, many cities in the developing countries are short of capital for investment and of the engineering capacity to dig roads and lay sewers all over the city. It will, therefore, be more realistic to consider building smaller on-site treatment plants.

Developing countries must learn to improvize with existing conditions when they cannot afford to invest in new large-scale construction projects. A system of on-site treatment plants discharging clean effluent into the storm drainage system could be as effective as building a sewerage system with pump-houses and a large central treatment plant.

There is as yet not enough effort in the design and development of household or on-site treatment plants because there is only limited marketing potential for such plants in the industrialized countries.

The bad reputation of existing low-cost treatment plants is due to factors such as: (a) incorrect design, especially in the hydraulic aspects, (b) lack of scientific knowledge of the process, (c) misuse of equipment, and (d) poor operation and maintenance. All of which are not fundamental failures but practical problems which can be solved. The lack of maintenance should not be a problem in developing countries where a large number of the population are still looking for jobs.

The use of low-cost systems, such as the natural treatment methods for suburban areas and the on-site waste treatment systems in urbanized areas, should be encouraged as an intermediate measure against urban water pollution.

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D. ACHIEVING COMPLIANCE WITH WASTEWATER STANDARDS* (INCENTIVES FOR INVESTMENT IN ENVIRONMENTAL INFRASTRUCTURE)

Introduction

This paper reviews the situation in the rapidly growing province of Samut Prakarn, Thailand, and then proposes sustainable solutions based on the specific nature of that growth itself. The specific examples used are based on programmes for control of Biological Oxygen Demand (BOD) in industrial wastewater but the procedures followed would be potentially applicable to other sources and other pollutants as well. BOD was selected for this example because it represents the most pervasive problem in the province and because it is generally accepted as the single best indicator of water quality. It provides both a direct indicator of the health of aquatic systems and an indirect measure of threats to human health.

1. Background

Samut Prakarn is a land of opportunities and problems. It sits strategically at the crossroads: serving as the gateway both to Bangkok and the Eastern Seaboard. Future visitors and investors will land at the new airport at Nong Ngu Hao and form their first impressions of Thailand based in part on the environment that awaits them in Samut Prakarn. What awaits them is a booming economy with over 1,600 factories, producing 4 per cent of gross domestic product and growing at over 16 per cent per year. What also awaits them is badly polluted air, land and water, and traffic jams that would choke the life from the very workers and investors that would build it. The dynamic growth that promises to build a better future also threatens to kill the environment that sustains it.

The environmental degradation that threatens the future of Samut Prakarn *is not* the inevitable consequence of investment and economic growth. Rather, it is the consequence of growth without investment in the infrastructure that can provide a sustainable future. Just as traffic jams are the consequence of growth in automobiles without the complementary investment in roads and mass transit; air and water pollution are the consequence of industrial, residential, and commercial growth without the necessary investment in pollution control. Citizens and policy makers involved in the development of this province must decide whether it is to collapse, like a building with a poor foundation, or whether they are prepared to insist that those who benefit from the growth of Samut Prakarn also invest in a foundation of environmental infrastructure which will sustain its future.

Unfortunately, without adequate environmental monitoring and enforcement, these investments are not likely to occur (or at least not likely to occur until long after the damage is done). With the limited staff available and the current control system there is no way to assure investment in pollution control or compliance with environmental standards. In the absence of enforcement, those who invest in pollution control are penalized while their non-complying competitors are subsidized and rewarded. Where the installation of equipment is enforced but not its operation and maintenance, the situation may be even worse. Society winds up paying for as much as half the cost of pollution control but receives none of its benefits. Ironically, the current system provides its greatest incentives (through the environmental impact assessment (EIA) process) for equipment purchases which may never be used while providing almost no incentive for very cost effective sustainable compliance.

2. Economic development and environmental quality

This is not a choice of growth versus environment but a choice for growth and environment. Far from destroying their economies, Singapore, Japan and other member countries of the Organization for Economic Cooperation and Development (OECD) have found that they can adequately protect their environment for an investment of about 1-2 per cent of gross national product. As their economies expand, so expands their investment in environmental infrastructure. In fact, many investments in pollution control actually increase the opportunities for economic growth. If for example, 60,000 tons per day of wastewater BOD were thought to be the maximum limit for minimal environmental quality in Samut Prakarn, this limit could either be met by 1,600 factories employing 100,000 workers but with no pollution control; or that same limit could be met by 3,200 factories employing 200,000 workers with only a

* This paper was prepared by J. David Foster, Regional Housing and Urban Development Office, the United States Agency for International Development, Bangkok, at the request of the ESCAP secretariat.

50 per cent level of BOD control. Similarly, if those factories would control BOD to at least the 90 per cent level (a level requiring an investment of less than 1 per cent of their profits), industrial production (and employment) could expand more than five times while simultaneously cutting pollution loadings in half. This provides a major economic and environmental benefit in return for a relatively small investment.

3. Implementation

Once the decision is made to provide a sustainable future for Samut Prakarn, two major questions remain:

(i) Who should pay?

(ii) How should it be implemented?

The first of these questions has already been answered. Thailand, like most other nations concerned about the environment, has adopted a "Polluter Pays" principle. This means that those who generate pollution and those who buy their products or services should pay the cost of controlling the pollution. Those who use the public environment to dispose of their wastes should be responsible for their impacts. To do otherwise – to use public funds (raised from polluter and non-polluter alike) – would be both inequitable and inefficient. Such an action would subsidize the polluter and provide no incentive for seeking the most efficient means of control.

Selecting the means for implementation is a much more difficult task. While the environmental community appears united on the "Polluter Pays" principle, no such unanimity exists on implementation. There is agreement on the need for standards but far too many countries have been content with adopting environmental standards without really confronting the difficult issues of enforcement.

(a) Barriers to implementation

Environmental standards are, of course, of little value without compliance and compliance assurance requires enforcement. Major improvements can be achieved through voluntary action but without effective enforcement, the environmentally good actors are ultimately penalized while their polluting competitors are subsidized. Every country with an effective environmental programme has ultimately determined that enforcement is required to assure reasonable compliance with environmental standards. The barriers to enforcement, however, remain formidable.

These barriers to effective implementation in Samut Prakarn include at least the following:

(i) Lack of public awareness,

(ii) Lack of effective cost recovery for environmental Services,

(iii) Limited authority,

(iv) Limited staff,

(v) Limited staff salaries, and

(vi) 1,600 factories of 20 different industries expanding at a rate of over 10 per cent per year.

4. Potential solutions

In Samut Prakarn, the problems hold the key to the solution. The extremely rapid growth and the vitality of the private sector can be effectively used to solve the environmental problems. The first step is to recognize the nature of the pollution sources and to then focus the limited resources available as closely as possible where they will achieve the most benefit. In the discussion which follows, the pollutant addressed is BOD in industrial wastewater but the procedures followed would be similar for other pollutants and sources.

(a) Analyse the distribution of sources of pollution

(i) Focus on a limited number of factories

While 1,600 different factories may be impossible to closely scrutinize, as shown in figure XII, most of the BOD is discharged from a relatively small number of sources. In fact, over 80 per cent of the BOD is generated by only 100 factories. This is not to say that the other sources should be ignored but clearly these 100 factories should receive the lion's share of attention. Once more information is obained about the relative compliance of these sources, the closest attention can again be focused on those with chronic compliance problems while providing more limited surveillance of those routinely achieving compliance.

Experience in the United States of America suggests that once systematic enforcement procedures are established, often 90 per cent of the problems are created by only 10 per cent of the pollution sources. Failure to attend to these problem areas, however, can soon cause them to rapidly spread to other areas.

Interestingly, while these 100 factories generate over 80 per cent of the industrial BOD in Samut Prakarn, they generate only about 30 per cent of the employment. Therefore, failure to control the wastewater from these factories is likely to harm rather then help employment opportunities in the province.

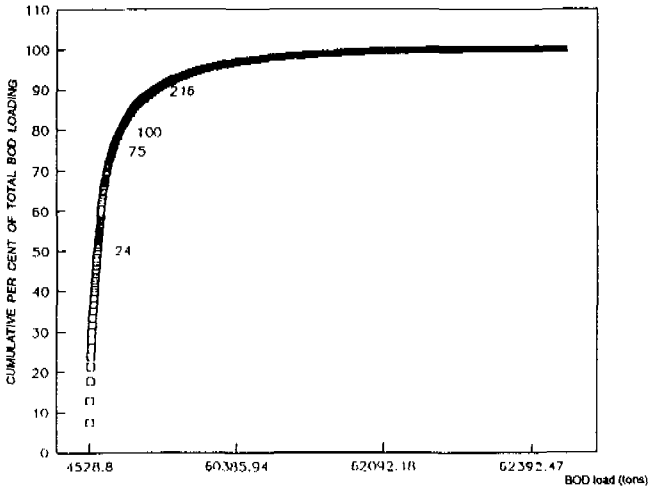

Figure XII. Distribution of sources by BOD loading, Samut Prakarn, Thailand

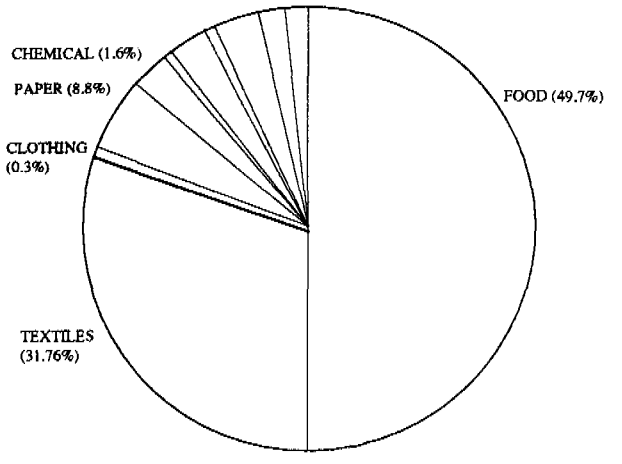

Figure XIII. Distribution by BOD load by source, Samut Prakarn, Thailand

(ii) Focus on a limited number of industrial categories

With only a limited staff it is almost impossible for enforcement agencies to develop expertise in each industrial category. Samut Prakarn has over 20 different kinds of industries, each with their own problems and peculiarities. As figure XIII illustrates however, analysis of the distribution of the 100 largest generators of BOD in Samut Prakarn reveals that BOD generation is dominated by only three or four major industrial categories. While these four categories represent only 25 per cent of all factories, they represent 90 per cent of the largest generators of BOD. Even a limited number of staff can develop extensive expertise in these most common sectors including textiles, food processing and paper manufacture.

(iii) Focus on supervision (use of environmental auditors)

With only a limited number of trained environmental specialists it will be impossible to provide regular government inspections of all the sources now regulated by the Division of Industrial Works much less the new sources being built every month. Furthermore, even if the inspection offices received major budget increases, the strict government salary limits would still severely limit the hiring of trained engineers.

What must be remembered, however, is that not all inspections need be performed by government officials in order to be effective. In most countries, for example, financial inspections, or audits, are generally performed not by government officials but by Certified Public Accountants (CPA). These private sector employees are trained in local universities, certified by their governments or associations and perform annual financial audits paid for by the firm whose records they inspect. Finally, the records of these inspections are then made available to government officials for their own inspection and review.

In a similar fashion the Government of Thailand can establish a system of "Certified Environmental Auditors" (CEA) who can be trained in local universities and certified by government examination. These individuals would then be paid by private companies to perform annual inspections or "audits" and report the results of those inspections to the government officials in charge. To limit the opportunity for false reporting, high standards would have to be maintained from the very beginning and penalties for falsification of certified audits would need to be severe. As with financial audits, this system allows environmental officials to focus their own limited resources on supervising the performance of private auditors and on individual problem cases. Not only does such a system greatly increase the number of factories that the goverment can effectively monitor but, consistent with the polluter pays principle, the cost of these inspections are rightfully paid by the industries themselves.

(iv) Focus on operation and maintenance

Pollution control is achieved, not by the purchase of equipment but by the incorporation of waste minimization techniques and by proper operation and maintenance of the control equipment and processes. Equipment purchase may well be necessary but by itself it is usually insufficient. Most new industries are already subject to some form of environmental impact assessment prior to being granted a permit. Unfortunately, many of the pollution control strategies

promised in the pre-construction review are never actually implemented. Even where the equipment is installed as indicated, the failure often rests with the operation and maintenance (O and M). Actually this should come as little surprise, the financial rewards under the current system for failing to operate and maintain control systems are far greater than the rewards for failing to install. Not only are chances of inadequate O and M less likely to be detected but the annualized costs of O and M are typically far greater than the annualized cost of capital construction of waste treatment facilities. For the factories in Samut Prakarn, average annual O and M costs are typically 2-5 times the annualized capital costs. Conversely, while the risk of being caught for failure to install the required equipment is fairly high, the current likelihood of an annual inspection of operations is almost zero. Even where the factory manager conscientiously intends to operate the control facility, malfunctions are common in a polluted atmosphere and the operator has little incentive for prompt repair.

Factories which have already installed pollution control equipment but failed to properly operate and maintain it represent the most cost effective opportunity for additional pollution control in Samut Prakarn. This opportunity for cost effective emission control exists precisely because most of the required equipment has already been purchased and therefore, major additional pollution reductions can be achieved for relatively minor additional investment. Ironically, under the current system, it is precisely these situations which receive the least attention and the lowest incentive. What is needed is a monitoring and enforcement system which provides incentives directly proportional to the potential benefit received.

(b) Development of environmental incentive system

Objective: Develop an environmental management system to improve environmental quality consistent with national policies and public and private resource constraints.

National policies:

(i) Promote sustainable development

- Rapid economic development and job creation,
- Preserve and enhance environmental quality,

(ii) Promote Cost effective pollution control,

(iii) Provide for implementation of polluter pays principle,

(iv) Promote use of industrial estates, and

(v) Promote decentralization of industry outside of the Bangkok Metropolitan Administration (BMA).

Resource constraints:

(i) Limited environmental budget,

(ii) Limited government-manpower,

(iii) Limited monitoring capability,

(iv) Limited central treatment facilities, and

(v) Limited private resources for pollution control.

Proposal: Reinforce existing regulations and policies with a comprehensive environmental impact fee proportional to pollution discharge in excess of the environmental standards. An environmental impact fee of this type is based not on the services rendered but on the "impact" imposed. The factory is, therefore, charged a fee for having dumped its waste in a public waterway just as they might have also been charged for dumping solid waste in a government regulated public landfill.

Purpose: Provide a fair and efficient incentive to promote sustained compliance with environmental standards while raising revenue to improve the environment.

Sources subject to fee: No factory in full compliance with current standards will be required to pay any additional fee under this programme. They will, however, be subject to its reporting requirements. All sources potentially discharging more than 3,000 kg of BOD/month into the public waterways of Samut Prakarn Province would be subject to these provisions. These sources include both public and private facilities, industrial estates and independent factories, and those with and without waste treatment controls. For purposes of this requirement, the phrase *potentially discharging* refers to the waste generated prior to application of any pollution control programme. While administrative constraints would initially limit this fee only to the largest sources, it is fully intended to be gradually expanded to include smaller and smaller sources so that no one would benefit by artificially dividing a large factory into several smaller ones. Similarly, while this fee is initially intended primarily for industries, there is no reason why it could not be extended over time to include commercial enterprises and housing estates.

Size of fee: The size of the fee must be at least as high as the charge per unit of BOD imposed on factories

located within the industrial estates. To charge less would clearly be a subsidy to the polluter, and would violate both the polluter pays principle and the Government's announced policy of encouraging factories to locate within the industrial estates.

In addition to charging a fee equivalent to the cost within the industrial estates for existing sources, consideration should also be given to charging an even higher fee on new sources locating in Samut Prakarn (but outside the industrial estates) after promulgation of this programme.

It should also be noted that the industrial estates, themselves, should also be subject to this fee. There is no point in envourgaing factories to locate within industrial estates if the estates do not also provide for continuous compliance with environmental standards.

Data collection and administration: The quantity of pollutant discharged will be calculated based on information obtained through three channels including:

(i) Monthly self reporting by the factory itself,

(ii) Annual audit reports prepared by an independent environmental auditor, and

(iii) Government estimates and inspections.

Monthly self reports: Monthly reports will be required from each factory subject to these provisions and provide the quantity of water used, the quantity of BOD discharged, the quantity of suspended solids and a description of any malfunctions occurring during the month and the steps taken to correct them. *Note*, malfunction of equipment should not be considered a legitimate excuse for failure to pay the fee. Failure to submit monthly self reports would trigger a requirement for additional independent audits at the expense of the factory owner.

Annual audits: Annual reports are prepared by independent certified environmental auditors verifying the existence and performance of the control equipment reported by the factory manager and certifying the routine removal efficiencies claimed for the control equipment. Where appropriate, records of chemicals employed for treatment and electricity and fuel use for operating equipment should also be reported to substantiate claims of continuous operation.

Government estimates and inspections: The Government can begin the process by making presumptive estimates of BOD discharge based on industrial averages. Factories can then be informed that effective within six months of notification they will be charged a fee based on these presumptive estimates until such time as they prove that their own waste discharges are less than the government estimate. All such proofs would need to be authenticated by an independent environmental audit. Government inspectors would also reserve the right to make there own inspections to evaluate the performance of the independent auditors. Those factories failing to cooperate with the required audits, fees, and inspections would have their permits revoked.

Impact of the fee:

(i) No source currently in compliance with environmental standards will have to pay any additional fee under this programme.

(ii) Factories located within industrial estates and/or in compliance will not longer be threatened by unfair competition from factories not controlling their wastes.

(iii) Factories required to pay fees because they are out of compliance can reduce their fees by reducing their pollution. Obviously their incentives will be highest where their pollution control costs are lowest.

(iv) Factories with control equipment already installed but poor operation and maintenance will be required to pay the full amount of the fee (per unit of BOD) and will receive an immediate incentive to upgrade their O and M in order to minimize their fee payments. As their estimated costs of control per unit of BOD removed will be comparatively low (because they have already installed their control equipment), these facilities with their comparatively cost effective control opportunities will logically be among the first to reduce their pollution.

(v) Factories with no pollution control will have to pay an additional fee amounting on average to about 1 per cent of their current profits. They will therefore need to determine whether to install and operate control equipment, join with other factories in building and operating central facilities, relocate to an industrial estate, or relocate outside of Samut Prakarn Province.

(vi) Industrial estates will experience an increased demand from clients for their facilities.

(vii) Companies providing environmental audits and environmental services would provide a significant increase in the demand for their services.

(viii) Finance companies and investors seeking to lend for and/or invest in wastewater treatment facilities would have increased opportunities for such ventures.

(ix) Workers should benefit from an improved environment with no significant loss of employment opportunities. Not only are the total costs of control less than 1 per cent of operating costs but the firms most affected are not generally the largest employers. In fact, in the long run the improved environment should lead to an increased interest on the part of foreign investors.

(x) Factories whose pollution control costs are less than the fee (per unit of waste) will have the greatest incentive to take prompt action. Thus assuring Thailand the most efficient allocation of new investments in pollution control.

(xi) Factories whose pollution control costs are greater than the fee may not be inclined to take very prompt action but at a minimum they will be contributing, through their fees to the cost of general pollution control in the province. Furthermore, even if these factories, because of their high control costs perform no better under this proposed fee system than under the current one, at least they will perform no worse. These sources tend to be the smallest, generate the least BOD, and have the least opportunities for cost effective control. Therefore, while they will continue to be subject to all existing penalties provided under the current system, it is appropriate that they be regarded as the lowest priority for enforcement.

5. Conclusions

Samut Prakarn has been described as being at a crossroads; offering a gateway to both Bangkok and the Eastern Seaboard. It represents a "crossroads" in time as well. Down one road lies a dismal future thick with pollution, severe health problems and limited prospects for economic growth. On the other road lies a sustainable future in which some revenues from development are reinvested to provide environmental infrastructure which can help sustain an even more prosperous future. Choices made at this "crossroads" will help choose the future for Thailand.

The control and enforcement options referenced in this paper are well within the reach of the people of Thailand. Samut Prakarn is booming economically and the necessary control equipment is both available and affordable. Effective implementation will require careful enforcement but if the Government of Thailand uses its resources strategically then Samut Prakarn can achieve major environmental improvements while continuing rapid economic growth.

Part Three

COUNTRY PAPERS

I. MANAGEMENT OF URBAN WATER SUPPLY, SANITATION AND WASTEWATER DISPOSAL IN BANGLADESH*

Introduction

The main objective of urban water supply, sanitation and drainage is to provide safe drinking water, sewerage and storm water drainage in urban areas with a view to improving the environment and quality of life. A general scenario of the national water management, sanitation and sewerage policies is given in the first part of this paper while the second part deals mainly with the management of water supply, sanitation and sewerage of metropolitan Dhaka.

A. National water management scenario

1. Physical features of Bangladesh

Bangladesh with an area of 55,126 square miles is a tropical country situated at the confluence of two major rivers, namely, the Ganges and the Brahmaputra. On three sides it is bordered by India and to the south is the Bay of Bengal. The general topography is flat and it is crossed by a number of small rivers and their tributaries and distributaries. Rainfall during the monsoon is quite heavy which sometimes leads to widespread flooding.

2. Urban areas

There are 64 district towns in Bangladesh. Dhaka is the capital city and Chittagong is a major port city.

3. National water management policies

Planned utilization and efficient management of water resources is considered one of the crucial elements for achieving the desired changes in productivity during the fourth five-year plan for 1991-1995. In Bangladesh, despite the unique dimension of water as a resource, its variation in temporal and spatial occurrence is a major impediment to water development for maximizing contributions to the national economy. Nowhere in the world does water possess such a contrast in its abundance in one season and scarcity in another. While there is a defined policy for the management of water resources in the country as a whole, a policy for the management or water in urban areas has not yet been formulated. The Bangladesh Water Development Board is responsible for water resources planning and development and deals mainly with the agricultural use of water and flood control. The Department of the Environment is responsible for polluton control of water resources. There is no adequate legislation to enforce the pollution control standards. As a result untreated sewage is discharged directly into the water courses by the urban areas, except Dhaka city.

