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ОБЗОР ПРОГРЕССА В ОТНОШЕНИИ ВОПРОСОВ, СВЯЗАННЫХ С ВОДНЫМИ РЕСУРСАМИ: РЕГИОНАЛЬНАЯ И ГЛОБАЛЬНАЯ ИНФОРМАЦИЯ О СОСТОЯНИИ ЗАПАСОВ ПРЕСНОЙ ВОДЫ В МИРЕ

Запасы пресной воды в регионе Азии и Тихого океана

Записка Генерального секретаря

В приложении ниже содержится доклад Экономической и социальной комиссии для Азии и Тихого океана о достигнутом прогрессе и возникших трудностях в осуществлении принятого в Мар-дель-Плате плана действий и связанных с водными ресурсами рекомендаций Повестки дня на XXI век, который имеется на представленном языке.

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Приложение

REPORT OF THE ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC ON FRESHWATER RESOURCES

6. The Asian