4. Major constraints to water resources development

Some of the major constraints which have been identified are as follows:

(a) Lack of an efficient and integrated approach based on regional and basin based planning and prioritization of schemes.

(b) Ineffective planning and slow implementation of schemes and consequent inability of the schemes to provide the stipulated modification of the land/water environment according to planned schedules.

(c) Inadequate attention to the institutional framework required for the operation and maintenance of schemes on a self sustaining basis with effective local participation.

5. Objectives and strategies of national water plan

Promotion of efficient use of water resources in respect to time and spatial location through emphasis on inter-basin water balances without causing harmful environmental effects is one of the major objectives of the national water plan.

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Use of the main rivers and basin-wide development of surface and groundwater balanced with time and space variants are the long-term strategies of national water development.

6. Urban water supply and sanitation

Of the district towns only two, namely, Dhaka and Chittagong have separate authorities for urban water supply management and only Dhaka has both a water supply system and a sewerage system.

In the urban areas (excepting Dhaka and Chittagong), the Department of Public Health Engineering (DPHE) is responsible for design, planning and constructing the water supply system including the development of resources and construction of reticulation and storage facilities. The source of supply is groundwater. After construction of the facilities by the DPHE these are handed over to the urban authorities or municipalities for operation and maintenance of the system. There is no sewerage system in these district towns where septic tanks or the bucket system are being used and the untreated effluent is discharged into the nearby water course or low-lying areas.

Drainage in the urban areas, except Dhaka, is also the exclusive responsibility of the DPHE. In most of the urban areas drainage of storm water is through surface drains and natural canals. In Dhaka, drainage facilities are the responsibility of the Dhaka Water Supply and Sewerage Authority (DWASA).

7. Water supply coverage and goals

At present 41 per cent of the population of all district towns (other than Dhaka and Chittagong) are served by piped water supply. Though the service is inadequate yet the achievement of 41 per cent coverage has been possible with Dutch and Japanese grants and project aid from the Asian Development Bank along with government funding.

Emphasis is being given for completion of on going aided projects and new projects are being started in important towns which have not been covered or which need expansion of water supply facilities. A proposal has been made to increase the relevant coverage in town to 75 per cent during the period (1991-1995). Package programmes are being started to integrate water supply, sanitation and drainage in district towns. Special care is being taken to provide water supply and sanitation facilities to the urban population of slums and fringe areas.

The existing water supply facilities of Dhaka cover about 65 per cent of the population of the city. The aim is to increase the water production to cover 84 per cent of population of the metropolis by 1995. The existing water supply facilities of Chittagong have recently been increased to cover about 65 per cent of the city population. The aim is to increase water production to serve about 75 per cent of the city population by the end of 1995.

8. Cost recovery for urban water, sanitation and sewerage facilities

In the areas of jurisdiction of the Water Supply and Sewerage Authorities of Dhaka and Chittagong, cost recovery is done in the form of direct billing to consumers. In other urban areas, cost recovery is inadequate and is the responsibility of the urban authorities. Cost recovery for water supply in these urban areas is done mainly in the form of municipal taxes. There is no direct cost recovery for drainage facilities. In Dhaka, it is operated and maintained from DWASA's own revenue income. In the other urban areas, the drainage facility is operated with funds from government grants.

B. Water supply sanitation and sewerage of Dhaka

1. Physical features of Dhaka

Dhaka lies almost at the centre of the country. Like the rest of the country it has a flat topography. There are rivers on almost all sides of the city. The annual rainfall in Dhaka city varies from 2814 mm (maximum) to 1,183 mm (maximum) (considering a 6-year cycle from 1987-1992) with an average of 2,052 mm. Surface water around Dhaka, while abundant, has not yet been utilized extensively for city water supply. The quality of the groundwater is generally good.

2. Historical background

The history of modern water supply in the city dates back to August 1874 when the foundation stone of the Dhaka Water Works (a small water treatment plant) was laid at a place called Chandnighat on the bank of the River Burhiganga by the then Nawab of Dhaka, Abdul Ghani. At that time piped water was supplied mainly through street hydrants and there were a few house service connections given to the elite.

The sewerage system came much later in 1923. Until the beginning of the 1940s the water supply and sewerage system was mainly confined to the old city areas.

After 1947 Dhaka became the then provincial capital and the demand for water supply and sewage disposal facilities started growing rapidly. With the growth of demand both water supply and sewage disposal facilities were extended on a piecemeal basis to cater to the needs of particular areas. Towards the end of the 1950s the Government felt the need for comprehensive water supply and sewage disposal plans. Accordingly a feasibility study was carried out and a master plan was prepared. To implement that master plan and to develop and operate a sound water supply and sewage disposal system in the city, the Dhaka Water Supply and Sewerage Authority (DWASA) was established in November 1963 under Ordinance XIX of 1963. DWASA started functioning from 14 November 1963. The Authority's jurisdiction includes six urban areas, namely, Narayanganj, Demra, Tongi, Ghazipur, Dhaka and Savar. But DWASA has not taken up all those areas and its activities are confined in and around the Dhaka metropolitan area and Narayanganj town. The responsibility of water supply in Narayanganj town was handed over to DWASA in March 1991.

3. Responsibilities of the Dhaka Water Supply and Sewerage Authority

DWASA is a utility organization having the following major functions:

(a) Construction, improvement and maintenance of water works for collecting, purifying, pumping, storing and distributing potable water to the public, industries and commercial concerns.

(b) Construction, improvement and maintenance of sewerage works for collecting pumping, treating and disposing of sanitary sewage and industrial wastes.

(c) Construction and maintenance of drainage works for drainage facilities. (This responsibility was handed over to DWASA in March 1989).

4. Organizational Structure

DWASA is divided into three departments, namely, Engineering, Commercial and Administration. Each of these departments is headed by a Member appointed by the Government, who oversees the activities of the respective departments in addition to their policy-making functions as Members of the Board. The Board has been functioning since 4, April 1992. The Chairman of DWASA is the head of the organization and Chief Executive Officer. He is assisted by the Members of the Board. The following divisions of DWASA are under direct control of the Chairman:

(a) Planning Evaluation and Monitoring;

(b) Internal Audit;

(c) Public Information Division; and

(d) Security and Intelligence.

From 1982 DWASA has fully decentralized its operation, maintenance, consumer services and revenue activities by dividing the city into six geographical zones. Each zone has a zonal office where engineering operation and maintenance and consumer services are run side by side with revenue functions so that the consumer can contact DWASA at one point for all of his services rendered by DWASA. This has added to the convenience of the consumers by bringing the services nearer to them.

5. Water supply system

In general, DWASA is operating two production systems in Dhaka city. The older being the old Dhaka Waterworks and the newer and more extensive production system being the supply of water (about 98 per cent) from boreholes with the help of Deep Tube Wells (DTWs). At present 159 DTWs are operating at different locations in and around Dhaka. On an average DWASA can supply about 643 million litres (January 1993) of water per day in Dhaka city which includes supply from both DTWs and the Dhaka Waterworks. In Narayanganj, 10 DTWs and 2 surface water treatment plants are operating and a total of 23 million litres/day (January 1993) of water is supplied.

Groundwater is the main source of the city water supply through DTWs. But the yearly recharge of the aquifer is less than the abstraction. Hence the groundwater table has been gradually going down at the rate of about 0.9 m per year on average. With the fall in groundwater level DTWs need to be installed deeper, which is one of the major problems of pumping water from DTWs. There is also marked seasonal variation in the groundwater level which also causes water shortages during the summer season. The quality of water supplied from DTWs is good and does not require treatment except for chlorination which is required to maintain the biological quality of water in the distribution system.

As in other developing countries DWASA has been encountering severe operational and maintenance problems in the distribution system due to inadequate system pressure, leakage, wastage, power failure and the excessive growth rate of the population, etc.

The existing distribution line varies from 100 through 450 mm in diameter. Most of the DTWs are directly discharging into the system through 200 mm diameter delivery mains. Only a few are located in the elevated storage tank sites which are directly pumping into the tank. Water from the overhead tanks is supplied to the system during peak hours.

At present there are about 1,227 km of waterline in the city through which water is supplied under an integrated system. Service connections are generally taken from the main supply lines. There are about 116,879 consumers in Dhaka and 4,803 consumers in Narayanganj. Water is also supplied through 1,209 street hydrants in Dhaka city and 430 street hydrants in Narayanganj.

6. Demand and supply of water

The present population of Dhaka is about 7 million which does not include the floating population. The daily requirement of water is about 1,260 million litres per day. But DWASA can supply about 51 per cent of the demand. The demand and supply of water from 1985-1993 is shown in table 23. The projection of demand up to 2010 is also shown in table 23.

Table 23. Demand and supply of water in Dhaka

Year	*Estimated population (million)*	*Demand (million litres per day)*	*Supply (million litres per day)*
1985	3.0	545	296
1990	5.5	1000	514
1993	7.0	1260	643
1995	8.0	1440	-
2000	9.5	1710	-
2050	10.5	1890	-
2010	11.5	2070	-

7. Development projects

The urban area is continually expanding. Consequently, the demand for water supply is also growing. DWASA is undertaking development activities to cope with the growing demand for water supply, sanitation and drainage. DWASA is at present implementing three development projects for improvement of the water supply in the city. These are briefly described below:

(a) Crash Programme

This programme included installation of 60 DTWs to produce about 220 million litres per day of water. All of these DTWs have been installed and 50 have been put into operation. The remaining DTWs will be in operation shortly. Six overhead reservoirs and 100 km of waterlines have also been constructed under this project. This project has been fully implemented with local financing and is expected to be completed by April 1993.

(b) Third DWASA Project

This project, financed by the World Bank, began in July 1985 and is scheduled for completion by June 1993. The major components of the Project together with their progress are shown in table 24.

Table 24. Progress in the implementation of the Third DWASA Project

Items	*Unit*	*Target*	*Progress*
Deep Tube wells	Nos	55	44
Water lines	km	367	298
Water Service Connections	Nos	35,000	26,000
Sewer Line	km	70	73
Sewer Connections	Nos	11,000	8,000

(c) Dhaka Urban Infrastructure Improvement Project

The physical works of the project commenced in January 1992 and the project is expected to be completed by December 1994. The project area will cover a small portion of the north-western part of Dhaka city. The project is being financed by the Asian Development Bank. The physical components of the project and their progress are given in table 25.

Table 25. Progress in the implementation of the Dhaka Urban Infrastructure Improvement Project

Items	*Unit*	*Target*	*Progress*
Deep tube wells	Nos	2	2
Water lines	km	3.5	1.0
Sewer Lines	km	123.26	Design in progress
Sewer rehabilation	km	20	Design in progress

The supply of water has increased considerably over the years. It has increased from 571 million litres per day at the end of June 1991 to 643 million litres per day at the end of January 1993 which is an increase of about 13 per cent over the previous year. The quantity of water that DWASA can supply is still inadequate compared to the demand. Consequently, supply to some areas, mainly in the old city, is intermittent. With its existing facilities and DTW- based ongoing projects DWASA cannot keep pace with the population growth of the city. Moreover, the changes occurring in the aquifer

are beyond its control and there is no scope for installing new tube wells in the old city areas. It is imperative, therefore, for DWASA to lessen its dependence on groundwater and to go for treated surface water as the alternative source for the city water supply.

It has been observed that a combination of groundwater and surface water is the most economic solution for the long-term water supply of Dhaka city. Recently DWASA with the help of French consultants has completed the preparation of a master plan for the long-term improvement of the city water supply. A surface water treatment plant with an initial capacity of 225 million litres per day is a priority component of this master plan.

8. Sewerage system

The average rainfall in Dhaka is 2,052 mm per annum. Due to heavy rainfall in the monsoon season a combined sewer is too expensive and not at all feasible. Therefore, a separate foul sewer and storm sewer have been planned in Dhaka city.

Initially a water-borne sewer system was developed in 1923. From that time as the city expanded to the north, east and west DWASA developed a system consisting of lift stations and gravity lines including trunk mains up to 1,350 mm in diameter, which carry all sewage to a 90 acre lagoon on the south-east periphery of the city (Pagla) on the bank of the River Burhiganga, from there the effluent is pumped into the river. The early stages of development expanded north and west with mains and lift stations all of which flowed to Narinda. In 1966, another extension began including a series of lift stations and trunk mains along the north and east side of the city, terminating at the lagoon, which also included the Narinda discharge.

The existing sewer system is based on gravity flow and consists of laterals, trunk lines, interceptors and lift stations. Due to the general flatness of the city the sewer lines have to be laid from a depth of about 2-8 metres. The sewage flows by gravity to lift stations where it is lifted and flows by gravity to the next lift station until it reaches the treatment faciity. From the treatment facility the effluent is discharged into the River Burhiganga after treatment.

Existing sewer lines in the old city range from 225 to 900 mm in diameter and in the rest of the city from 200 to 1,350 mm throughout the system. Particularly in the old city operation is plagued by infiltration from illegal pipe joints and clogging of sewer lines due to the dumping of garbage into the manholes. DWASA has taken intensive measures to reduce the infiltration. At present, there are about 454 km of sewer lines and 39,423 sewer service connections in Dhaka city. Narayanganj is not yet served by a sewerage system.

9. Drainage system

Construction of a storm water drainage system was started in 1964 by the Department of Public Health Engineering. The responsibility of storm water drainage was transferred to DWASA in March 1989. At present, there are about 130 km of drainage line ranging from 450 to 3,000 mm in diameter and a pumping station with a capacity of 9.6 m^3, which serves an area of about 60 km^2. In addition there are 13 major canals and 22 other smaller canals which serve to drain the city storm water. The total length of canals is about 80 km.

10. Development of drainage

In order to improve the storm water drainage facilities, DWASA has implemented a project under which a pumping station with a capacity of 10 m^2 and a sluice gate have been constructed in the north-west of the city. About 0.8 km of channel culvert has been constructed and 3.3 km of canal has been re-excavated. Under another project about 80 km of canal will be re-excavated and 45 km of drainage lines will be constructed.

11. Problems

The major problems facing DWASA are water loss in the system and accounts receivables. DWASA has recently taken some important steps to reduce water loss by 10 per cent by the end of June 1993 and to reduce accounts receivables to a 6-month average billing level. Those steps are as follows:

(a) Consumer survey

A consumer survey was started in June 1992 to collect up-to-date consumer information including (but not limited to) the following information which will have direct bearing on commercial performance:

(i) Correct classification of consumers according to type of establishment;

(ii) Identification of both legal and illegal consumers not on DWASA records;

(iii) Identification of meter manipulation, defective meters, inaccessible meters, etc;

(iv) Verification of the actual amount of receivables; and

(v) Verification of the correct valuation of each holding.

The consumer survey is expected to be completed by the end of May 1993. At the end of January 1993 about 105,940 holdings had been surveyed.

(b) Metering programme

A major part of water loss in the system or non-revenue water occurs in the non-metered connections where billing is done at a fixed rate on the basis of an annual valuation of the holdings. At present there are 33,768 (about 29 per cent) non-metered connections out of 116,879 consumers (December 1992) in Dhaka and almost all (99.5 per cent) of the 4,803 registered connections of Narayanganj are non-metered. In those holdings more water is used than the amount actually billed. Conversion of non-metered connections to metered connections is an important component of the ongoing World Bank financed Third DWASA Project aimed at improvement of commercial operations. About 21,931 meters were installed from 1985 to June 1992. Metering is being done on a selective basis with priority to those connections which are expected to yield substantial amounts of revenue. The metering programme will help in both increasing revenue and in the reduction of wasteful water use.

(c) Computerization of billing

Until recently DWASA had a manual billing system. Computerization of billing was started in December 1992. Computerization of billing with an up-to-date database with data from the consumer survey has been established. Manual billing is being gradually discontinued in areas where computerized bills are issued. It is expected that by December 1993 computerized bills will be issued to all customers.

(d) Ensure delivery of bills

Non-delivery of bills on a timely basis has been a major problem. The computerized bills of Zone-V are being sent by mail on a test basis. If this proves successful then this system will be introduced to the whole service area.

(e) Reduction of water losses

To reduce water loss, DWASA has already replaced 93 km of old and worn out leaky pipes and another 43 km will be replaced by end-December 1993. An additional 33.33 km have been identified for replacement shortly thereafter. DWASA personnel are also being given training in proper pipe laying and service connection in order to reduce leakages.

(f) Reducing receivables to a 6-month level

Due to many reforms accounts receivables, in terms of months of average billing, have been gradually reduced. They have been reduced from the level of 10.39 months average billing in 1988 to the level of 6.26 months average billing in January 1993. With the present level of effort it is expected that receivables will be reduced to the level of 6 months within a short time.

II. URBAN WATER SUPPLY IN CHINA*

Introduction

Along with the steady growth of society and the economy in China, urbanization is developing rapidly. It is estimated that by the end of this century, the number of cities will have increased from 409 to 640, the population in the cities from 140 million to 220 million and the urban water consumption from 53 billion to 120-150 billion m^3. The question of how to meet the demand for water not only directly affects urban development but also the process of the Four Modernizations of the People's Republic of China. Study of the problems related to urban water supply is, therefore, of great significance.

A. The characteristics of urban water supply

Urban domestic water generally includes the water supply for the daily life of the urban population and for public facilities. In metropolises and tourist cities such as Beijing and Tianjin, etc., the water consumed by public facilities accounts for 55-70 per cent of the total water consumption, while in other cities it accounts for about 30-40 per cent.

Average domestic water consumption is 100-120 litres per capita per day for the whole country, however, it can be over 150-200 litres in some larger cities. At present, in some water-deficient areas the water used for irrigating vegetables is also considered to be domestic water.

The water in the urban industrial sector is used mostly for cooling, air-conditioning, and technological processes. The water consumed by six industries namely, paper-making, chemical, petroleum, construction materials, coal and metalurgy in Beijing and Tianjin accounts for 75.6 per cent of the total industrial water.

The characteristics of urban water supply are as follows:

1. Priority of urban water supply

According to article 14 of The Water Law of the People's Republic of China, "In the development and utilization of water resources, the domestic water demands of urban and rural inhabitants shall be satisficd first, while agriculture and industrial water demands as well as navigation requirements shall also be considered and taken care of. In areas deficient of water, urban growth and the development of high water consumption industries and agriculture shall be restricted".

In the northern water-deficient cities, water supply is prioritized in the order of domestic, industry and agriculture. Under severe conditions, the water for agricultural purposes is reduced to satisfy the water demands of the urban areas.

2. Rapid growth

In China from the 1950s to the end of the 1970s, the urban water consumption increased 8 times, and the industrial water (including thermal power) increased 22 times. In Beijing, the urban water consumption increased 40 times, and in the less developed cities of the provinces of Hebei, Henan, and Anhui it increased 10 times, however, in a few cities it increased over 100 times.

3. High requirements for the quality and quantity of water

The guaranteed rate of water supply in important cities is set above 95 per cent, and not below 90 per cent in ordinary cities. The quality of urban water resources must conform to the regulations of "The Quality Standards of Surface Water," the quality of tap water must conform to the regulations on "The Quality Standards of Drinking Water."

4. Close interrelation between water supply and drainage

Water supply has a close interrelation with

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drainage, since 60-70 per cent of the water supply needs rational and prompt drainage, and part of the wastewater will be reused after purification treatment; therefore, the construction of water supply and drainage systems must be done simultaneously in order to utilize the water resources rationally.

5. Predominance of groundwater

Groundwater is used predominantly for water supply in 174 cities in China, and partially in another 49 cities with the daily supply capacity of 11.58 million m^3, accounting for about 25 per cent of total capacity.

Since 1980, the surface water supply from the Miyun Reservoir which supplies Beijing has been increased in order to control the overdrawn groundwater situation in the city.

6. Industrial water supply

In China, many large industrial enterprises located in urban areas have their own water supply facilities. However, small- and medium-size factories often rely on water supplied by public water supply systems.

In 1982, the capacity of industrial waterworks was 2.5 times that of 1972, while the capacity of the public urban water supply systems only doubled. The construction of public urban waterworks is slow, and running water accounts for only 32.4 per cent of the industrial water supply, which cannot meet the demands from urban industries.

B. The situation and problems of urban water supply

At present, there are 409 cities which have public water supply facilities, consisting of 1,059 waterworks, 86,230 km of pipelines, with a daily water supply capacity of 49.65 million m^3 and a daily water supply capacity of the urban industrial waterworks of 77.5 million m^3. So the total daily water production capacity in these cities is 127 million m^3, of which 70-75 per cent is for industrial water uses and 25-30 per cent for domestic uses.

The daily sewage quantity generated in the urban areas is about 71.64 million m^3, but the daily capacity of the 69 municipal sewage treatment plants is only about 2 million m^3. In addition, there are 30,000 water treatment facilities in the factories, with a daily treatment capacity of 27.4 million m^3.

The main problems of urban water supply are as follows:

1. The water supply capacity cannot catch up with the increasing needs for water

Presently, there are 200 water-deficient cities, of which 40 cities suffer seriously, their daily water shortage amounts to about 4.3 million m^3. Only in 14 rapidly developing coastal cities the daily water shortage is up to 1.9 million m^3.

2. Low effeciency in the utilization of the water supply

Water meters and water conservation facilities in urban areas are lacking. Obsolete equipment and the low technical level of the industries cause inefficient utilization of water. The water reuse rate is only 30-40 per cent.

Scattered and numerous waterworks owned by industries in urban areas make control and supervision difficult, which affects the rational utilization of water.

3. Urban water resources are seriously polluted

Presently, the delays in the construction of sewage treatment plants and the incomplete sewerage systems of factories cause difficulties in controlling the pollution of urban water resources.

C. Solutions

1. Developing water resources properly and conserving water

Water resources per capita in China represent about a quarter of the world's average level and moreover these resources are not distributed evenly. Thus, the establishment of "water-saving" systems in cities should be a long-term policy of the State.

To solve the problem of the uneven distribution of water resources between regions, interbasin water transfer projects are imperative. For example, one large-scale project is designed to convey water from the Yangzi River to the basins of the Yellow, Huai and Hai Rivers, while another project conveys water from the Songhua River to the Liao River basin.

2. Unification and strengthening of management

Management improvement is the key to ensure the rational use of water resources. The relationship between urban and rural areas, upstream and downstream areas, new and existing consumers, industry and agriculture, surface water and groundwater must be well coordinated. The principle of a unified administration for water resources at various levels and by various departments must be carried out in order to unify the arrangements and optimize control.

The overall control of the water-deficient cities should be strengthened: the development of high water consumption and high pollution industries should be restricted, the industrial structure should be regulated so as to harmonize the water resources availability and the disposition of productive forces.

An effective management and administration must be established, the legal aspects must be strengthened, the management laws and regulations must be formulated and improved, and the personnel concerned with the law enforcement must be trained.

Water conservation must be promoted with the help of economic methods, adjusted water charges, rules for water uses and allocations, and the management and financial policy must be defined in order to ensure the fully rational use of the water resources to obtain the maximum benefit from the water supply.

3. Laying equal stress on utilization and protection

The harnessing and protection of water resources are inseparable from their development and utilization. The key is to ensure a steady water supply for the long term. First of all, the drinking water supply must be well protected from pollution in order to guarantee water quality. In urban areas, controls against the overdrawing and pollution of groundwater should be introduced.

4. Construction of a complete water supply and drainage system

Water supply and drainage are linked and need a unified arrangement. Losing sight of either aspect could cause serious consequences. The construction of drainage systems and sewage treatment in urban areas must be improved. The utilization of treated sewage must be speeded up, this will not only increase water resources but also improve the environment.

5. Stressing technological and scientific research in water supply and sanitation

(a) Planning methods and development forecasting for urban water supply.

(b) Measures for raising the utilization ratio of the available urban water supply.

(c) Technologies and facilities for water conservation.

(d) Economic and practical techniques in comprehensive sewage treatment.

(e) Computerization for the management and supervision of the water supply.

(f) Policies and regulations related to urban water supply.

(g) Economic analysis of the urban water supply.

III. HONG KONG'S EXPERIENCE IN WATER RESOURCES MANAGEMENT*

Introduction

Hong Kong's water supply history is a history of its water resources management. The territory has no natural lakes, or large rivers, or substantial underground water resources. Hong Kong's 1,076 km^2 total land area consists mainly of hilly lands where streams are generally small. The annual rainfall averages 2,210 mm but this has never been sufficient to meet demands, though rainfall was the only source of Hong Kong's water supply up to 1960. At present Hong Kong's two sources of water are rainfall from natural catchment and river water delivered from the neighbouring Guangdong Province of China. These two sources supply Hong Kong's current demand of 2.4 million m^3 per day generated by a population of 5.7 million and a vibrant trade and industrial centre.

A. Development of local water resources

Since Hong Kong's first days as a trading centre in South China in the 1840s the Hong Kong Government has embarked on a continuous struggle to find sufficient water resources to meet the ever increasing demand for water.

Hong Kong's rainfall varies from year to year and fluctuates widely during the year. About 80 per cent of the rain falls between May and September during which tropical cyclones reach Hong Kong or its vicinity. With the variable rainfall, Hong Kong is dependent on adequate storage for maintenance of a regular supply. The practice over the first hundred years or so of the development of water resources was to construct catchwaters and reservoirs to collect and store water. The first water resources project was the construction of the 9,000 m^3 Pok Fu Lam Reservoir which was completed in 1863 by building a dam across the valley. The supply at that time could only reach a small proportion of the total population of 100,000.

Since then, one water resource project was completed after the other in an attempt to bring the supply closer to demand. By the outbreak of the Second World War in 1939, 12 more reservoirs by damming up river valleys had been completed bringing the total reservoir storage capacity to 27 million m^3. By that time the population had increased to 1.0 million. Despite the long history of Hong Kong's water resources development, the real expansion of Hong Kong's waterworks took place after the Second World War in parallel with Hong Kong's progress and emergence as a world-famous trading and manufacturing city with a high concentration of population. Bigger and more ambitious water resources schemes were required because the water demand had increased tremendously as Hong Kong industrialized and prospered. It was not uncommon that the additional supply from a new scheme would not even meet the existing deficit.

Shortage of natural storage reservoir sites made Hong Kong water engineers turn to the sea. The Plover Cove Reservoir was the world's first reservoir in the sea and was completed in 1967 by damming and draining an inlet at Plover Cove. The Plover Cove Reservoir added 170 million m^3 to Hong Kong's reservoir storage capacity. Six years later at 1973 the height of the dam was raised to increase the Plover Cove Reservoir's capacity to 230 million m^3. In 1971 in the face of a further rise in demand, the Government of Hong Kong decided to go ahead with the equally ambitious High Island Water Reservoir also to be built in the sea. The High Island Reservoir, completed in 1979, added 273 million m^3 to Hong Kong's total reservoir storage capacity. At present the total reservoir storage capacity is 586 million m^3.

As Hong Kong's population registered almost a twofold increase from 3 million in 1960 to 5.8 million in 1992, the demand for water has increased eight-fold from 0.28 million m^3 per day to 2.40 million m^3 per day representing a sustained average annual growth rate of 7 per cent over 30 years! The high growth rate is due to great improvements in living standards and the thriving manufacturing industries and service trades.

The Plover Cove and High Island Reservoirs are the most impressive parts of these water resources schemes. Less obvious, but no less spectacular is the network of underground water tunnels and shafts which collect stream water from the surrounding hills and catchwaters and carry it to the reservoirs. At present 366 km^2, or slightly more than one-third of Hong Kong's land area, have been developed as waterworks catchment

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areas. In addition, there are 120 km catchwater channels of various sizes. Probably nowhere else in the world have catchwaters been so highly developed. Constructed around hillsides, the catchwaters collect water from areas where it would normally drain more or less directly to the sea or into valleys unsuitable for reservoirs. Further extension of the existing water catchment area or development of new water catchment area is very expensive due to the scarcity of land and is thus economically not justifiable because Hong Kong has another source of water from outside its territory.

B. China water – resource from outside Hong Kong

Even with the very intensive use of local water resources, the water collected from Hong Kong's water catchment area is only sufficient to meet 30 per cent of Hong Kong's present day needs. As early as 1960, an agreement was reached with China to pipe river water across the border to Hong Kong on a regular basis. The annual supply quantity was 23 million m^3 in the first year of supply or about 22 per cent of Hong Kong's total demand at that time. The annual supply quantity was progressively increased over the years as new agreements were reached with China. The current annual supply quantity from China is 630 million m^3 which is about 70 per cent of Hong Kong's total demand. The latest agreement with China provides for further annual increase in supply quantity from 1995 onwards up to a maximum quantity of 1,100 million m^3 per year. In line with that agreement both China and Hong Kong are upgrading their water transfer facilities. The China water is "imported" at a price, and on reception in Hong Kong, the water is distributed along three strategic routes consisting of tunnels and pipelines to storage reservoirs or water treatment works. An extensive but well-integrated reception and transfer system for China water has been installed in stages over the past 30 years under large-scale water resources projects. Water from China has become the most important single source of Hong Kong's water supply and all future increases in demand will be met by additional supply from China

C. Water restriction – an artificial means to reduce demand

No history of Hong Kong's water supply is complete without reference to water restriction over the years especially the early years. Despite tremendous effort and ingenuity by water engineers, the gap between supply and demand has seldom been closed. Until the mid-1960s water restriction was the norm rather than the exception. In actual fact Hong Kong first experienced full supply throughout the year as late as 1965 and during the severe drought in 1963 and again in 1967, supply was restricted to four hours on every fourth day! Although water restriction cannot be said to be a thing of the past, with the long-term agreement with China for water supply, the threat of water restriction in Hong Kong is bound to be small. The last time water restriction was imposed was in the winter of 1982.

Although water restriction was common in the past, the improvement in living standards has resulted in an expectation that full water supply will be maintained. Water restriction is costly to implement and it causes great inconvenience to the public's way of life although restriction will not be applied to industrial consumers. Hong Kong's experience has shown that precautionary measures taken during a dry season – such as to maintain suitable reservoir storage in order to avoid the possibility of the reservoirs running dry before the next wet season – have been justified.

While in the longer term there is a correlation between catchment and the Observatory rainfall data which assists with long-term forecasting of availability of supply, quite frequently overall catchment rainfall can be considerably less than that recorded at the Observatory and, in addition it may not be evenly distributed over the catchment area. Also, dry ground can absorb a very significant proportion of the first rains and, indeed, of any rainfall if there has been a sufficiently long interval between rainstorms and the ground has dried out. This means that no direct relationship can be drawn from published Observatory rainfall data and gain in reservoir storage over the same period and, more importantly, that these rainfall figures are not necessarily representative of catchment rainfall in the short term. Thus, in any particular year, or in any particular storm the distribution of rainfall can be quite variable and yields unpredictable.

The Water Supply Department has to ensure, as far as is possible, that the reservoir storage situation does not deteriorate to a critical degree. At the end of the rainy season it is a relatively simple matter to determine what supply levels should be maintained, but to decide what should be done during the wet season in the absence of rainfall and with low reservoir storage is far more difficult. Early imposition of restrictions could prove unnecessary in the event of subsequent heavy rainfall, whereas if appropriate steps are not taken and the situation worsens there could be insufficient water to meet the minimum requirements for supply in the dry season.

Therefore, the Water Supply Department keeps the situation under constant observation and review. Taking into consideration the amount of water in storage at any point in time and supplies from other sources, it

formulates different combinations of supply levels and studies the consequences. Such reviews are not limited to the immediate future position, but must project ahead to forecast what conditions might exist at the beginning of the next wet season. In order to determine probabilities, a sophisticated computer program has been designed.

D. Salt water supply for flushing – a means to reduce fresh water demand

The resourcefulness of Hong Kong's water engineers is again manifested in the use of sea water to substitute for fresh water for flushing purposes. In order to save fresh water, Hong Kong turns to the sea for its flushing water. Of the total quantity of fresh water consumed, only about 7 per cent is used for flushing toilets. Hong Kong is able to keep this percentage low because the majority (65 per cent) of Hong Kong's population use salt water from the sea to flush their toilets. Only one-third of the flushing water in Hong Kong is fresh water. The other two-thirds are salt water taken from the sea.

The use of salt water for flushing began in the late 1950s when sea water was pumped to supply government buildings or government housing estates. Since then salt water supply has been extended to all urban areas and many new towns. The Hong Kong Water Supply Department now supplies and distributes 350,000 m^3 of salt water per day through a system of sea water pumping stations, service reservoirs and distribution mains which coexist with but are separated from Hong Kong's fresh water supply system.

In Hong Kong, the use of fresh water for flushing without permission is an offence under the Waterworks Ordinance. In areas where salt water supply is available, consumers will not be permitted to use fresh water for flushing and they must accept salt water as flushing water. In areas where salt water supply is not yet available, fresh water is being used for flushng, but this, to all intents and purposes, is a temporary measure only. Works are being implemented to further extend salt water supply so that by 1996, 90 per cent of Hong Kong's population will use salt water for flushing. Hong Kong is determined not to allow fresh water to go down the drain.

E. Desalination

In the continuous search for additional fresh water, our eyes turned again to the sea. A 182,000 m^3 per day desalter was built in 1975. The desalter was considered as a "reserve resource" to be used to supplement supply when necessary, for example, if reservoir storage was low. It was used twice in 1975-1978 and 1981-1982 when it operated for 39 and 14 months respectively. This helped to avoid severe water restrictions. When the desalter was planned, the price of fuel oil was still at a low level. However, with the escalation of operating costs due to soaring fuel oil prices after completion of the desalter, and the successful expansion of other water resources, the desalter has not been in use since 1982. With a reliable supply available now from China, the desalting plant was closed in 1991.

F. Protection of water catchment and water quality

The protection of the water catchment is of paramount importance to Hong Kong's water resources. As Hong Kong's population increases and as Hong Kong expands its industries and service trades, there is an insatiable demand for land, and land in the catchment area is seen by some developers and enterpreneurs as readily available land. Measures are already in place to control developments within the water catchment area to guard against contamination, loss of yield and erosion. The catchment area in Hong Kong is classified into direct catchment area, indirect catchment area and flood pumping catchment area. The direct catchment area in which rainwater can drain straight into the reservoir is subjected to the strictest control. No new development whatsoever is permitted within 500 metres of the reservoir top water mark. The control of development in the flood pumping catchment area is less strict than that in the indirect catchment area. Non-industrial development including recreational uses within the catchment area when permitted is subject to the requirement that the whole of the foul water drainage including that from swimming pool filters and carparks is conveyed in pipes to be discharged outside the catchment area. For existing developments within the catchment area, permission to continue is subject to the ability to maintain the quality of effluent within an acceptable level. For any proposed development in the catchment area, permission will only be granted after an assessment is made to confirm that there are no adverse consequences of pollution or erosion from such a development. Hong Kong has stepped up its efforts in environmental protection in recent years. A scheme to prevent pollution by livestock waste was implemented four years ago. Since then, the polluting load on some of the territory's streams arising from indiscriminate discharge of livestock waste has been gradually reduced. It is expected that this and other environmental control measures will bring about an increase of some 20 million m^3 in the yield per year mainly from the flood pumping catchment area in the next 10 years due to improvements in the stream water quality.

As 70 per cent of Hong Kong's water is supplied from the East River in the Guangdong Province of China, the quality of China water is closely monitored. Under the

water supply agreement with China, the quality of water supplied to Hong Kong is to comply with the Environmental Quality Standard for Surface Water (Category II) adopted in China. This standard is comparable to other international standards. The quality of the China water is regularly monitored at receiving points at the border and at inlets of treatment works. Despite the fact that there are now busy development activities along the East River, no significant deterioration in the quality of water received in Hong Kong has been detected so far. Although there has been slight variation in the values of certain parameters, as a whole, the quality of China water remains well above the specified standard. In recognition of the need to maintain the existing water quality, Hong Kong and China jointly review regularly the monitoring and control of the quality of the East River water.

G. Conclusion

The struggle to find sufficient water resources to meet Hong Kong's water demand is a never ending challenge for Hong Kong's water engineers who have been successful in the implementation of water resources projects and the management of water resources. In recent years, increased attention has been given to the protection of water resources to ensure that a sufficient quantity of good quality water is made available to support Hong Kong's drive to maintain its leading position as an international trade and industrial city.

IV. COUNTRY PAPER: INDIA*

A. Long-term planning of water resources

As the demand for fresh water is increasing and the availability of both surface and groundwater is reducing gradually due to erratic monsoons, it is essential to make judicious allocations of the available water resources. The National Water Policy of the Government of India has accorded top priority to drinking water supply in the allocation of water resources for various beneficial uses. It is, therefore, very necessary to carry out long-term planning of water resources management for a period of 30-40 years ahead keeping in view the supply and demand. The National and Provincial Governments must prepare water resources management master plans and implement them effectively.

The majority of the metropolitan and mega-cities are presently drawing water from very distant places, as all the nearby water resources have either been fully tapped or are reserved for other uses. Due to this, the cost of transmission, treatment and distribution of drinking water is much higher than it was about two decades ago. On an average, the cost works out to Rs 10-12 per thousand litres depending upon the location of sources and lift involved. Although groundwater is a replenishable resource, overexploitation of this precious commodity may result in the deterioration of water quality and increase in cost of pumping. It must therefore be ensured that the balance is not disturbed and the annual exploitation is set within permissible limits.

For effective regulation and control of both surface and groundwater extraction, proper central legislation is necessary. While preparing master plans for cities and towns, it must be ensured that all nearby water sources are earmarked for drinking water supply on a priority basis. At the same time, whenever multi-purpose dams or reservoirs are planned, an adequate quantity of water for drinking water should be reserved for a period of 20-30 years keeping in view the long-term needs of all the cities and towns in that area. If the dependability of the source is ensured, it is possible to supply the requisite quantity of water to the community without any interruption and in that case, the beneficiaries do not hesitate to pay the water tariff regularly for the services provided to them.

Owing to the indiscriminate discharge of untreated sewage and industrial effluents into natural water bodies, the quality of surface water as well as groundwater is deteriorating. A result of this is that the principal drinking water supply sources of cities and towns are becoming polluted of which is increasing considerably the cost of water treatment. Therefore, concerted efforts have to be made to treat municipal as well as industrial effluents so that they conform to the discharge standards before disposal. The Environment Protection Act of 1986 has to be implemented effectively by the Government of India and the State Governments. At the same time, water quality monitoring programmes should be chalked out and implemented in a systematic manner to check the possible pollution of various water sources.

B. Implementation of water supply and sanitation schemes

Although about 84 per cent of the urban population has been provided with safe drinking water supply facilities and about 46 per cent with adequate sanitation facilities as of 31 December 1990, the situation in most of the cities and towns is not satisfactory. The water supply ranges from as low as 12 l/person/day to as high as 460 l/person/day in Class-I cities. However, the national average for Class-I cities is 147 l/person/day. In the case of Class-II towns, the water supply ranges from as low as 7 l/person/day to as high as 500 l/person/day with a national average of 78 l/person/day. Thus there exists a wide gap in the per capita water supply in different urban areas of the country. Even in a given city equitable distribution of water to all citizens is not available.

Turning to the sanitation scenario, it may be mentioned that as per the survey conducted in 1988, a total of 12,145 million litres of wastewater per day is the estimated generation from the organized sector of 212 Class-I cities surveyed. Out of this, 6,462 million litres of wastewater per day is generated from 12 metropolitan cities alone, which represents about 53 per cent. The survey revealed that only five metropolitan cities have proper wastewater collection systems through which about 1,493 million litres per day is collected. Ten

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metropolitan cities are reported to have sewage treatment facilities, of which, four have only primary treatment facilities, four have partial primary and partial secondary treatment facilities, and two have secondary treatment facilities. The information available from 142 Class-I cities shows that, in 41 cities wastewater is discharged onto agricultural land, in 44 into rivers either directly or through drains, in 32 on to agricultural land and into rivers, and in 24 into other recipient systems such as sea, lake, pond, etc. Out of 165 Class-II towns, the mode of wastewater disposal in 66 towns is on to agricultural land, in 42 into rivers either directly or through drains, in 12 on to agricultural land, and into rivers, and in 46 into sea, lake, pond, etc. From this, it is evident that there is an urgent need to take effective steps for collection, treatment and disposal of wastewater from urban communities to control environmental pollution and degradation.

C. Criteria for selection of towns under NRAP

Under the National River Action Programme (NRAP), certain reaches of major rivers with high or intermediate levels of pollution were identified by the Central Pollution Control Board. It has been recommended that sewage collection and treatment works should be installed to reduce the pollution load of these rivers. Specific point sources of pollution, which emanate high concentrations of the pollution load into the river basin should also be addressed. The increase of nitrates in the groundwater is mainly a result of the high degree of pollution taking place near the point sources. The reduction of nitrates in water should also be one of the main objectives along with the removal of the faecal coliform organisms. In this regard, the towns having populations of more than 1 million, should all be included under the programme irrespective of their location being along the river banks or in the river basin.

Efforts need to be made to provide safe water supply facilities to 100 per cent of the urban pollution and hygienic sanitation facilities to at least 75 per cent of the urban population in the foreseeable future. In order to achieve these targets, proper planning and implementation of schemes are necessary by adopting technically sound, appropriate, affordable and sustainable technologies in the water supply and sanitation sector. Implementation of the schemes may be done using a modular approach, keeping in view a time-frame of 10 years or so. In the case of sanitation schemes, conventional sewerage systems may be designed and implemented for the fully developed areas and for the fringe areas which are still under development, while low-cost water seal toilets with twin-pit system may be appropriate until an area is fully developed. As and when the situation warrants, sewer lines could be extended to such areas and household toilets may be connected to them without any problem. The cost component of connecting individual household toilets to public sewers may be included in the project cost.

To achieve high efficiency in the storage, supply and treatment of water, it is necessary to keep a proper account of unaccounted for water. For this purpose, there should be a well-equipped unit for leak detection and leakage control, and also the design of the treatment plant should be such that it does not involve too much use of chemicals and mechanical equipment.

D. Appropriate and affordable technologies

In a developing country, it is very essential to adopt technically sound, affordable, simple, cost effective and sustainable technologies in the urban water supply, sanitation and solid waste management sectors. For instance, in small- and medium-size towns, horizontal roughing filters followed by slow sand filters may be a good alternative to conventional rapid sand filters, not only from the capital cost point of view but also from the operation and maintenance angle.

It is a known fact that sewage treatment by conventional techniques is a costly proposition and as such is not affordable in most cases. Therefore, a few technologies which have been developed recently must be tried and used widely in urban areas to the extent possible. For example, if a package of three new processes, namely, (a) Upflow anaerobic sludge blanket (UASB), (b) Duckweed ponds, and (c) Horizontal roughing filters, is adopted for treating municipal wastewater, it is possible to get an effluent of acceptable quality before its final disposal. The said processes do not require much electric power for their operation and maintenance. At the same time it is possible to generate some revenue from the sale of biogenic gas (from an UASB plant), and harvested duckweed as fish, poultry and animal feed. In addition, the treated wastewater could be used for aqua- and pisciculture. A 5 million litres per day UASB treatment plant was set up in Kanpur in 1989 under the Ganges Action Plan to treat municipal wastewater. Presently another plant of 14 million litres per day capacity is under construction in Mirzapur. Duckweed ponds are yet to be installed in the country and research work is being carried out with a view to rationalizing various design parameters under local conditions for attaining optimum efficiency in removing various pollutants and studying the techno-economic aspects to make the process technically sound and economically viable. Horizontal roughing filters in water purification have been in use in India for several years. However, it is planned to undertake further research work on the use of horizontal roughing filters for treating

municipal sewage at the tertiary level preferably after duckweed pond treatment in order to attain optimum efficiency in reducing various pollutants including bacterial count so that such an effluent may be recycled. Plans are being made to install a full-scale UASB, duckweed pond and horizontal roughing filter in series in one of the medium-size towns to treat domestic wastewater up to the tertiary level and if the desired results are obtained, this combination of treatment processes may be adopted in other parts for municipal wastewater management.

E. Raw sewage utilization for tree plantations

An appropriate technology has been tried at Karnal on a pilot scale involving forestry, wherein waterlogging, stagnation and groundwater contamination have been controlled by utilizing the irrigation and nutrient potential of raw sewage. It is possible to apply about 0.3 to 1 million litres of raw sewage per day per hectare under different conditions. Each tree acts as a bio-pump absorbing liquid through the surrounding soil and releasing it to the environment through transpiration. This technique utilizes the entire bio-system as a "living filter" for supplying nutrients to the soil and plants. It also decreases the soil pH from high alkaline to neutral levels without significantly building up salinity. Though three different species of trees have been tried, eucalyptus seems to be the best choice. Another important positive aspect of this system is the generation of revenue through the sale of trees from time to time.

Though the technique appears to be relatively cheaper involving less capital and recurring cost, it cannot be adopted as an independent method of sewage disposal in urban areas for various reasons such as (a) lack of adequate land, (b) possibility of groundwater and surface water contamination during a non-irrigation period; (c) difficulty in controlling odour, fly and mosquito breeding problems; (d) possible health hazard to farm workers and possible leaching of pollutants to the groundwater.

F. Operation and maintenance

It is needless to emphasize the importance of proper operation and maintenance of water supply and sanitation systems. Inattention to this critical aspect could easily result in undue deterioration by reducing the useful life of the systems by 50 - 60 per cent necessitating the premature replacement of many system components. Due to inadequate outlays provided for operation and maintenance in many urban areas and also due to the inadequate trained technical manpower available for the purpose, the maintenance of systems by and large is not satisfactory leading to deterioration of quality of services. Gradually, the system becomes defunct and the assets created by investing millions of rupees are lying idle. Therefore, there must be a clear cut demarcation of responsibilities among local bodies, Public Health Engineering Departments, Water Supply and Sewerage Boards, etc. For instance, planning, designing and execution of water supply and sanitation schemes may be entrusted to agencies such as State Public Health Engineering Departments and Water Supply and Sanitation Boards which are technically competent for such works. Operation and maintenance is the primary responsibility of local bodies which have to be strengthened adequately with due autonomy for carrying out this important task with full efficiency. In many cases, due to poor operation and maintenance of water distribution systems water losses of the order of 30 - 40 per cent of the total flow have been observed. In addition, losses occur at the source in transmission and treatment plants accounting for another 10 per cent of the total output. In India, water supply is intermittant in most cities and towns and therefore during non-supply hours, when the system is not under pressure, external pollution may get into the system through the points of leaks posing a health hazard. Therefore, a systematic approach towards waste and leakage survey, its detection followed by prompt corrective action and preventive maintenance should form an integral part of the operation and maintenance to save a considerable quantity of water, prevent possible contamination, improve pressures in the distribution system and increase revenue to make the system self-sustainable. In order to prevent and control wastage of water, it is necessary to install water meters to measure the actual consumption and recover water charges accordingly.

Wastage of water also occurs through public stand posts, in individual houses and public buildings, in backwashing of rapid sand filters and through evaporation and seepage in reservoirs. Normally about 12 litres of water is used for flushing toilets after use which is not really necessary. In order to conserve water, there is an urgent need to design low volume flushing cisterns of 3 - 4 litres capacity and water closets may also be designed with proper slopes and smooth internal surface for thorough flushing of night soil. The backwash water of rapid sand filters can conveniently be recycled back to the treatment plants. Public taps should be designed to prevent wastage and conserve water.

Rainwater harvesting structures may have to be installed to collect and store as much rainwater as possible during the monsoon. Regular monitoring of the quality of both raw and treated water is very essential and therefore suitable laboratories with adequate facilities should be set up in each city.

G. Continuous and intermittant supply system

It has been generally observed that although water supply systems are designed for 24-hour supply of water, after completion of the schemes, these systems are maintained as intermittant supply systems. As a result, there is always the danger of pollution entry into the pipelines through leakage points and thus deterioration in the quality of water reaching the consumer. Also, the consumer has to provide sufficient storage capacity in the premises for storing water. These storage capacities designed for the distribution system are also increased from time to time to maintain good pressure in the pipeline. This requires additional investment of money on the schemes. The reliability of the supply is always at stake. In order to keep the systems efficient and economically maintained, it is desirable that a continuous supply of water be arranged. In such systems, it is also possible to keep a proper account of the water balance, i.e. how much water is being produced and for how much money is being realized from the consumers. This would help in water conservation as well because if the consumers have to pay for the water they are using they will pay for the water that they are loosing on account of leakages. This would motivate them to plug the leakages and reduce the wastage of water.

H. Reuse and recycling of effluents

Reuse and recycling of municipal wastewater and industrial effluents is very important on account of two distinct advantages (a) reduction of pollution load in the receiving water bodies; and (b) reduction in the requirement of fresh water for various uses. Reuse of municipal wastewater after necessary treatment to meet industrial water requirements has been in practice for quite sometime in India. Though in a limited way, several industries in Bombay, Madras and other major cities are reusing/recycling the effluents for airconditioning, cooling and other industrial uses. The city of Chandigarh is using 45 million litres per day of treated sewage for horticulture, watering of lawns, etc. thereby saving fresh water for drinking purpose. The treated sewage may also be used for flushing public sewers and toilets. It is also possible to utilize the treated sewage for groundwater recharging and development of pisci- and aquaculture.

A considerable quantity of water is often lost due to evaporation from reservoirs and natural lakes which are sources of drinking water especially in arid and semi-arid regions of the country with scanty rainfall. It has been estimated that there is a loss of about 450 million m^3 water every month on average from the 2000 km^2 surface area of lakes and reservoirs in the country. This could be controlled by using proper chemical retardents such as cetyl alcohol. This process has successfully been adopted in the cities of Madras, Jaipur, Ajmer, Udaipur, Jodhpur, etc. particularly during the summer season so as to reduce evaporation losses by up to 40 per cent.

I. Renovation of old water mains and sewers

In the core areas of cities and towns some of the water supply mains and sewers which were laid about 75 to 100 years back are badly corroded and have developed internal encrustations. As a result, the carrying capacity of such pipes is reduced considerably and the quality of water also deteriorates day-by-day. Therefore, condition assessment of such pipes has to be taken up to ascertain the status before taking corrective measures. Such an exercise has already been taken up in Bombay, Hyderabad etc. through closed circuit TV survey under the World Bank assisted schemes. The stretches of pipelines which are still structurally stable can be cleaned up and lined *in-situ* with appropriate lining materials such as cement mortar, fibre reinforced glass plastic, etc. to extend their useful life for some more years, thereby replacement of such pipes by new ones can be postponed for some time.

J. Transfer of technology

In order to increase the efficiency of implementation of the schemes and to facilitate the manufacture of equipment within the country, it is necessary that new collaborations should be entered into with multinational companies for the manufacture of improved water meters, manufacture of leakage detection equipment and variable speed pumps and motors. As for collection of wastewater, so far in India submersible pumps of higher discharges have not been made available. It is necessary to manufacture these pumps within the country.

K. Integrated use of water and municipal waste

It is quite possible to adopt new technologies for the treatment of municipal waste and wastewater. The use of vermiculture and aerobic composting for the degradation of organic municipal waste has been found to be quite useful. It is important to organize the community to provide such services and also to adopt suitable designs which do not involve a high expenditure. For smaller communities, it would be useful to encourage the use of vermiculture technology for the disposal of solid waste. After separation of the plastics, glass, metals and paper, the remaining material which is organic in nature, can be disposed of by resorting to aerobic composting. The collection and disposal of solid waste can become cost effective while enforcing the levy of user charges.

Water is a renewable resource and in some places it can be recycled and reused by providing suitable treatment and charging a reasonable cost for supplying such water. In a situation, which exists today, where most of the nearby sources have already been used, it is necessary to bring water across long distances. The cost of raw water, therefore, is quite high. On the other hand, collection and treatment of wastewater does not cost so much; and therefore, it becomes quite cost effective to reuse and recycle the treated wastewater collected for the town. It is not enough only to provide a water supply scheme for a town. Unless the wastewater generated in the town is properly collected and disposed of, the sanitary conditions of the area are not going to improve, therefore, there is a need to have an integrated approach with regard to the use and disposal of water and disposal of community waste.

L. Poor to be provided with the basic facilities

At the very base of the social pyramid, the availability of clean water may make a difference between life and death. It does not cost much to provide this facility to the poor. The only consideration is that the services should be available to them continuously. The sanitation aspect can be organized by involving the community and by adopting technology for improving their needs. More attention, therefore, should be given for providing these facilities to the urban poor. It is not enough to liberate the sweepers or making the practice of carrying nightsoil a cognizable offence, since it is quite possible that this will deprive the sweepers of their livelihood. It is more important to provide alternative jobs for them. This would be possible if we organize the communities living in the slums to take up the job of providing services for better sanitation facilities.

M. Privatization

Privatization of the water supply and sanitation sector is a long felt need in India to make the sector efficient, effective, reliable and self-sustainable. If the system were in the hands of private agencies, it would be possible to maintain financial discipline, curb wasteful consumption and ensure a net return on investment for future development. A privatized water authority would be able to prepare a well-structured and well-defined operating policy to mobilize funds from the open market for the installation, operation and maintenance, upgrading and rehabilitation of the system in a more efficient and systematic manner. In India, a start has to be made as far as the water supply and sanitation sector is concerned. To begin with, newly developed urban areas could be entrusted to private agencies to build the water supply and sanitation schemes, and operate and maintain them applying a realistic tariff structure for a period of 10-15 years and then transferring them to the local bodies concerned for further maintenance and improvement. Even in the existing systems, it would be possible to introduce privatization in areas such as billing and collection, construction and maintenance of low-cost community water seal toilets, solid waste management, etc.

N. Research and development

Research and development in this field should be channelled towards the transfer of suitable technologies from developed countries to India, which cut down on capital investment and operation and maintenance costs. It is also essential to develop suitable biological methods and physical features which can provide good results for the treatment of water and wastewater. Attention should be focused on operational research and on the adoption of methods which will help in increasing the efficiency of the systems.

V. URBAN WATER AND SANITATION IN INDONESIA*

A. Urban development

Indonesia has a total population of 180 million, about 60 per cent of which lives on Java, an island covering some 132,000 km^2. Of the total population, 31 per cent lives in urban areas which have an annual growth rate of 5 per cent compared with the Indonesian national average of 2 per cent.

B. Topography

Many large cities are situated on the coast, experiencing waterlogging, high water-tables and chronic flooding. This situation is exacerbated by the inability of water supply provision to keep up with the rapid urban expansion. Overpumping of groundwater acquifers has resulted in the consequent worsening of flooding owing to the land subsidence caused.

To help overcome the land subsidence problems, several of the larger cities (Jakarta, Bandung) have introduced building regulations requiring the new houses to infiltrate roof rainwater run off directly into the ground.

C. Density of development

The unplanned nature of past urban development has produced extremely high population densities. Table 26 shows that in Jakarta, while an average density of 275 persons/ha may occur in some kampung areas, the actual densities may range from less than 200 persons/ha to more than 1000 persons/ha in the areas in which sanitation is urgently required. These high densities generate problems for the type of technologies to be used to deliver water and sanitation facilities. It is generally considered that where the population density exceeds 300 persons/ha, the use of on-site sanitation is inappropriate because of the difficulty in construction, possible damage to dwellings, the difficulty in operating and maintaining such facilities, and the impossibility of locating effluent disposal systems at a safe distance from well water supplies. However, when surveys are carried out on existing development, it is common to find high on-site sanitation coverage (70-80 per cent) – usually septic tanks.

Where water supply is concerned, the main problem encountered in these conditions is difficulty in obtaining the use of land for the location of facilities.

D. Early sector development

Urban expansion in almost all Indonesian cities suffered in the past from the effects of unplanned development. This resulted in the situation where most of the necessary urban infrastructure essential to proper urban living was either not available or substandard. Whilst it has been a relatively simple matter to provide electricity and telephones at a later date, the provision of water, sanitation, drainage and solid waste collection services has been not only extremely difficult from a technical point of view but also extremely costly.

In the past, most drinking water was obtained from wells as is the case today. However, certain cities were also provided with piped water supplies. Spring water was usually conveyed through steel pipelines to elevated reinforced concrete reservoirs for distribution.

Many cities, including the following, were provided with some form of sewerage, some of which is still in use today or has been incorporated into larger systems: Cirebon, Bukit Tinggi, Medan, Bandung, Sukabumi, Jogyakarta, Solo, Ujung Pandang, Semarang.

The early sewerage systems were gravity based without treatment. Several cities were provided with treatment (trickling filters) towards the end of the colonial era. In the immediate post-colonial period, considerable urban expansion took place often without the participation of skilled planners and technicians and urban infrastructure sometimes failed to keep up the pace. It was in the early 1950s that the expansion of water treatment capacity commenced (in Jakarta). This situation prevailed up to the 1979-1984 period when the first of a number of

* By Warman, Project Manager, Community Water and Sanitation Project; Ir. Roland Hutapea, Engineer, Directorate of Environmental Sanitation, Ministry of Public Works; Richard W. Cross, Senior Sanitation Advisor, Community Water and Sanitation Project.

Table 26. Residential densities and sanitation facilities for selected Jakarta kampungs, Indonesia

No.	Kampung	Toilet System in House (percentage of the total no. of houses)								Where no toilet in house the people use (percentage)4					
		None	WC to Canal	WC with ST + LS	WC with ST only	Water Seal	Squat Plate[2]	Open hole[3]	Other	Neigh-bour's Latrine	Public bathing, washing and toilet facility	Open land	River	Drains	Others
1	Dukuh Setia Budi	–	–	62.4	9.7	24.7	1.1	2.2	–	–	–	–	–	–	–
2	Karet Karya Utara		2.5	16.2	23.7	26.3	12.4								
3	Karya Karya Selatan		2.5	16.2	23.7	26.3	12.4								
4	Karet Belakang		–	16.2	23.7	26.3	12.4						73.9	1.5	20.0
5	Karet Balakang II		–	16.2	23.7	26.3	12.4								
6	Karet Pedurenan	2.5	–	7.0	8.3	50.0	22.7			4.6			73.9	1.5	20.0
7	Kuningan III	7.0		7.0	6.0	59.0	17.0	4.0	–	100.0					
8	Karet Gang Mesjid	2.5		7.0	8.3	50.0	22.7	–	–	4.6					
9	Kuningan I	2.9	1.0	11.4	15.2	48.6	19.0	4.0	1.0	100.0					
10	Kuningan II	5.0	1.0	3.0	17.8	44.5	26.7	2.0	–	100.0					
11	Karet Sawah/Depan	5.0	1.0	3.0	17.8	44.5	26.7	2.0	–	100.0					
12	Guntur	34.7	12.5	12.5	11.1	11.1	13.9	–	4.2	26.3		2.6	68.4	2.6	
13	Kawi Gembira	34.7	12.5	12.5	11.1	11.1	13.9	–	4.2	26.3	30.0	2.6	38.4	2.6	
14	Menteng Wadas I	29.4	5.9	17.6	5.9	36.7	2.9	1.5	–	50.0	90.0	5.0			
15	Menteng Wadas II	14.4	5.9	17.6	10.9	36.7	2.9	1.5		95.0		5.0			
16	Menteng Atas	1.9	1.9	15.4	12.5	56.7	11.6	–		100.0					
17	Menteng Rawa Panjang	6.1	9.2	17.3	29.6	23.4	3.1	3.1	8.2	10.0	40.0		20.0	20.0	10.0
18	Kebon Obat	37.4	1.9	7.5	6.5	46.8	–	–		7.3	–		91.2	2.4	
19	Menteng Rawa Panjang		–	62.4	9.7	24.7	1.1	2.2		–	–				
	Total Setia Budi	10.3	2.8	15.3	13.4	43.3	12.9	1.2	1.1	25.9	10.8				
20	Menteng Dalam Pal Batu	1.9	1.9	15.4	12.5	56.7	11.6	–	–	100.0	–	–	–	–	–
21	Warung Pedok			45.4	18.2	18.2	18.2								
22	Warung Pedok II	4.6	21.5	12.3	16.9	41.5	3.1			25.0					
23	Menteng Dalam Gang K.	1.5		13.6	16.7	63.6	4.5								
24	Manggarai Barat/Timur	48.6	1.9	5.7	12.4	24.8	5.8	1.0							
25	Bali Matraman	1.4	1.0	24.8	15.2	46.7	10.6			50.0			50.0		
26	Bukit Duri Puteran	15.1	19.8	10.4	9.4	44.3	0.9				30.0		63.8	6.3	
27	Bukit Duri Selatan	15.1	19.8	10.4	9.4	44.3	0.9				30.3		63.8	6.3	
28W	Bukit Duri/Malayu Kecil			46.7	46.7	6.7									
28E	Bukit Duri/Malayu Kecil	4.8	6.3	17.5	20.6	46.0	3.2	1.6		12.5			87.5		
29	Bukit Duri Tanjakan	4.8	6.3	17.5	20.6	46.0	3.2	1.6		12.5			87.5		
30	Malayu Kecil	15.1	19.8	10.4	9.4	44.3	0.9				30.0		63.8	6.3	
31	Tebet Barat			46.7	46.7	6.7									
32	Tebet Timur			46.7	46.7	6.7									
33	Kebon Baru Kavling			46.7	46.7	6.7									
34	Dalam Melayu Besar	1.5		13.6	16.7	63.6	4.5								
35	Kebon Baru Utara	1.5		13.6	16.7	63.6	4.5								
36	Kebon Baru	1.5		13.6	16.7	63.6	4.5								
37	Dalam Barat			46.7	46.7	6.7									
	Total Tebet	13.7	7.6	15.5	16.2	41.1	5.4	0.4		8.2	58.8	1.2	30.6	1.2	
	All Kampungs	11.5	4.4	15.4	14.1	42.5	10.3	0.9	0.7	20.9	24.6	1.0	46.8	2.0	4.7
	Non-Kampung	0.7	4.0	63.3	8.0	24.0				50.0			50.0		
	Total Project Area	10.6	4.4	19.4	13.6	41.0	9.5	0.8	0.7	21.3	24.3	1.0	46.8	2.0	4.7

Notes: 1 Water seals with pour flush or cistern flush; 2 Squat plates with pour flush or cistern flush; 3 Open hole without water seal; 4 Percentage of the total number of houses without any toilet on the plot.

major city development plans was prepared which led to the initiation of major city development projects in Medan, Bandung and Jakarta. It is noteworthy that whilst both Medan and Bandung decided to use sewerage, Jakarta proceeded with development based largely on the use of on-site sanitation with provision to pilot the use of sewerage.

E. Government policy for sector development

The government departments and agencies responsible for water and sanitation are: the Departments of Public Works, Health, Home Affairs and Finance; and BAPPENAS (National Development Planning Agency). The Department of Population and Environment is responsible for environmental matters. The leading sector agency is the Department of Public Works which assists provincial and town authorities in identifying their needs for water and sanitation and implementing and monitoring projects. The Department of Home Affairs establishes and supports local government institutions, including community participation and the local water and sanitation enterprises. The Department of Health is responsible for water quality monitoring, health education and public health. BAPPENAS establishes the national development plan for all sectors, prepares annual development programmes and coordinates the activities of the line departments. BAPPENAS also approves all foreign assistance (bilateral or multilateral).

Indonesian development is based on a five year planning period known as a Repelita. The setting of development targets for each Repelita follows the Basic Guidelines of National Policy which are brought down by the national legislature before the commencement of each Repelita. Table 27 lists the development targets for Repelitas III, IV and V.

Table 27. Urban water development targets, Indonesia

Details	*Unit*	*Repelita Target*		
		III (1979-1984)	*IV (1984-1989)*	*V (1989-1994)*
Population to be supplied by interim and Regional water enterprises	persons (million)	9	21	29
	percentage	23	42	47
Population to be supplied by private systems	persons (million)	13	17	20
	percentage	32	33	33
Total population supplied	persons (million)	22	38	49
	percentage	55	75	80
Production capacity (interim and Regional Water Enterprises)	x 1000 L/s	36	51	65

The water and sanitation policy for Repelita VI has not yet been released but is expected to generally follow that for Repelita V which is detailed below:

(a) Expansion of water supply coverage to 80 per cent in urban areas and 60 per cent in rural. These activities are to be concentrated in 820 cities and towns and 3,000 villages with special attention to the needs of low-income groups.

(b) Strengthening of local water enterprises to improve their service, administration, and operation and maintenance.

(c) Reduction of unaccounted-for water (physical and administrative leaks).

(d) Control of the pollution in rivers and groundwater sources.

(e) Increased community participation in operating and maintaining infrastructure and willingness to pay.

(f) Raising the awareness of the need for safe human waste and wastewater disposal both in the Government and in the communities.

(g) Developing economic mixes of appropriate technologies for human waste and wastewater disposal in large and medium-sized urban areas.

(h) Encouraging private sector involvement in construction and renovation of water supply and waste disposal systems.

(i) Improved project/programme delivery and performance, including developing means of cost recovery to allow financially sustainable wide-scale project/programme implementation.

The growth in budget allocation to the sub-sector during the last three Repelitas can be seen in table 28. This reflects the increased emphasis by the Government on public health issues. This budget increase, however, has been largely funded by external assistance. External funding accounts for 72 per cent of the Repelita V budget.

Table 28. Sub-sector and programme expenditure on water supply and sanitation, Indonesia

Sub-sector	*Repelita III (1979-1984)*		*Repelita IV (1984-1989)*			*Repelita V (1989-1994)*		
	Amount (US$ m)	*percentage total*	*Amount*	*percentage (US$ m)*	*percentage change*	*Amount (US$ m)*	*percentage*	*percentage change*
Water Supply	198	56	450	62	+127	1,686	45.4	+275
Sanitation	24	7	89	12	+271	338	9.1	+280
Total	222	63	539	74		2,024	54.5	

During the current Repelita the Government has assisted the development of the sector with the provision of sanitation facilities as listed below in table 29.

Table 29. Repelita V (1989-1994) sanitation development by the Government of Indonesia

Facilities	*Total Numbers*
Private latrines	66,099
Public toilets	3,360
Communal latrines	362
School latrines	140
Septic tank sludge treatment facilities	4

F. Existing water and sanitation facilities

1. Water supply

A common form of water supply in urban areas is the shallow well. These wells are usually constructed from concrete (reinforced or unreinforced) of diameters ranging from 75 to 100 cm in the case of concrete and approximately 3 m for stonework. They range in depth from 2 to 3 m up to 10 m.

Shallow wells are usually uncovered and may use a bucket and pulley for extracting water. Some wells are covered and use a handpump to extract water. Handpumps for shallow wells are generally locally made. Deep wells are used in the outer islands or in urban areas where there is significant saline intrusion of groundwater or where large extraction discharges are required. Deep wells can extend to over 100 m. Electric pumps are frequently used instead of handpumps.

Urban piped water supplies commonly consist of treated water supplies using raw water from springs, groundwater, rivers, lakes, canals and reservoirs. Standards methods of treatment are used and supplies are disinfected at the treatment facilities.

Development of urban water supplies is handled by Interim Regional Water Enterprises (BPAMs) assisted as necessary by Public Works to be responsible for the design, construction and operation of distribution networks. When water sales reach the "break even" point the water enterprise becomes an autonomous local government water enterprise or regional water enterprise (PDAM). Water enterprises aim to establish as many water connections as possible to ensure financial viability. PDAMs are also responsible for a nominal number of "social" connections providing subsidized water to the low income communities in accordance with government development policy. Social connections consist of public hydrants (typically 6 m^3 reservoirs filled from the reticulation) and water terminals (fiberglass tanks of 15 m^3 capacity). Public hydrants and water terminals have paid caretakers charged with their operation and maintenance. Water is paid for according to a tariff set by level II local government – the tariff for Jakarta is provided in annex I as an example. This tariff provides for various users such as domestic, commercial, industrial and special users. It also provides for social connections at subsidized prices. Urban water supplies are metered.

In urban low-income communities, water supply sources would typically be (for a kampung in Surabaya) as shown in table 30). This shows that houses with connections often have a second source of supply - typically a shallow well.

Table 30. Sources of water supply for a typical kampung in Surabaya, Indonesia

Source	*Usage(%)*	
	Bathing, washing, toilet	*Drinking, cooking*
Regional water enterprise	22	47.1
Tube well	9.9	3.3
Shallow well	42.3	6.2
River	0.9	0
Rainwater	0	0.9
Vendor	24.7	42.5

Households applying for a water connection usually have a waiting time of 2 - 5 months. Connection costs range from Rp 150,000 to Rp 500,000 with an average of Rp 250,000. Some households with a connection may sell water to their neighbours.

For the social connections, users may choose to obtain their water directly i.e. by filling containers or receive their water from a vendor. The costs associated with such sales are shown in table 31.

Table 31. Unit cost of water delivered at social outlets, Indonesia

Source	*Public Hydrant (Rp/m^3)*	*Water Terminal (Rp/m^3)*
Direct	1,150	2,165
Water vendor	2,990	4,325

2. Sanitation

Conventional sewerage remains limited to the larger cities. Therefore, on-site facilities are the commonest form of sanitation. In typical low-income communities such as in Jakarta, sanitation can be

expected to consist of on-site facilities made up of septic tanks, leaching pits, simple pit latrines. As table 32 shows, up to 11 per cent of residents may possess no facilities at all. Where there are no facilities, 21 per cent of such residents will use a neighbour's toilet, 24 per cent will use public bathing, washing and toilet facilities (MCK), 1 per cent will use open land, 47 per cent will use the river, 2 per cent will use the drain and 5 per cent will use other means (table 33). It is clear from this that the effective coverage of sanitation is relatively high by comparison with other developing countries. However, the large number of malfunctioning facilities and the use of inappropriate facilities are major causes of the high pollution of waterways.

Table 32. On-site sanitation in Jakarta kampung areas, Indonesia

Type of facility	*Percentage of users*
None	11
WC to canal	4
WC septic tank, leaching system	19
WC plus septic tank	14
Water seal	41
Squat plate	9
Open hole	1
Other	1

Source: Jakarta Sewerage and Sanitation Project, Vol. 8, Sanitation Study, May 1982.

Table 33. Personal human waste disposal by households without private facilities

Facility	*Percentage of users*
Neighbour's facility	21
Public bathing, washing and toilet facility	24
Open Land	1
River	47
Drain	2
Other	5

Source: Jakarta Sewerage and Sanitation Project, Vol. 8, Sanitation Study, May 1982.

The Government has developed criteria for the selection of technology for sanitation development. These criteria are applied by all agencies carrying out urban development. The criteria are listed in table 34 below.

Table 34. Human waste management technology selection criteria

Criterion	*On-site*	*Off-site*
Population density	< 150 persons/ha	> 200 persons/ha
Water table	At least 1 m below the ground surface	none
Application	Mostly in rural areas	Urban areas
Income per capita	Low	High
Soil conditions	Stable permeable soil	none

Apart from the sewers built in the past, two cities have significant coverage of sewerage. These are Medan and Bandung which have been provided with sewerage under urban development projects funded by the Asian Development Bank.

Repelita V planning strategy (the expected basis for Repelita VI) for development is detailed in section E. According to the strategy, sewerage is presently being proposed for a number of large cities - Denpasar, Jogjakarta, Jakarta, Surabaya, Semarang, Cirebon and Padang.

Several approaches are being followed. These are conventional sewerage, shallow sewerage and small bore sewerage. In the case of shallow sewerage and small bore sewerage, only pilot projects are carried out to demonstrate the feasibility of such approaches.

Treatment processes currently in use consist of lagoons with or without aeration, upflow anaerobic sludge blanket (UASB), carrousel and biological (trickling) filters. Large hotels and office blocks utilize packaged treatment plants to dispose of their waste. The treated effluent is generally discharged to the storm water drainage system.

G. Current issues

1. Water supply

From the national viewpoint, the Government is endeavoring to reduce the debt burden of the large amounts of external assistance used for sector development. As already stated, 72 per cent of the Repelita V budget is externally funded. One approach being used is to increase private sector participation in both water and sanitation development. The private sector is being encouraged to participate in the construction and operation of water and sanitation facilities and in the provision of services such as septage removal. The Government is also working to reduce the level of unaccounted-for water from the current high rate of 40 - 50 per cent to a more reasonable 20 per cent.

At the local government and community level, the issues are different. Urban water supplies suffer from problems of reliability, quality, availability and user perceptions. To improve the first three, the Government is assisting water enterprises to: improve the capacity of their personnel (technical and administrative); upgrade their accounting systems, improve their revenue generation; expand their services through access to facilities. To deal with the fourth, community awareness

of the benefits of clean water is being raised through public awareness campaigns, delivered by local government and water enterprise staff whose capability has been developed for this purpose.

With the prevailing high population density in urban areas and common usage of septic tanks and wells for the provision of water, it is almost impossible to avoid gross pollution of the groundwater. In such circumstances, residents resort to the purchase of drinking water from vendors at prices far exceeding that charged by water utilities for house connections. Surveys often show that households may be able to afford the cost of a water connection but are unwilling to pay the cost of the connection, preferring to make ad hoc and much higher payments for vendor supplied water. To overcome this, the Government is giving high priority to the provision of piped water supply to urban areas in need and the use of public awareness campaigns to increase the demand for water connections and the willingness to pay.

2. Sanitation

The community is often unaware of the significance and the need for sanitation. Where sanitation is provided such as individual and communal facilities, the following attitudes may sometimes be observed:

(a) belief that foul smells emanating from facilities are natural rather than a result of poor maintenance;

(b) unwillingness to use facilities because they are considered to be haunted.

Because of the low community awareness of the need for sanitation, the community often places a low priority on its acquisition. As already noted, community awareness campaigns along with other actions such as the prohibition of the use of unsatisfactory facilities are effective in changing community preferences.

The collection of septic tank sludge becomes very difficult in the densely populated kampung areas where the normal vacuum truck (2 to 6 m^3 capacity) cannot gain access. In such cases, sludge may be collected by hand operated vacuum carts or, in their absence, by hand alone. There are also cases where, because on non-enforcement of standards, footpaths are even too narrow for the passage of the hand vacuum carts.

Proper operating practices are often not well understood. Thus septic tanks are often operated until full with consequent damage to leach fields. When leach fields are no longer operational, they are often bypassed to the open drainage and rivers. On-site facilities, as a result of difficulties with supervision during construction are often not constructed to proper standards. As a consequence, facilities may be unsanitary from the time they commence operation. Another unfortunate consequence of this is that first time users of sanitation facilities lose faith in their effectiveness. The Government is addressing these issues through formal training of local government staff responsible for sanitation. Such training includes not only technical and operational aspects but also raising public awareness, etc.

Public toilets are necessary and often the only viable solution for low-income communities in very crowded urban areas. Whilst most deliver satisfactory service, a significant number either fail or are underutilized for such reasons as: incorrect siting, poor design; inability of the owners to operate and maintain them effectively. Most of these problems can be resolved by raising public awareness of the issues involved. It is an interesting fact that whereas individual families find difficulty in obtaining credit to acquire private sanitation facilities, banks are generally willing to provide credit for a public toilet as it can be made to operate effectively as an income generating concern.

It is also common for septic tanks to either be provided without leaching facilities (to save costs or because of lack of space) or with faulty leaching facilities. In both these instances direct connection of the effluent drain to the surface water drains is common with resultant high faecal contamination of the water ways. This pollution is also increased by the common practice in low-income high density areas of constructing latrines (commonly known as "helicopters") over drains and rivers with direct discharge of untreated human waste. In an effort to clean up the rivers the Government has embarked on a clean river programme ("Prokasih") which requires the reduction of all such polluting discharges, including industrial waste. In support of Prokasih, local governments are steadily removing the "helicopters" which causes a shift in interest by the users to the acquisition of private or public facilities to replace the "helicopters". Local governments are supporting this with programmes to facilitate the acquisition of such facilities.

Conventional sewerage, where affordable, is considered to be necessary in reducing the high pollution of ground and surface water resources. The schemes being implemented are in cities that have high income generating capacity allowing them to ease the financial burden of sewerage construction on the low-income communities by the use of cross subsidies, etc. This is not the case in other urban areas where off-site sanitation is required for technical reasons but where such an approach is not affordable by the low-income areas without

extensive credit assistance. In these cases the local government must be prepared to fund the construction of the sewage collection and treatment facilities and recover the costs from the users through long-term credit. To keep operating and maintenance costs as low as possible and to achieve sustainability, these systems will be designed and constructed such as to maximize community operation and maintenance. The local governments concerned, being generally inexperienced in such systems will be provided with capacity building and other support by the Central Government.

Many cities and towns have sludge treatment facilities whose effluent is disposed of the solid waste disposal sites, to rivers or to open land. To address this issue, the current policy of the Government in dealing with the large volumes of septic tank sludge that must be disposed of is to require each local government to operate, or have access to, a treatment facility. The Ministry of Public Works has recently issued design guidelines covering septage treatment facilities. Two cities currently operating comprehensive septage treatment facilities are Jakarta and Surabaya.

Effluent discharge standards are set by the Environmental Protection Authority (EPA) and are listed in annex II. At this stage, the legal infrastructure and enforcement procedures are under development. With assistance from several external support agencies the EPA is training staff in detection of unlawful discharges and the prosecuting of offenders. It is anticipated that this capability will be developed by the end of 1993.

Willingness to pay is determined through surveys and with experience from completed projects. In a survey carried out in Bogor in 1986, residents were questioned as to their willingness to contribute to the cost of private latrines in the form of money, labour or materials. Table 35 shows the results of this survey.

Table 35. Respondents potential ability to afford a private latrine, Indonesia

Type of Contribution	*Type of Respondent*	
	Receivers	*Non-receivers*
Money	2 (7 percentage)	1 (2 percentage)
Labour	5 (16 percentage)	1 (2 percentage)
Credit Rp 200 – 1000/month	3 (10 percentage)	5 (11 percentage)
Labour + credit	12 (40 percentage))	7 (15 percentage)
Everything	8 (27 percentage)	33 (70 percentage)

Source: United Nations Development Programme Project INS/85/005

In other projects, experience has generally been that low-income households can afford and are willing to pay up to 3 per cent of their monthly income to acquire private (on-site) sanitation facilities.

Where sewerage is concerned and the much higher costs are taken into consideration, considerable assistance is required to keep tariffs affordable for low-income communities. In the pilot project proposal for Surabaya, the monthly tariff was restricted to Rp 2,300 a month through substantial subsidy from the Central Government. This tariff represented 4.6 per cent and 2.3 per cent of monthly salaries of Rp 50,000 and Rp 100,000, respectively. The cost of the connection is built into the monthly tariff.

In another case, the financial feasibility was analysed of providing low-cost (shallow) sewerage to a low-income community in area in which a substantial number of residents already possessed individual facilities (septic tanks). This analysis showed that the local government would be required to contribute the capital cost of establishing the sewerage reticulation and treatment facility and recover the cost over a period of some 20 years. Under this analysis, the connection cost would be paid by the users.

H. Emerging trends

1. Water supply

It is clear from a consideration of budget implications, taking into account the existing high foreign debt burden that the Government will continue to seek funding alternatives. The private sector involvement can be expected to continue and increase.

A logical complementary action to the above is the reduction of the unaccounted-for water in water enterprises. This will take time to realize and will also have significant cost implications. It is, however, a necessary action.

With the recent large budget increases in the current Repelita 1989-1994, there is strong pressure on trained resources throughout the sector. There is a clear need for action to produce more appropriately trained and experienced professional and technical personnel to work in the sector.

2. Sanitation

High urban development densities are already established and will require planning to avoid their proliferation in the future. This trend is changing the approach to sanitation development from one of on-site to control costs to one of a mix of on- and off-site. The greater use of off-site sanitation will require a strong community involvement with all the associated human resources development requirements.

This is a clear trend emerging for the increasing use of conventional sewerage in the larger cities which have the financial capacity to subsidize the costs to the low-income communities. Smaller cities and towns without such financial capacity and which also require such technology will be forced to use modified or low-cost approaches and will be forced to pass on more of the capital costs to the communities served. This will have implications for the Government equity policy.

One of the unfortunate costs of the rapid development during the 25 years that will end with Repelita V is the extensive pollution of water resources by the discharge of human waste and industrial wastewater. This is well understood by the Government which is putting in place the necessary regulatory framework to allow it to prevent a worsening of the situation, to gradually commence the task of removing polluting sources and repairing the damage done.

Annex I

City of Jakarta water tariff, Indonesia

Type of Customer	*0-15 m^3 (Rp/m^3)*	*16-30 m^3 (Rp/m^3)*	*31-50 m^3 (Rp/m^3)*	*> 50 m^3 (Rp/m^3)*
1. Social				
a. General	150	150	150	150
b. Special	150	270	360	540
2. Non-Commercial				
a. Household	180	360	550	900
b. Government Institution	270	450	725	1100
3. Commercial	←	→	←	→
a. Small business	600		1200	
b. Large business	750		1500	
4. Industry	←	→	←	→
a. Small industry	630		1260	
b. Large industry	840		1680	
5. Special Tanjung Priok	←	2800	→	

Annex II

Government of Indonesia effluent discharge standards

No.	*Parameter*		*Unit*	*I*	*II*	*III*	*IV*
	PHYSICAL						
1.	Temperature		°C	35	38	40	45
2.	Total dissolved solids		mg/L	1500	2000	4000	5000
3.	Total suspended solids		mg/L	100	200	400	500
	CHEMICAL						
1.	pH			6-9	6-9	6-9	5-9
2.	Iron	(Fe)	mg/L	1	5	10	20
3.	Manganese	(Mn)	mg/L	0.5	2	5	10
4.	Barium	(Ba)	mg/L	1	2	3	5
5.	Copper	(Cu)	mg/L	1	2	3	5
6.	Zinc	(Zn)	mg/L	2	5	10	15
7.	Chromium	(Cr^{6+})	mg/L	0.05	0.1	0.5	1
8.	Chromium	(Cr)	mg/L	0.1	0.5	1	2
9.	Cadmium	(Cd)	mg/L	0.01	0.05	0.1	0.5
10.	Mercury	(Hg)	mg/L	0.001	0.002	0.005	0.01
11.	Lead	(Pb)	mg/L	0.03	0.1	1	2
12.	Strontium	(Sn)	mg/L	1	2	3	5
13.	Arsenic	(As)	mg/L	0.05	0.1	0.5	1
14.	Selenium	(Se)	mg/L	0.01	0.05	0.5	1
15.	Nickel	(Ni)	mg/L	0.1	0.2	0.5	1
16.	Cobalt	(Co)	mg/L	0.2	0.4	0.6	1
17.	Cyanide	(Cn)	mg/L	0.02	0.05	0.5	1
18.	Sulphide	(H_2S)	mg/L	0.01	0.05	0.1	1
19.	Fluoride	(F)	mg/L	1.5	2	3	5
20.	Chlorine	(Cl_2)	mg/L	0.5	1	2	5
21.	Ammonia	(NH_3-N)	mg/L	0.02	1	5	20
22.	Nitrate	(NO_3-N)	mg/L	10	20	30	50
23.	Nitrite	(NO_2-N)	mg/L	0.06	1	3	5
24.	BOD_5		mg/L	20	50	150	300
25.	COD		mg/L	40	100	300	600
26.	Hydro-carbons		mg/L	0.5	5	10	15
27.	Phenol		mg/L	0.01	0.5	1	2
28.	Vegetable oil		mg/L	1	5	10	20
29.	Mineral oil		mg/L	1	10	50	100
30.	Radioactivity (**)						
31.	Pesticide including PCB (***)						

Notes: * *Samples of impurities to be evaluated in accordance with these standards must be based on direct sampling from the water bodies they represent and may not be diluted. The concentrations indicated are maximum permissible except in the case of the value for pH which also defines the minimum permissible value.*

** *Radioactivity concentrations should comply with regulations locally in force.*

*** *Wastewater containing pesticides may not be discharged to receiving waters such that the existing usage could be compromised.*

Group I: Water suitable for human consumption without treatment.
Group II: Water suitable for human consumption after treatment.
Group III: Water suitable for fish culture and animal farming.
Group IV: Water suitable for agriculture, commerce, industry and hydro-electricity generation.

VI. RESTRUCTURING THE WATER AND WASTEWATER UTILITIES, ISLAMIC REPUBLIC OF IRAN*

Introduction

The Islamic Republic of Iran covers 1,648,000 km^2 in south-western Asia. It is bordered to the north by Armenia, Azerbaijan, Turkmenistan and the Caspian sea, to the east by Pakistan and Afghanistan, to the south by the Persian Gulf and the Gulf of Oman, to the west by Turkey and Iraq. The capital is Tehran.

Altitude, latitude, maritime influences, seasonal winds, and proximity to the mountain ranges or deserts play a significant role in the fluctuation in temperatures which vary from a high of 55°C in Khuzestan, on the Persian Gulf to a low of -37°C in the north-west. Precipitation also varies widely, from less than 50 mm in the south-east to about 1,980 mm in the Caspian region. The annual average is about 406 mm. Winter is normally the rainy season for the country as a whole, more than 50 per cent of the annual precipitation occurs in that three-month period. The high mountains, which seal off the narrow Caspian plain, wring moisture from the clouds, trap humiditity from the air, and create a fertile semitropical region with luxuriant forests, swamps, and rice paddies, temperatures may soar to 38°C and the humidity to 98 per cent. Frost is extremely rare. Except for this region, summer is a dry season. The northern and western parts of Iran have four distinct seasons. Moving south and east, spring and autumn become shorter and ultimately merge in an area of mild winters and hot summers.

A. Review of the urban water supply sector

The water crisis in the cities of the country is basically related to the growth of the population over the past two decades. Urban population growth was 5.5 per cent between 1970-1986, even if growth decreased to 3 per cent, the urban population of the country, which is at present 33 million, will reach about 70 million by the year 2011. The critical state of this issue becomes more clear if we consider the fact that the populations of some cities have increased 3-4 times since 1978.

At present the amount of urban potable water consumption is 2.5 billion m^3 per year. Assuming the rate of urban population growth to be 5 per cent and the increase of water consumption per capita to be 2 per cent, 7 per cent will be the average annual increase of water consumption in the cities. Accordingly, the urban potable water demand will reach about 7 billion m^3 by the end of 2011. Apart from drinking and irrigation water, it has been estimated that the water consumption of the large industrial units of the country it has been estimated will be about 2.6 billion m^3 by the year 2011. Therefore, the water demand of the cities for drinking and industrial purposes by the end of 2011 will amount to 9.6 billion m^3.

It is worth mentioning that by the end of 1991 about 85 per cent of the country's urban population had been covered by proper water services, and the total number of connections was estimated to be about 4 million, half of which were achieved by the Ministry of Energy in 45 cities.

The urban population growth of the country is presently 1.7 million per year. The capital investment to supply water to the population amounts to approximately Rls 150,000 per individual. This figure has been estimated by taking into account the government price exchange rate in the foreign currency portion of the cost. At present one-third of this amount is invested by the government. The foreign currency portion of the investment is estimated to be at least US$ 800 million per year, however, only a quarter of this figure is currently provided by the government.

One of the factors causing ineffective use of investments is the inability of water companies and authorities to recover the depreciation and reconstruction of water supply facilities and the distribution systems and the loss of water in the system.

Average loss of water in the system in Iran is 35 per cent. Such water loss is due to factors such as the wearing away of pipes, non-conformity of the valves and fittings with the standards, improper taps, poor maintenance and operation. To recover such loss of water, many of the water supply systems should be

* By A. Zarkoob, Member of the Board, National Water and Wastewater Engineering Company.

reconstructed, and the capital investment required for this work is estimated to be about Rls 250 billion. Therefore, in many cities of the country, an enormous investment should be made to prevent the loss of water from the systems in addition to the capital investment for the supply of water.

The significant point is that the price of water is usually determined on the basis of the operation and depreciation cost. In those countries where the private sector administers and manages the drinking water supply, the capital profit is also taken into account. If such a method is applied, the water expense will also find its place among the other household expenses, while in Iran, the water supply is considered a low-cost or almost free of charge service which is of course a wrong assumption particularly for Iran where there is a shortage of resources.

The average price of selling water in Iran is about Rls 30 per m^3, while the average cost of operation is about Rls 50. On the other hand we calculate the depreciation cost at the present price, the average price of water will reach Rls 100. In our opinion we must reach this figure, and even to a figure of Rls 150 taking into account capital profit. In some parts of the country, such as the Persian Gulf Islands and Lengeh port, water is made available by desalination at a price of Rls 1,500-2,500 per m^3, at the same time such water is made available to the Tehran citizen at a price of Rls 60 per m^3.

On the other hand, the average water consumption per capita in the country, taking into account the losses in the administrative and commercial sections, etc, is 250 l/day, and without the above mentioned losses 150 l/day which constitutes a high figure for Iran. The two indices of price and consumption of water are interrelated and should be balanced.

The industrial sector has also used underpriced water, and the cost value of the products have not been real. A comparision of water prices before and after 1980 shows that the price of water, taking into account the inflation index, is lower now and this fact indicates that Iran has acted contrary to the essential policies, and that a problem still exists.

The main principles which should be taken into account with regard to the water issue are:

(a) Provision of a suitable pattern for the utilization of urban water and its enforcement.

(b) Determination of the actual price of urban water utilization and its enforcement.

(c) Prevention of water resources pollution by wastewater.

(d) Use of suitable equipment and application of proper management to realize the above mentioned policies and plans.

(e) Avoid creating industries which require a large volume of water consumption in the regions where water is limited.

B. Formation of water and wastewater companies

Simultaneously with the review of the plan for the formation of water and wastewater companies in the Islamic Consultative Assembly, the Ministry of Energy initiated certain arrangements to accept responsibility for the establishment of the above mentioned companies.

In August 1989 a deputy minister's office under the title of the Deputy Minister of Energy for Urban Water and Wastewater Affairs was formed to undertake the duties pertaining to the formation of the water and wastewater companies.

With the approval of the said statutory plan, the management and actions were followed-up more closely, and with the formation of various committees, the preparation and compiling of by-laws, directives and regulations for the enforcement of the act were put into effect.

The most significant measures taken so far are as follows:

(a) Preparation of typical articles of association for water and wastewater companies.

(b) Modification of the articles of association of the Water Engineering Service Companies, in implementation of article 17 of the Act on the establishment of water and wastewater companies, and submission there of to the council of Ministers for approval.

(c) Preparation of the executive by-laws, referred to under article 18 of the Act, which are expected to be ready for submission to the Council of Ministers for approval by the end of 1993.

(d) Preparation of the operation by-laws for the purpose of determining the relationships between water and wastewater companies and the partners and the manner of accepting partners, transfer of water connections and manner of determining

rates of connection and water charges.

(e) Preparation of transaction by-laws and financial by-laws.

(f) Preparation of a uniform accounting system.

(g) Preparation of the training programme for directors of water and wastewater companies.

(h) Preparation of identification cards for all personnel including those in the water and wastewater units.

(i) Preparation of a typical general organization chart, for the establishment of any of the provincial water and wastewater companies, the detailed organization chart will be drawn-up and presented within the framework of the general chart.

(j) Appointment of the managers of the water and wastewater companies establishment project in 24 provinces, and assignment of qualified managers for other provinces. The holding of short-term seminars successively for discussion, exchange of views and evaluation of the different stages of the task of establishing the companies.

(k) Iran has established, 30 water and wastewater companies. It should be mentioned that in a large province, from two to three different independent companies have been established.

C. A new national model for effective management of water and wastewater utilities

In order for a provincial water and wastewater company (PWWC) to become more responsive to local needs and utilize the local private sector, they are given more and more independence from the central company – National Water and Wastewater Engineering Company (NWWEC). In order to explain the relationship among NWWEC, PWWC and city water and wastewater companies (CWWC), a model is presented in figure XIV. From that model, the following conclusions can be made:

(a) As long as a PWWC, demonstrates that it can do the job without supervision, they can enjoy more and more independence from the central company.

(b) The distance (the "orbit" of rotation) between a typical PWWC and NWWEC will be determined by NWWEC experts after careful examination of that particular PWWC's resources, capacities and potentials.

(c) Once the "orbit" has been established, the PWWC must stay on that course. In order for them to climb to a higher "orbit" (gain more independence), they must demonstrate their ability to manipulate their resources, local environment, and develop their managerial staff.

(d) In turn, PWWC will be given permission to establish and control CWWC.

(e) Based on the following criterion, the level of CWWC independence will be established:

(i) Financial resources;

(ii) Speed and accuracy in dealing with clients;

(iii) Public relations strategy;

(iv) Accuracy of their accounting systems;

(v) Quality of their personnel;

(vi) Ability to maximize the use of their water facilities;

(vii) Ability to minimize the cost of repairs and maintenance;

(viii) Accuracy of their inventory system;

(ix) Rate of enforcement of standard codes;

(x) Level of cooperation that they are willing to show toward the PWWC;

(xi) Level of accuracy of their collected statistics and information; and

(x) Rate of investment by private sector in that particular area.

(f) If a CWWC shows its inability to keep up with the above guidelines, then PWWC will exert more control over that particular company.

(g) In order for a PWWC to establish leadership in its province among its CWWCs it must have the ability to:

(i) Design and implement development projects;

(ii) Plan on a provincial level;

(iii) Develop its human resources;

(iv) Achieve speed and accuracy in its information systems;

(v) Keep its organization and methods up-to-date;

(vi) Organize and manage;

(vii) Project management capabilities;

(viii) Develop financial resources;

(ix) Prepare and implement budgets;

(x) Develop purchasing management capabilities;

(xi) Provide an environment in which creativity and new ideas have value; and

(xii) Create standards.

Also, the NWWEC will define the level of PWWC independence based on the above criterion.

(h) In order for NWWEC to control all PWWCs it must establish leadership through:

(i) Exceptional information systems;

(ii) Computerization;

(iii) Planning and organizational development capabilities;

(iv) Scientific and engineering capabilities;

(v) Establishing an extremely good relationship with law makers; and

(vi) Strategy for the control of all the PWWCs.

(i) If NWWEC is not capable of showing leadership, then, this model will not work.

(j) An effective relationship with the private sector in various parts of the country is only possible, if, the model can be implemented and Iran has strong and independent CWWCs.

(k) As soon as a city has an independent water company, it can start to transfer some of its responsibilities to the private sector. It is recommended they do this after consultation with PWWC.

D. Establishment and commissioning of water and wastewater companies

The main concepts pursued for the establishment and commissioning of water and wastewater companies may be summarized as follows:

(a) Non-government status

For the purpose of putting into effect non-government rules, regulations and principles in the company in order to reduce the activities of the companies and to create work motivation, as well as to assign various areas of the company's activities to the private sector and eventually to transfer the company to the private sector.

(b) Participation of the people

For the purpose of creating suitable mechanisms and programmes for the participation of the population in the projects and plans whether directly or indirectly, knowing that the government sources are not sufficient for the fulfilment of the projects and plans of the companies.

(c) Decentralization

For the purpose of creating the independence of the companies in the provinces and independence from the Ministry of Energy in different works, as well as, the participation of the provincial municipalities and to make use of local motivation.

(d) Uniform procedures

For the purpose of codifying uniform laws, regulations, by-laws, standards, codes, forms and directives in order to achieve the smooth and uniform planning and management of the companies, and to provide the possibility for control and checking of their activities and to make the best use of national and worldwide experience and achievements.

(e) Training

For the purpose of generalizing and extending training courses for different levels of the companies staff, in order to enforce and put into effect the policies and programmes of the companies stressing applied training by the companies themselves and/or through the water and wastewater engineering company and by making use of the other capacities available in Iran.

(f) Promotion of output

To increase the output and efficiency of the various units of the company by means of applying the above five policies with the objective of rendering better services and reducing expenses.

(g) Development

The planning and implementation of programmes which could meet the requirement for water supply and distribution for the increasing population of Iran and futhermore to create facilities suitable for the wastewater treatment of the cities taking into account the extensive demand.

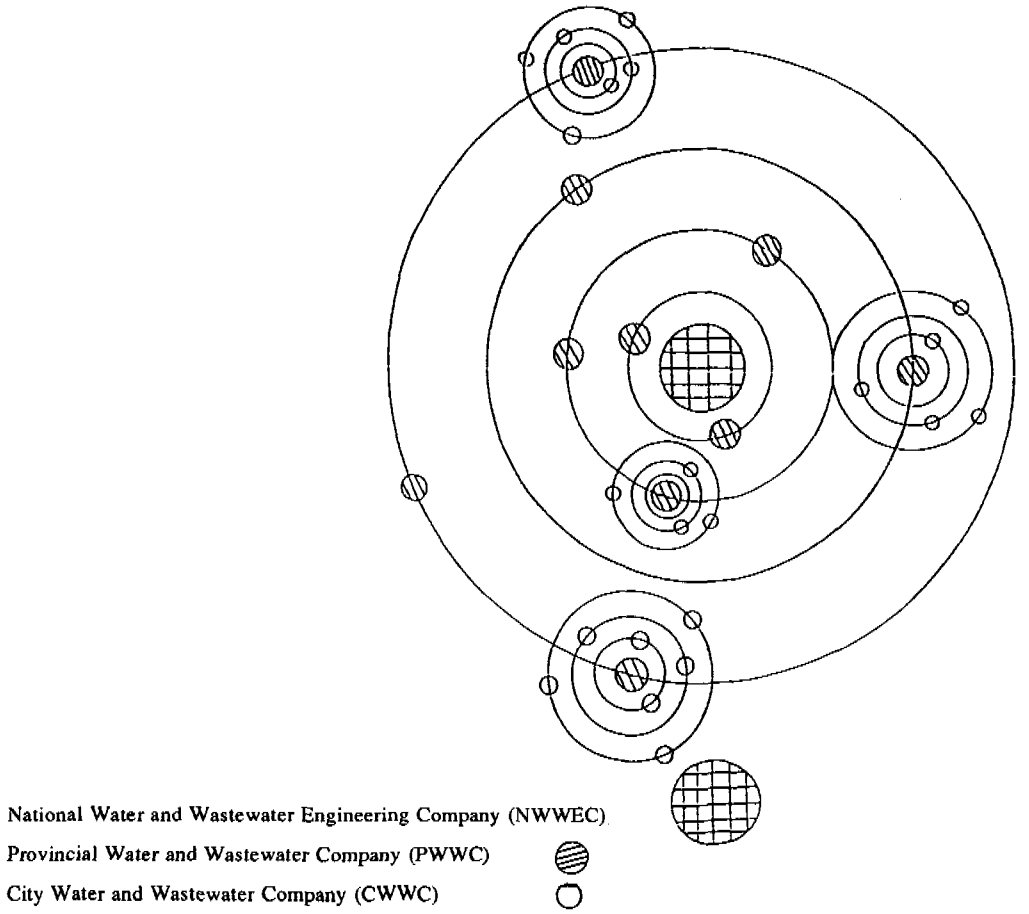

Figure XIV. Relationship among national, provincial and city water utilities, Iran.

VII. WATER MANAGEMENT PROBLEMS IN BISHKEK, KYRGYZSTAN*

Bishkek, the capital of the Republic of Kyrgyzstan has a continental climate – cold winters and hot summers.

The city of 700,000 in population has groundwater resources for water supply in the Orto-Alysh and Ala-Archa aquifers in the Chui River valley. Quaternary sediments there contain a large volume of drinkable quality water, the stock of which is replenished by an infiltration of atmospheric precipitation and seepage from surface water flows and irrigation systems.

Water supply and sewerage facilities are the property of the city, and the city administration has given them to the Water Management Directorate "Bishkekvodokanal" to be run. The "Bishkekvodokanal" Directorate governs 226 artesian wells and 1,056 km of water pipelines with a supplying capacity of 460,000 m^3/day. Fifteen water collection points have pumps for the secondary lift of water, there are also 110 booster pump stations used for the water supply of high buildings. Bactericidal plants and chlorination are used at water collection points for disinfection. The number of technical personnel operating and managing the water system is 350. The municipal supply system is intended to deliver potable water to the population, organizations and institutions as well as to meet the technological needs of industrial enterprises and for firefighting.

The city's demand for drinking water ranges from 400,000 m^3/day to 645,000 m^3/day. The highest rate of water consumption, because of the summer heat, lack of rain and the vegetable growing season, takes place in June to August. During this period there are irregularities in the water supply to some residential districts and the upper floors of buildings.

The main reasons for that are:

(a) inadequate production capacity of water supply system;

(b) decrease in water abstraction from wells because of a fall in groundwater level;

(c) utilization of drinking water by the population for watering vegetable gardens owing to the lack of water in the irrigation network;

(d) wasteful water use by consumers; and

(e) shortage of necessary materials and equipment for the maintenance of the water supply system.

The water supply and sewerage networks in Bishkek are in a critical condition. The capacity of the water supply system is insufficient, 20 per cent of the water supply pipelines are heavily corroded, and about half of the pumping stations do not have pumping units in reserve. The disintegration of the Union of Soviet Socialist Republics has caused a breach of economic ties resulting in disruption in the supply of machinery and spare parts.

The main and most urgent task in the city's water supply and sewerage sector is to adjust the economic mechanism of the "Bishkekvodokanal" company to a market economy's requirements and to ensure its normal financial standing. In 1992 the tariffs for all water users except the public were raised. Collected taxes have been invested in the construction and reconstruction of water supply facilities. In addition, some funds have been alloted from the municipal budget for these purposes too. However, those financial resources are not sufficient because of the limited assets of the municipal budget, therefore one way out would be to give permission to the water and sewerage enterprises to increase revenue.

There are many state-owned and collective farms in the suburbs of Bishkek which provide the city with agricultural products. In the spring and autumn an overwhelming part of the surface water is directed to the fields where irrigation water is not used economically because it is free of charge. As a result, the ecological situation in the city is deteriorating and the level of groundwater is falling. It is expected that with the privatization of the farms and the imposing of charges for water, the existing situation will improve, but it is necessary to arrange the proper regulation of water allocation by the Ministry of Water Economy. Also, the

* By A Isaev, Head, Bishkek Water Management Directorate, Bishkek, Kyrgyzstan.

City Administration has now started to implement a project which will make it possible to obtain cheap water from the upper groundwater layers some of which are not fit for drinking but are quite acceptable for the watering of gardens in the city. Because of the fall in the groundwater level a reconstruction project for 60 wells in the Orto-Alysh water collecting area is being drawn up.

Along with the stabilization of the economy of Kyrgyzstan and the development of market relations, it would be possible in the long term to create state joint-stock companies on the basis of the "Bishkekvodokanal" Directorate.

Such measures will make the operating personnel change their attitudes to business, raise their incentives to work and create real preconditions for improvement of the administration. Finally, it will lead to a better service to the consumer.

VIII. SEWERAGE MANAGEMENT IN MALAYSIA*

Introduction

Sewerage management is an important component of overall water management. Typically in a developing country, sewerage affluent increasingly becomes a major pollutant of a country's water supply system and its environment. It diminishes water resources for human consumption and threatens public health. Therefore, development of proper sewerage systems is an important infrastructural development which must not be neglected.

Sewerage development, however, is a capital intensive venture. Therefore, its success depends very much on the economic strength of a nation. This perhaps is one of the reasons why sewerage development always seems to lag behind other infrastructures which are more closely linked with economic development.

As far as Malaysia is concerned, sewerage development is at the critical stage where the impact of less than satisfactory disposal practices over the years has stretched the assimilative capacity of the natural ecosystem so much so that in many places it has gone beyond the limit of tolerance.

A. Current situation

1. Status of sanitation

The efforts made in sewerage development in the last two decades have resulted in overall improvements in terms of access to proper sanitation facilities. Data derived from the population censuses of 1970 and 1980 as well as the 1990 projections of the Ministry of Housing and Local Government (MHLG) given in table 36 will attest to this fact. However, the same cannot be said of the impact due to discharges of sewage effluent. The 1990 annual report of the Department of the Environment ranks sewage effluent among the top pollutants. This situation has resulted from a combination of factors including an increase in the total volumetric discharge of sewage effluent and poor operation and maintenance of sewerage systems.

* Prepared by the Planning and Developing Division, Ministry of Housing and Local Government, Malaysia.

Table 36. Sanitary facility coverage, Malaysia

Type of Facility	*Percentage of population served*		
	1970	*1980*	*1990*
Central Sewerage System	3.4	4.0	5.0
Septic Tank/Communal Treatment Plant	17.2	21.8	37.3
Pour Flush Latrine	2.6	30.3	45.0
Bucket Latrine	19.8	7.7	0.0
Pit Latrine	29.9	15.3	4.3
Hanging Latrine	9.4	4.5	2.1
No Facility	17.7	16.4	6.3

Sources: 1970 and 1980 population censuses and 1990 estimates by the Ministry of Housing and Local Government, Malaysia.

The socio-economic performance of Malaysia has been thriving on a solid foundation built over the years. All indications seem to show that the current trend of high growth rate will be maintained at least for the foreseeable future. Therefore it is reasonable to expect that the high rate of urbanization which has been fueled mainly by socio-economic development, will continue. In fact it has been projected that by 1995, more than 50 per cent of the total population in the country will be living in urban areas. Moreover, urbanization tends to concentrate large numbers of population in a few growth poles. This phenomenum usually adds to the urgency for the implementation of a sewerage development programme in these areas. On the other hand, owing to steady progress over the years, rural sanitation has reached a level where complete coverage by proper sanitary facilities is within sight. The reduction of the rural population will further lessen the burden and make it easier to achieve the target of 100 per cent coverage.

2. Sewage generation and discharge

The increase in the urban population as well as the tremendous improvement in water supply coverage tend to increase the production of sewage in urban areas. The end result is more sewage to be collected, treated and disposed often into the same catchment where the natural assimilative capacity has been increasingly overburdened by the ever increasing discharges both in terms of volume and concentration.

According to the 1990 Environmental Quality Report released by the Department of the Environment

and based on ammonical-nitrogen concentration which has been used as a barometer for the degree of sewage pollution, out of 53 rivers monitored in Peninsular Malaysia, 22 (42 per cent) were found to be seriously polluted and 18 (34 per cent) slighty polluted.

3. The green movement and consumer expectations

Public environmental consciousness is at an all time high, so much so that the green message is now being carried by many sectors of society including many policy-makers. This is a positive development as far as sewerage development is concerned as there will be more supporters for the development of this sector. Also, it is to be expected that public expectations will rise correspondingly and that the authorities responsible for sewerage development will have to carry it out more effectively and respond to the needs of the public.

4. Sewerage development financing

(a) National sewerage development programme (NSDP)

The fundamental reason why the implementation of the National Sewerage Development Programme (NSDP) encountered so much delay was the weakness in the project financing structure. Local authorities were responsible for sewerage development in their areas of jurisdiction and therefore were expected to raise the major portion of the financing for such projects and services. However, the level of local taxation in most, if not all, of the local authorities areas could not support such capital intensive infrastructural development without a hefty increase. Such an increase is often found to be politically unacceptable.

To overcome the above problem, under the Sixth Malaysia Plan (6MP), there has been a change in the federal sewerage development financing policy. A sizeable portion of the sewerage development cost can now be financed by Federal grants. It is expected that the remaining portion of the financial outlay for such development could be financed through a combination of Federal grants and loans raised by the local authority concerned or where possible through privatization of such development.

(b) Sewerage charges

Besides the capital cost, the operation and maintenance cost of a sewerage system has to be financed. The current policy is for the "user pays" principle. This is normally imposed through a combination of assessment rates and a surcharge on water used or by a pedestal charge. However, many local authorities are not imposing any of the above charges at present. Instead, consumers are billed for specific services, such as desludging of the septic tank.

This is one of the reasons why many existing sewage treatment systems are not functioning as they should due to the ignorance or apathy of the owner in the operation and maintenance of these systems. This situation has resulted in partially treated sewage being discharged into the environment.

5. Management of sewerage development

(a) Development planning and control

Most of the major urban centres in Peninsular Malaysia have their own sewerage master plan. Therefore, a blue print for sewerage development is available and development control in such an area can be carried out effectively as the trunk sewer routes and central sewage treatment sites have already been identified. However, there is a practical implementation problem, the local authority cannot reserve the site identified for the central sewage treatment plant without having to purchase the site if it is under private ownership.

Nevertheless, since the gravity sewer is the only viable alternative in most, if not all cases, the natural topography of the area can offer the municipal engineer some guidance in development control as to the siting of the treatment plant for each development to ensure linkage to the sewerage master plan.

The technical criteria and standards established in various sewerage master plan documents offer a good reference to the municipal engineer to assist him in the management of sewerage development. The release of MS1228 standards by the Standards and Industrial Research Institute of Malaysia (SIRIM) will not only make this task easier but will also ensure that uniform standards are adhered to throughout the country.

Currently, mainly due to the lack of staff and expertise in many local authorities, the Ministry of Health (MOH) has been playing an active role in helping these local authorities to carry out the sewerage development control function. This situation will continue until the capabilities of the local authorities improve.

(b) Operation and maintenance

Because of ignorance or apathy on the part of owners, many privately owned sewerage systems are not being operated and maintained properly. This situation has been compounded by the fact that many local

authorities are not taking over the operation and maintenance responsibility from the developers as they should.

To a large extent, the three basic chronic weaknesses of the local authorities, i.e. lack of money, manpower and management capability, all contribute to the present state of general neglect in the operation and maintenance of sewerage systems in many local authority areas. This situation has rendered hundreds of millions of ringgits worth of sewerage development that have been invested in the construction of the existing systems totally ineffective in giving the returns (both economic and environmental) they are designed for and capable of.

6. Human resources development

(a) Professional

As stated earlier, the NSDP has a built-in strategy to promote the growth of local professionals in this field. However the existing structure of the consultancy industry and the high rate of staff turnover have not been conducive to achieving this goal.

Besides sewerage master plan projects, the other avenue which provides a base for the growth of local professionals is consultancy services for infrastructural development for housing, industrial and other developments. A basic problem associated with this sector is the fact that it is basically a buyer's market. This is further compounded by the great number of small consultancy firms in existence, many of which are no more than a one-man operation. It appears that, in general, the level of professional capability in this field has not improved much over the last 20 years. Over-dependence on the sewerage system suppliers by many consultants is the main obstacle to professional development in this sector.

(b) Manager and operation

There is still a misconception in many quarters regarding operation and maintenance of sewerage systems. To many laymen, as long as the machinery of the system keeps on turning, the system is considered functional. However, a sewerage system cannot function properly without process engineering control. For this purpose, a well trained manager supported by competent operators is needed.

Due to the above misconception, adequate numbers of appropriate staff are not available to carry out the operation and maintenance function in most local authorities. Similar phenomena take place when private contractors are engaged to carry out this function mainly because the requirements for specialist and trained operators are often not specified in the contract.

(c) Technological development

The days of the Imhoff tank and oxidation pond have long gone. Today, various high rate biological systems are being used and other advanced systems are being introduced into the country. Although the imported technology has been well developed and can function under local environmental/climatic conditions, its optimal performance can only be achieved with local fine tuning and adaptation. So far the "Malaysianization" of the imported technology has not been carried out systematically.

However, the local industrial capability has improved over the years. It is believed that although it may not be ready yet to develop its own range of sewerage equipment, it is more than capable of fabricating a variety of plants and equipment under foreign license. Perhaps it will soon be able to perform reverse engineering and eventually turn out some equipment of its own to suit local requirements and conditions.

To overcome the problems associated with the operation and maintenance of sewerage systems, an increasing number of local authorities are contracting out such services to private contractors. This approach has produced mixed results. In many cases, failures are linked to the weaknesses in contract packaging, contract specifications, selection of contractors and supervision of contractors.

B. Areas of concern

1. Sewerage policy

To achieve the objective of providing proper sewage collection, treatment and disposal for all communities, to provide adequate public health protection, to enhance environmental quality and to conserve water resources, a sewerage policy having the following elements was proposed a few years ago:

(a) All sewage including excreta and sullage should be treated prior to disposal.

(b) Existing sewerage master plans for major urban centres should be implemented. Similar master plans should be prepared for other urban centres.

(c) All new developments, except those with an equivalent population density of less than 60 persons per hectare or having less than 30 dwellings, should incorporate waterborne sewerage systems with suitable treatment facilities capable of conforming to the effluent requirements of the 1979 Sewage and Industrial Regulations.

(d) All existing insanitary sanitation facilities such as pit and hanging latrines, should be replaced with sanitary systems.

(e) All sewerage systems should be properly operated and maintained. Manpower and financial resources for this purpose should be made available.

(f) Manpower resources development as well as research and development for the sewerage sector should be enhanced.

Presently, there are various weaknesses and discrepancies in the implementation of the above policy at the state and local levels. In view of the adverse impacts created by sewage discharges as reported in successive annual reports of the Department of the Environment, it is important that the above policy be adopted and implemented effectively by all concerned in a concerted manner.

2. Finance

Financial constraint is the biggest stumbling block to sewerage development in Malaysia. Therefore, the problems related to finance must be overcome before any progress can be made.

The "user pays" principle has been commonly applied in many countries in financing sewerage development. However, in order for this principle to be implemented, the users must be able and willing to pay. The ability of the user to pay has improved over the years as a result of the socio-economic progress achieved by Malaysia. However, willingness to pay is a phenomenum which has to be nurtured by public education on the one hand and enforcement of legal provisions on the other. A high degree of political determination will certainly help to bring the message across to the consumers.

It is believed that the rising environmental awareness among the population provides the authorities with a golden opportunity to implement a suitable financial programme and to take the first step towards breaking the financial stranglehold on sewerage development.

However, many local authorities have not taken this opportunity to act. It is important that as a minimum, the local authorities should impose a small monthly sewerage charge to enable it to carry out proper operation and maintenance of existing sewerage systems. Once the principle of paying for services has been accepted by the consumers it will be easier to adjust the payment according to the level and quality of services provided.

3. Human resources development

(a) Professional

Generally, the performance of many consultants in this field has not improved over the years. Reliance on suppliers for providing system designs is still prevalent. The need for environmental engineering professionals continues to rise. However good and systematic training courses in this sector are few and generally not available locally. The local universities can help to meet at least part of the need by offering relevant post-graduate and part-time or short courses. This will provide the opportunity to practising engineers to acquire the needed skills and knowledge to be able to offer their services in this field effectively.

(b) Sub-professional

At present anybody willing to work in the environment associated with sewage treatment plant can be a sewage treatment plant operator without the need for the relevant qualifications, training and experience. This situation may have been acceptable during the days of Imhoff tanks and oxidation ponds which require very little knowledge, if any, on process engineering matters associated with the job. However, the scenario has changed tremendously with the introduction of various high rate biological treatment systems. The level of skill and knowledge of treatment plan operations has become a vital element on which the successful operation and maintenance of the treatment system rests.

The need for properly trained sewage treatment plant operators is apparent. However, unless this is required under some appropriate legal provision it is unlikely that such a requirement will be met voluntarily by the parties concerned. Moreover, a suitable training course as well as an evaluation and registration system must be established. A suitable agency should be given the responsibility of managing this.

(c) Operation and maintenance

As stated earlier, the huge investment made by Malaysia in the construction of the existing sewerage systems is not producing the expected environmental

benefits. This arises from the acceptance by the authorities concerned of ineffective treatment systems such as substandard septic tanks, as well as from the neglect or low priority given to the proper operation and maintenance of sewerage systems.

Lack of manpower and experience can no longer be accepted as an excuse for not carrying out the responsibilities associated with the operation and maintenance of sewerage systems. Private contractors capable of performing the tasks are now available locally. What is needed is adequate funds, proper planning and effective contract management. The vital step, as stated earlier is to impose a minimum sewerage charge to generate the funds needed. The rest of the steps are much easier to take.

(d) Research and development

At present sewerage technology in Malaysia is almost totally imported from foreign countries where the conditions are quite different from ours. While nobody will deny the fact that such technology works in Malaysia, one cannot be sure that it works at optimum level under the set of design assumptions and criteria currently used in this country.

This situation is not without financial implications. The imposition of unnecessarily conservative design criteria will result in the wasting of millions of ringgits of the limited funds channelled into this sector. Moreover, the extra expenditure will not necessarily result in better sewerage systems. Instead it may well cause numerous operation and maintenance problems and consequently higher recurrent cost.

A better understanding of the performance and behaviour of various systems under local conditions will also enable the professional to select the most appropriate sewerage system for a specific project. Again it will result not only in better system performance but also in much superior operating economies.

C. The future

1. Tackling the backlog

As shown in table 36, currently only approximately 5 per cent of the population have access to city-wide sewerage systems. Even if the coverage by self-contained sewerage systems associated with new development schemes is included the total population coverage by water borne sewerage systems is estimated to be just over 20 per cent. After discounting the rural sector, there remains approximately 30 per cent of the population not covered by sewerage systems. This represents more than 65 per cent of the total urban population. Therefore, there is a lot of catching up to do as far as sewerage development in the urban sector is concerned.

Owing to the limited funds available for sewerage development, the scope of the individual sewerage projects originally envisaged under their respective master plans has to be reduced to cover only the highest priority areas. The so called "decentralized concept" of development strategy will most likely be employed.

As explained earlier, the sewerage development financing policy has been modified to include a federal grant element. This situation will improve the feasibility of greater private sector participation in the whole spectrum of development of this sector. However, unless the local private sectors gear up their efforts there is a risk of them losing out to foreign concerns.

2. Sewerage authority

The nature of the water cycle dictates that pollution control, water supply and sewerage system management are part of the closely knitted elements of water resources management. This is the reason why many countries have found that more effective management of water resources could be achieved under a single water basin authority. The complicated nature of the existing administrative and legal structures in Malaysia make it extremely difficult to make any progress in this direction. This is best illustrated by the difficulty encountered by the federal proposal to establish a single water supply authority in the country.

Nevertheless, if the desired progress in sewerage sector development cannot be achieved under the existing administrative framework, the situation may well force all concerned to consider the above concept more closely in the future.

3. The green movement

The green movement has gained momentum worldwide. Malaysia is no exception. The enhanced environmental awareness of the public will demand that the authorities concerned function effectively in all areas which have some bearing on health and the environment. The sewerage sector will become a prime target if sewage continues to be the major source of organic pollutants. The authorities concerned have no choice but to take immediate and effective action to avoid problems in the immediate future.

However, the green movement can be a friend and partner to the authorities. The momentum created can become the force to mobilize greater resources for the development of this sector. It can be used to assist in the implementation of specific programmes and projects involving the masses. In short the authorities concerned have to learn to manage the impact created by the green movement for the benefit of all.

D. Conclusions

Sewerage development in Malaysia, especially in the urban sector development has been delayed for too long. As a result, sewage effluent has become the major pollutant threatening public health and the well-being of the environment. Therefore immediate and effective action must be taken to develop this vital infrastructure.

Sewerage development requires the input and the cooperation of all sectors including the private sector and the public at large. It is hoped that the green movement can be harnessed to create a base condusive to fostering such cooperation and the willingness to provide the necessary input by all concerned to ensure success in the development of this sector.

Apart from the direct benefits of better public health and environmental protection, it is believed that sewerage development can also bring economic benefits to the country.

IX. PROBLEMS OF WATER RESOURCES MANAGEMENT IN MONGOLIA*

Mongolia occupies 1.56 million km^2 in central Asia at an average elevation of 1,600 m above sea level, the highest point reaching an altitude of 4,653 m, and the lowest being 553 m above sea level. The climate is of the continental type, with sharp contrasts and abrupt fluctuations in temperature. Precipitation is low and unevenly distributed. Sixty-five to seventy-eight per cent of the annual precipitation occurs in the summer; very little snow falls in the winter; spring is extremely dry and windy. The territory can be subdivided into three geographical areas, which are part of three large watersheds in central and eastern Asia, namely, the Northern Arctic Ocean Basin; the Pacific Ocean Basin; and the Central Asian Endorheic Drainage Basin.

Some 1,200 lakes and 6,900 springs can be found in Mongolia. The annual volume of water resources is estimated to be 34 billion m^3, of which 28 billion m^3 consist of run-off water.

Surface water resources are distributed as follows:

(a) 51 per cent for the Northern Arctic Basin (20.5 per cent of the territory;

(b) 37 per cent for the Pacific Ocean Basin (67 per cent of the territory); and

(c) 12 per cent for the Endorheic Basin (12.5 per cent of the territory).

Water resources are abundant amounting on a yearly basis to 24,000 m^3 per capita and 19,000 m^3 per km^2. However, in semi-desert areas these values decrease to 4,000 m^3 and 1,500 m^3, respectively. As the country is subjected to a very dry climate, water development is directed towards irrigation in order to secure food for the population and fodder for the livestock.

A significant part of the financial and manpower resources of the country has been allocated to the development of irrigation projects. At the present time annual water demand is 330 million m^3, some 70 per cent being used for irrigation which is expected to increase threefold in the near future. The needs for 1995 being estimated at 65 million m^3 for industry, 230 million m^3 for community water supply, 125 million m^3 for livestock and 250 million m^3 for irrigation.

An elaborated master plan for the utilization and conservation in quality and quantity of the water resources of Mongolia was prepared in 1971-1975, taking into account the rapid expansion of industry and agriculture and also urban development. The plan includes regional schemes for the development and protection of water resources in the Kherulen, Khovda, Selenga and northern Gobi river basins and also the catchments of the Great Lakes. The documents include quantitative and qualitative water and ecological data for each area, taking into account environmental considerations.

The watering of vast pasture areas, exploitation of the groundwater resources for irrigation, implementation of water supply to rural settlements, design and construction for flood protection, and the rational use and protection of water resources are at the heart of national water policy.

It is important to carry out measures for the rational utilization and conservation of water resources in accordance with the rapid increase of water demand owing to the expansion of towns and rural settlements. The population has grown, large industrial centres have been established, agricultural production has intensified and new arable lands are being cultivated.

The water management department of Mongolia is directing its efforts at securing water supply to the people and to all sectors of the economy. Its field of competence also extends to flood control and to the protection of water resources.

It is clear from the above that in considering the achievements and shortcomings of the water organizations one must take into account their policies, organization and level of productivity.

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At present, no central agency specialized in water economy exists in Mongolia. Economic water policy has been made partially by the Ministry of Food and Agriculture, and partially by the Ministry of Nature and Environmental Protection.

With a view to solving the fundamental problems of water utilization and protection, special mechanisms to replace the policies of administrative, economic, scientific and technical segments as well as the interested public must be devised.

The need clearly exists for a control agency specialized in water economics, with activities geared toward merging technical capability with skilled personnel. The following steps must be taken:

(a) Training of qualified personnel.

(b) Preparation of legal and economic regulations governing water utilization and conservation.

(c) Preparation of water standards and publication of scientific and technical documentation on water economics.

(d) Establishment of a public library of technical literature and maintenance of a central information system for water resources data.

(e) Establishment of norms and standards for the chemical analysis of clean and polluted water and soil testing, etc.

(f) Establishment of a central laboratory for hydro-engineering, hydraulics and hydro-chemisty.

X. WATER SUPPLY MANAGEMENT IN SINGAPORE*

Introduction

The Republic of Singapore is situated between latitudes 1° 09'N and 1° 29'N and longitudes 103° 38'E and 104° 06'E, approximately 137 km north of the Equator. Apart from the main island of Singapore there are 57 small islands and reefs which are mostly uninhabited. The main island with an area of 572 km^2 is 41.8 km from east to west and 22.9 km from north to south. The island is generally flat with most parts rising to no more than 15 m above the mean sea level. The central region is more hilly. The total land area including the smaller islands is 620 km^2.

The climate is equatorial. Rain falls all year round but tends to be most copious during the monsoon season from November to January. The average annual rainfall is 2,370 mm.

The population of Singapore is approximately 2.7 million. By the year 2000, Singapore's population is expected to be about 3 million. Singapore, unlike other countries in South-East Asia, has no natural resources.

The Public Utilities Board (PUB) was formed in 1963 as a statutory authority to take over the functions of the then City Council, to provide electricity, water and gas to meet the demands of the increasing population and industrialization. The Water Department is responsible for the provision of potable water supply in Singapore.

A. Water resources

The Republic's water demand is approximately 1.05 million m^3 per day. It is met by supplies from sources in the island as well as in the neighbouring State of Johore in western Malaysia. Singapore is not self-sufficient in water and imports about 50 per cent of its needs from Johore. Except for the central hilly zone (also the Republic's only protected forest reserve), the rest of the island is too flat to facilitate inland reservoir construction and too highly urbanized for water resources development.

There are altogether 14 impounding reservoirs in Singapore with about half of the total land area as catchment areas. Besides the four impounding reservoirs constructed in the protected catchment of the central forest reserve, PUB also constructed seven estuarine reservoirs and other storm water collection systems for tapping run-offs from highly urbanized catchments. Water from these reservoirs is treated at six water treatment plants.

B. Water pollution control

With limited land area, judicious land use planning is a key factor in the development of the Republic's water resources. Suitable catchments have been earmarked and anti-pollution legislation with stiff penalties has been enacted to control pollution of watercourses.

The various Anti-Pollution Acts are administered and enforced by the Ministry of the Environment, which monitors jointly with PUB the quality of both surface run-off and reservoir water throughout the Republic by means of an elaborate network of sampling points. Close liaison with Government agencies and statutory boards such as the Planning Department, Housing and Development Board, Jurong Town Corporation, Ministry of the Environment and Building Control Department is necessary to control and curtail proposed residential, agricultural and industrial developments in water catchments.

Strict anti-pollution measures and enforcement and proper catchment management have been instrumental in reducing significantly the pollution load into reservoirs. The raw water quality in terms of chemical oxygen demand, phosphates, total nitrogen, etc. has shown marked improvements. The following broad-based policies are being pursued throughout the Republic:

(a) setting up of a green belt in the periphery of reservoirs;

(b) prohibition of pig farming and rearing of other hoofed animals within water catchments;

(c) implementation of modern sanitation for all

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premises located within water catchments (indeed throughout the whole of Singapore);

(d) control of trade effluent discharge by setting up separate wastewater treatment units if the quality of trade effluent fails to meet required standards;

(e) density of buildings is controlled when new towns are developed for public housing; and

(f) pollutive industries are located outside water catchment areas.

C. Water distribution

The treated water is conveyed to customers by gravitation from the service reservoirs through the transmission and distribution network. There are altogether 13 service reservoirs in Singapore with a total capacity of 962,000 m^3.

The mode of water supply adopted by the Water Department is generally as follows:

Height of Fittings	*Method of Supply*
(a) Level of highest fitting less than 25 m above mean sea level	Direct
(b) Level of highest fitting above 25 m but below 37 m above mean sea level	Indirect supply through high-level storage tank
(b) Level of the highest fitting above 37 m above mean sea level	Indirect supply through low-level tank with pumping to high-level tank.

For mode (a), storage tank may be required for important installations where supply cannot be affected or interrupted. For mode (b), the high-level tanks have capacities for 24-hour supply. For mode (c), which is to be adopted for water supply to premises and tall buildings beyond the reach of direct mains pressure, water flowing into the low-level tank will be pumped into the high-level tank of 24-hour storage capacity.

The total length of the transmission and distribution mains in the network, varying from 75 to 2,200 mm in diameter, is approximately 4,300 km. The smaller diameter mains (300 mm diameter and below) are mainly cement-lined ductile iron. The larger mains are mainly cement-lined steel pipes. For smaller connecting pipes (28 - 54 mm in diameter), stainless steel, copper, and pvc-lined galvanized iron pipes are used. Only dezincification-resistant brass fittings are allowed for use in the system as non-dezincification-resistant brass fittings were found to pit when in contact with water of higher chloride content in certain zones.

Water from estuarine reservoirs has higher chloride and sulphate contents. Corrosion of old and unlined cast iron mains and galvanized iron connecting pipes was the major cause of poor water quality or discoloured water complaints in past years. Besides, corrosion also causes leakage and reduction in carrying capacity of pipes which lead to complaints of low flow rate and poor pressure. In view of the need to use more durable and corrosion-resistant pipes, PUB has since prohibited the use of unlined galvanized iron pipes. Since 1980, only corrosion-resistant pipes made of copper, stainless steel and galvanized iron pipes which are internally lined with PVC or high density polyethylene are allowed for use.

In 1983, PUB embarked on programmes to replace old unlined cast iron mains with cement-lined ductile iron pipes and unlined galvanized iron connecting pipes with stainless steel or copper pipes in the western and eastern parts of Singapore which receive water from estuarine reservoirs. The replacement programmes for the western and eastern areas have been completed. Replacement work in the central areas of Singapore which is estimated to cost S$27 million is currently in progress and is scheduled for completion in 1993. In addition to PUB's pipe replacement programmes, customers including managing agencies of buildings are advised to replace the unlined galvanized iron service pipes within their premises with corrosion-resistant pipes to tie in with PUB's replacement work.

The programme to review and upgrade the system is on-going and measures include:

(a) Laying new systems of pipelines to replace old ones in redeveloped areas.

(b) Linking up dead-end mains to form ring mains systems.

(c) Where dead-end mains cannot be linked up owing to site constraints, a systematic flushing programme is carried out to reduce the likelihood of corrosion due to stagnation of water in the mains.

Water storage tanks used for high-rise supplies can be potential sources of contamination if they are not properly maintained by the owners of buildings. Since 1985, PUB has disapproved the use of pressed steel, coated or galvanized tanks. Tanks made of stainless steel,

glass reinforced polyester (GRP) and reinforced concrete were introduced and are now commonly used.

D. Water accounting

The entire water supply system from Waterworks to customers' taps is fully metered. Magnetic flow meters are used to meter the production at each Waterworks. Calibration tests are conducted monthly through draw-down of the clear-water tanks in the Waterworks to ensure accurate recording.

Water consumption by customers in Singapore is fully metered. There are currently 823,200 water accounts of which 91.3 per cent or 751,850 of them are domestic accounts. The remaining 8.7 per cent or 71,360 of them are commercial and industrial accounts. The water meters used range from 15 mm to 200 mm types. These meters are tested to ensure recording accuracy of within 3 per cent before installation. This system of full accounting from Waterworks to customers' premises is necessary to keep unaccounted-for water to a minimum. Current unaccounted-for water is about 6.7 per cent of the total demand. In the definition of the Water Department, unaccounted-for water is the difference between the total amount of water supplied to a transmission and distribution system and the consumption of water accounted for (which includes water sold to customers, water stored in service reservoirs, water used for flushing and sterilization of new and existing water mains and routine cleaning of service reservoirs, etc.) from the system.

E. Water conservation

The rapid industrial, social and economic development in Singapore have resulted in a sharp increase in water demand. In 1950, the population of Singapore was a little over a million and the demand for potable water was 142,000 m^3 per day. In 1990, the population had gone up by only 2.7 times but the water demand had increased by about 8 times. Until recently the Republic's water demand had been growing at more than 5 per cent per annum. Such growth rate is a great strain on Singapore's limited water resources. There is therefore a need to control wastage, and implement water conservation measures.

Wastage of water can be defined as the loss of water due to inefficient usage by customers and losses from the transmission and distribution system. In order to identify accurately the extent of water wastage in the system, Waterworks output and quantity consumed must be accurately accounted for.

Measures to curb wastage in the transmission and distribution system include inspection for leakage along pipeline routes for transmission mains of 700 mm diameter and above and implementation of a yearly leakage detection programme for all distribution mains of 500 mm diameter and below. The objective of the programme is to check the soundness of the entire distribution network at least once a year. Any leaks detected will be repaired immediately to curb wastage. Leakage detection tests are carried out for the entire distribution network within eleven months, leaving one month to re-test the leak prone areas.

Leakage detection testing is conducted by isolating a predetermined region and observing the flow recording chart on the waste detection meter installed at the flow inlet of the region. Any registration of flow on the flow recording chart indicates the presence of water leakage in the region. Further tests are then carried out by using a sonic instrument to locate the leaks for repair.

In 1991, 1,010 leaks were detected. Had the 1,010 leaks not been detected and repaired up to the end of the year, the total cumulative wastage could have amounted to 165,829 m^3 per month. The leakage detection programme has contributed significantly to keeping underground leakage to a very low level.

The Board has also implemented the following measures to conserve water on customers' premises:

(a) Installation of water saving devices such as self-closing delayed action taps, constant flow regulators, spring loaded nozzles, etc. at all non-domestic premises and high-rise residential apartments.

(b) Substitution of potable water with non-potable water such as treated sewage effluent, so called industrial water, rainwater, or sea water for non-potable use in commercial and industrial premises. Currently there are about 56 industrial water users using approximately 867,000 m^3/month of industrial water. Besides that, there are 10 large sea water users using some 11.1 million m^3/day of sea water for cooling purposes. Rainwater is also being used by many companies to replace potable water for toilet flushing and gardening.

(c) Encouragement to industries to recycle or reuse their processed water whenever possible.

(d) Education of the public on the importance of water conservation through exhibitions and

talks on water conservation to schools and both private and public organizations. Water conservation is also included in school textbooks.

In line with the national effort to conserve water, the Economic Development Board (EDB) grants investment allowance incentives to companies which have invested in plant and equipment to conserve substantial amounts of potable water. Taxable income of an amount equal to a specified percentage (up to 50 per cent) of the cost of the plant and equipment are exempt from tax. Setting up of water-intensive industries is discouraged.

F. Summary and conclusion

Singapore with a population of 2.7 million and an area of 620 km^2 has limited water resources. Hence, water conservation and prevention of wasteful use of this scarce resource play a dominant role in ensuring continued supply of piped water. A comprehensive leak detection programme with efficient follow-up maintenance action is absolutely necessary to maintain the high degree of water tightness in the system.

In view of the high degree of urbanization and the various human activities in the water catchments, stringent pollution control measures are enforced. Close monitoring of the quality of stream and reservoir waters and frequent physical surveys of possible polluting activities are carried out. Daily chemical and bacteriological tests are conducted on potable water samples taken from strategic points in the distribution network. All these activities are necessary to ensure a potable water supply in such an urbanized nation as Singapore.

XI. WATER SUPPLY IN THE BANGKOK METROPOLITAN AREA, THAILAND*

A. The establishment of the Metropolitan Waterworks Authority (MWA)

The Metropolitan Waterworks Authority (MWA) was established as a state enterprise under the Ministry of the Interior on 16 August 1967, with the following functions:

1. To explore and locate raw water sources, and procure raw water for waterworks purposes.
2. To produce, distribute and sell water in the Bangkok Metropolitan area as well as in Nonthaburi and Samut Prakan Provinces.
3. To operate other types of business that are relevant or otherwise beneficial to the organization.

B. Developments and obstacles

Water is essential to daily life and demand is ever increasing due to the growing size of the population. The onerous task consistently facing MWA is to strive towards meeting rising demand in the service area, and at the same time expanding the service to cover more parts of the area under its responsibility.

Such undertakings require massive investment. But the general public, in the past, was of the opinion that water supply was a public service the Government should provide for a minimal fee. MWA thus found it difficult to adjust the water rates, allowing them to fall short of production costs for a longtime, and as a result MWA suffered losses for many years.

But development and expansion projects are always indispensable to operations. MWA, therefore, had to seek subsidies from the Government as well as secure loans from both domestic and foreign sources, and it became heavily burdened by debt.

Nevertheless, MWA managed to survive the crisis, and again became a self-sustaining enterprise at the end of the 1985 fiscal year. The remarkable breakthrough was attributed to extensive improvements in efficiency, with the adoption of a new administrative philosophy. In short, the old semi-bureaucratic system gave way to a more streamlined one organized along the lines of the private sector.

C. MWA: the modern era

In every respect it can now be said that MWA has entered a new era of "modern" and "efficient" operations whether these relate to administration, production or service. The enterprise is resolute in its determination to achieve the goals indicated in the slogan "Water supply for the people".

1. Good service

This means rendering service that is convenient, rapid, reliable, courteous, honest and attentive, with regard to the water user; and includes taking care of the welfare of MWA personnel.

2. Good quality

As running water is the only product of MWA, its quality must be controlled to ensure high standards in terms of purity, quantity and pressure; in this respect, modern technology must be utilized more extensively.

3. Good management

This includes good performance with regard to overall direction, administration, the handling of personnel, coordination and public relations, as well as discreet internal auditing and control.

4. Good cooperation

This means cooperation and the willingness among the personnel to maintain and observe the established rules and regulations, and to develop a feeling of devotion and loyalty to the organization.

* By the Metropolitan Waterworks Authority, Bangkok, Thailand.

MWA's main policies read as follows:

To provide the public with sufficient water supply as well as efficient service, whilst, increasing revenue and reducing expenditure to facilitate improvement and the expansion of operations, without becoming a financial burden to the Government.

D. Organization structure

MWA's Board of Directors, appointed by the Cabinet, serves as the top policy-making and supervisory body; with the "Governor" assuming the role of chief executive in charge of the entire operations.

Internally, the affairs of the organization are divided along five main lines as follows:

1. The administrative line

Dealing with general administration to facilitate the operations of other lines; including accounting, personnel management, procurement and inventory control.

2. The service line

Dealing with all kinds of service that concern the consumer, mainly via branch offices; these include fixture installation of new users, water meter reading, revenue collection and pipe repairs, etc.

3. The technical line

Dealing with engineering work including design, the preparation of bidding documents, inspection and control of standards of materials and equipment; as well as supervising the construction of production, distribution and other facilities.

4. The production and distribution line

Dealing with production and distribution; and also control of quality, volume and pressure to ensure the required standards are met.

5. The planning and development line

In addition, there exist several other organs reporting directly to the Governor. They serve the organization in the fields of planning, inspection and follow-up, electronic data processing and public relations.

E. Office and facilities

Apart from the head office at Bangkhen, MWA boasts an extensive network of bureaux and facilities scattered in the area under its authority. The major ones are as follows:

1. For service activities

A branch office in each zone serves as a comprehensive service centre offering consumers every convenience ranging from receiving applications for tap-water service, to payment of fees and charges, as well as other necessary services. At present, there are altogether 10 branch offices.

2. For production activities

The facilities include a raw water intake station at Tambon Samlae in Pathum Thani Province, and a canal about 30 km in length. This canal exists as the main supply line conveying raw water from the intake to three large-scale water treatment plants at Bangkhen, Samsen and Thonburi.

The Bangkhen water treatment plant, which is MWA's main production facility, stands as the largest and the most modern of its kind in South-East Asia. Besides these, MWA has two other small-scale plants located in the suburban areas of Nongchok and Bang Bua Thong. They operate outside the central waterworks systems.

3. For transmission and distribution activities

The transmission system is made up of conduits which bring the water supply produced by the Bangkhen plant to seven distribution pumping stations. The distribution pumping stations then pump the water into the water mains which are connected to distribution and service pipelines that convey running water to the taps on the consumers' premises. The transmission and distribution network, if measured end-to-end, would cover a total distance of more than 13,700 km.

F. Service area and population served

Upon the completion of the "Third Bangkok Water Supply Project", MWA's service area was planned to cover an area of up to 750 km^2. The total volume of water supply in the 1992 fiscal year was expected to reach 1,175 million m^3 with 5.7 million people served, the figures represent 76.3 per cent of the whole population in the 3,080 km^2 area under the jurisdiction of MWA.

G. Production under strict quality control

The raw water used in the production of water supply can be divided into two categories; surface water and groundwater.

MWA obtains surface water from the Chao Phya River at Tambon Samlae in Pathum Thani Province, and conveys it via the canal generally called Khlong Prapa to the water treatment plants.

As for groundwater, this is acquired from a number of artesian wells in various areas of the city. Most of the water from these sources is of good quality, and it is even possible to pump it directly into the pipeline system. Formerly, about one-third of the water supply was from artesian wells, but in 1982, MWA began to reduce the use of groundwater, in compliance with government measures to curb the indiscriminate use of groundwater in order to prevent a land subsidence crisis in the Bangkok Metropolis. MWA has definite plans to terminate the use of groundwater in all critical areas.

H. Water treatment process

The treatment process for surface water consists of four major stages:

1. Preliminary improvement of quality

As the source of raw water is about 30 km north of downtown Bangkok, it is thus far enough away from the city pollution and beyond the reach of saline water from the Chao Phya estuary.

Preventive measures are also taken against any act that may pollute the water in the supply canal. And while the water is flowing along the canal, it becomes naturally cleaner due to the effects of sunlight and aeration.

In certain seasons, the raw water is also conditioned initially by chemicals such as lime, alum and chlorine before undergoing the treatment process.

2. Sedimentation process

The optimum amount of alum (sometimes together with other coagulants) is put into the water while it is entering the clarifier or sedimentation tank. More than 90 per cent of the sediments are removed from the water at this stage, and the clear water flows out of the clarifier through the effluent channel.

3. Filtering process

Fine particles left over from the sedimentation process are held back by a filter bed consisting of layers of sand of various sizes as well as anthracite. In terms of its physical constitution, the filtered water proves to be completely in accordance with the required standards for potable water.

4. Disinfection process

To make the clear water hygienic and safe for drinking, chlorine is put into the water while it is flowing into the storage reservoir. The dosage of chlorine used is normally determined so as to be adequate not only in terms of disinfection but as a further safeguard against contamination when the water is pumped into the distribution system.

I. Water quality control

Inspection, analysis and quality control remain, as always, of paramount importance because MWA realizes that its commitments to the public include providing them not only with a supply of water that is sufficient but also a quality that is potable.

Stringent quality control is undertaken at every stage throughout the production and distribution processes; during the influx of raw water at intakes and in the canal, and during the water treatment process, in addition to which the treated water and the water supply in the distribution system is subjected to rigorous testing. Inspections are made on a regular and continuous basis. For instance, turbidity is gauged every four hours, and chlorine content every hour; the water supply about to be discharged from distribution pumping stations is examined every day. In addition, water samples collected from various spots in the service area are also tested regularly.

As a direct result of strict quality control, the Ministry of Public Health has certified that the MWA's water supply is on a par with the standards set by the World Health Organization (WHO). At present, consumers in areas where old pipelines have been replaced, can drink fresh water immediately at the turn of a tap.

J. Service plays a vital role

1. Service : the key function

MWA is fully aware that its task is not finished merely because the water supply has been produced and distributed to the public. Another of its integral responsibilities is to ensure that the consumers are provided with every conceivable convenience.

From the very first step, when people apply for the use of running water, the regulations and procedures in question have been revised to eliminate red tape. The terms of payment for the application itself have also been made more flexible; for instance, applicants paying in cash will enjoy a 10 per cent discount, and low-income earners can secure loans arranged by MWA to meet this particular need.

2. Convenient means of water fee payment

Normally, MWA sends its officials to collect the fees at the consumers' premises on a monthly basis. The consumer may also pay the fees by means of bank account debit or money transfer via automatic teller machine.

K. Machinery for dealing with urgency

Besides the branch offices which are directly in charge of routine services for consumers in their respective zones, MWA has special service units to deal with immediate problems. This is due to an awareness that water supply is one of life's basic necessities; if anything should go wrong, prompt action must be taken.

There exists a "Water Supply Service Centre" which is open round the clock to receive reports of mishaps, to coordinate activities and follow up on repairs of damaged pipes. Working in close liaison with the Centre is the "Urgent Service Unit".

L. Reasonable water rates

As a state enterprise concerned with the provision of a public utility, MWA policy does not include amassing maximum profits among its aims as do business concerns in general.

The water rates (table 37) are, therefore, based upon the principle that the lowest possible profit is adequate as long as MWA is self-supporting and can go ahead with its expansion schemes in order to cope with the steadily increasing demand for water.

Table 37. Water tariff in Bangkok, Thailand

Category I: Residence

Volume (m^3)	*Rates (Baht/m^3)*
0 - 30	4.00 (But totally no less than 20 Baht)
31 - 40	5.53
41 - 50	5.85
51 - 60	6.18
61 - 70	6.50
71 - 80	6.83
81 - 90	8.00
91 - 100	8.32
101 - 120	8.65
121 - 160	8.97
161 - 200	9.30
201 and up	9.95

Category II : Business, State Enterprise, Government Agency, etc.

Volume (m^3)	*Rates (Baht/m^3)*
0 - 10	50.00 (Package rate)
11 - 20	6.20
21 - 30	6.45
31 - 40	6.70
41 - 50	6.95
51 - 60	7.20
61 - 80	7.45
81 - 100	7.70
101 - 120	7.95
121 - 160	8.20
161 - 200	8.45
201 and up	8.70

M. Personnel : The significant factor

1. Personnel administration policies

MWA firmly believes in the sound managerial principle which regards personnel as the most precious resource within an organization, and the key factor in the accomplishment of the organization's goals and objectives. Thus, MWA adopts a policy whereby its personnel receive reasonable and fair remuneration plus fringe benefits taking into consideration the general criteria adopted by other state enterprises, and its own financial status in any given period.

Furthermore, special care is taken with regard to promotion and the development of employee capabilities. Career development plans are now being implemented for the benefit of employees at all levels, enabling them to make continuous progress in their careers which would coincide with the organization's growth.

2. Personnel training

The MWA Training Centre is in charge of organizing training courses and seminars to raise the expertise, ability and efficiency of the personnel, in accordance with the specific requirements of the various sections.

The training courses are divided into three main types: firstly, orientation sessions for new employees; secondly, refresher courses to acquaint personnel with recent advances in technology and more efficient working methods, and lately, staff development programmes to upgrade proficiency and to prepare personnel so that their competence accords with the organization's expansion plans.

The training methods include both sending the trainees to attend courses offered by outside institutions, as well as inviting competent instructors to organize workshops at MWA. As for study tours abroad, MWA appears to be somewhat different from other establishments. One interesting fact is that the opportunity to attend is not only given to the upper echelon of employees but also extended to junior personnel.

N. The National Waterworks Technology Training Institute

This establishment is the first of its kind in Thailand. The construction of buildings and facilities is already completed in the compound of the Bangkhen water treatment plant.

O. Technology to enhance efficiency

1. Computerization

Computer technology was introduced into MWA's operations in 1970; and has been applied to facilitate many lines of undertaking. They included: water billing and revenue collection, various accounting systems, analyses of water-rates and pipelines, water consumption statistics, personnel information system and inventory control; among other things. Currently, MWA is moving ahead towards the real era of computerized systems, by setting up an on-line network linking all branch offices with the computer centre and its headquarters.

Another significant project, in the meanwhile, is to develop the Mapping and Facilities Information System which promises great benefit to both service and technical operations. The system will offer much more convenience to the public especially when applying for a new installation. Because all branch offices will be able to retrieve all required data, such as maps of existing pipelines and location of the applicant, for immediate planning and estimation of the costs. The quick access to accurate data will also boost efficiency of engineering works; ranging from planning and design to expansion of the distribution system, maintenance and actions to deal with water leakage.

P. Equipment for water leakage detection

A remarkable part of the distribution system is much the worse for wear. The soil is soft and highly corrosive in nature and the land subsidence crisis prevails. These are the reasons why the water leakage in the area records a higher scale when compared with other waterworks systems.

However, MWA has mapped out both short- and long-term plans to tackle the problem, including procuring sophisticated equipment for locating leaks invisible on the ground. The set of equipment comprises various types of tools. To mention a few, the low-frequency sound-wave pipe locator is employed for locating the line of the suspected pipe; while the plunger bar, or iron pipe locator, and non-iron pipe locator can be used for locating both the line and the level of the pipe. When the position of the pipe has been identified; the geophone, a device similar to a stethoscope, is used for detecting the leakage. Later, a water leakage detector and leak noise correlator are normally employed to confirm the discovery, prior to repairs or changes to the pipe, as necessary.

Q. Towards continuity of progress

1. Expansion under the Master Plan

Expansion schemes of a large-scale public utility like MWA certainly entail planning well in advance in order to allow adequate time for procuring all the necessary resources. Normally 2-3 years are spent on the design stage; thus, each project takes at least 3-5 years for completion.

To cope with the water shortage in the long term, MWA has drawn up a 47 year Master Plan embodying improvement and expansion projects to be implemented by phases from 1970 to 2017. So far three major projects involving an investment to the tune of 21,400 million baht have been completed; resulting in an increase of 2.85 million m^3 of water supply per day and an additional 4.4 million people being served. At present, the fourth project

with an estimated investment of 7,200 million Baht is underway. Upon its completion the production capacity will rise by another 400,000 m^3 per day, for an additional 800,000 consumers. By the end of the Master Plan 2017, the total production capacity will reach a record 6.85 million m^3 per day for 13.1 million consumers.

Two-thirds of the investment fund usually go to construction of the distribution system which comprises pipes of diverse types and sizes, corresponding with the volume of demand at each spot on the line between the plant and consumers' residences. As the Bangkok Metropolis is a large city and lacks a definite pattern of growth, it is difficult for MWA to determine the exact size and direction of a pipeline which will remain usable over a longtime. More often than not, the distribution system is subject to changes.

2. Corporate plan

Apart from the long-term Master Plan, MWA also mapped out a five-year Corporate Plan in mid-1991, to set up guidelines for operations between the fiscal years 1992 and 1996. In doing so, MWA became one of the first state enterprises in Thailand to originate plans of this kind.

The MWA Corporate Plan contains a package of clear-cut policies and goals as well as strategic approaches. The Plan is aimed at achieving efficient coordination, effective accomplishment of tasks, and regular evaluation. On a yearly basis, MWA draws up an annual plan to set down the working criteria for inspection, control, follow-up and evaluation.

In the Corporate Plan, MWA has set some remarkable targets as follows:

(a) As regards marketing and service, the number of water-users will be expanded as far as possible, with an annual net increase of no less than 70,000. There are also plans to persuade bulk consumers currently using groundwater to switch to MWA's water supply, so as to prevent, and hopefully, solve the problem of land subsidence.

(b) As regards investment programmes under the Master Plan, several schemes are to be undertaken to cope with the rising demand for water supply. These include the improvement of raw-water supply systems, an increase in production capacity, the improvement and additional construction of transmission and distribution systems, and the construction of a control centre for production and transmission.

(c) The efficiency of MWA manpower will be continually enhanced by maintaining an appropriate ratio of employees to water-users; the target is to adjust the ratio from 1:180 in the 1991 fiscal year to 1:200 by the fiscal year 1996.

(d) As regards water leakage, MWA has plans to reduce the loss of water from 42 per cent of the total water distributed in the 1984 fiscal year to 29 per cent by the fiscal year of 1993.

XII. PROBLEMS OF URBAN WATER SUPPLY AND SEWERAGE MANAGMENT IN UZBEKISTAN*

The region of central Asia and Kazakhstan is now facing an environmental crisis in the Aral Sea basin which covers the basins of the Amu Darya, Syr Darya and Zerafshan rivers. The important aspects of the crisis are shortage of drinking water in some areas and pollution of surface water by herbicides, fertilizers, and industrial scrap, etc. Uzbekistan is situated in the centre of central Asia, therefore, it faces the consequences of anthropogenic load on its environmental system, especially on the drinking water supply.

There are 202 municipal waterworks in Uzbekistan, comprising 198 in urban areas and 4 interregional water pipelines supplying water to cities and rural areas.

Seventy-five per cent of the population are users of the municipal water supply. Seventy-nine per cent of the urban population, 97 per cent of the inhabitants of Tashkent and 60 per cent of those in suburban settlements enjoy this service.

Over past years the quality of water in rivers and reservoirs has sharply deteriorated. The shortage of drinking water and depletion of water resources has dictated the development of water management in Uzbekistan, as follows:

(a) There is a need for the creation of large regional water supply systems which could transfer water from remote areas. Such schemes exist in Bukhara, Navai and Samarkand provinces. For example, the Damhodga water pipeline was commissioned in 1992 in Samarkand province. Its capacity is 70,000 m^3 per day. Water goes through two 168 km long pipelines (d= 1,400 mm) from the Zerafshan aquifers to towns in Samarkand province. In 1993 its capacity will be increased to 300,000 m^3 per day.

In order to improve the quality of the water supplied to the Karakalpak republic and Khorezm province, regional water pipelines were commissioned. They are the Tuyamuyun-Nukus pipeline (length 243 km, d = 1,400 mm, capacity 170,000 m^3/day) and the Tuyamuyun-Urgench pipeline (length 155 km, capacity 200,000 m^3/day). Water being supplied by the pipeline system from the Tuyamuyun reservoir is subject to two treatment stages including chemical treatment, filtration and chlorination.

(b) Local water resources will also be used. In this case, deep treatment and repeated treatment of water will be implemented after construction of new water treatment projects.

(c) Water desalination installations will be used in remote areas. One of them will be commissioned in 1993 in Tahtakupur district in Karakalpakia. All equipment was donated by the German Red Cross Society under its humanitarian aid programme.

(d) Two or three plants for bottling drinking water will be constructed soon in Tashkent or Samarkand provinces. Their capacity will reach 500 m^3 of water per day. At least 300,000 people are expected to buy bottled water. The policies for the water supply development in Uzbekistan are formulated in the documents: "The development scheme of urban water supply and sewerage in Uzbekistan up to 2005" and "The development scheme of rural water supply in Uzbekistan up to 2010".

There are 61 municipal sewerage systems in Uzbekistan and 25 industry-owned sewerage systems. Of the population, 45.6 per cent is served with sewerage facilities. Sewage is mainly treated by mechanical and biological methods. Several large regional sewerage systems will be constructed during the 1990s. They will provide environmental protection from pollution by sewage and improve the sanitary conditions of cities and towns.

* By Erkin Youldashev, Deputy Minister of Housing and Municipal Economy, Tashkent, Uzbekistan.

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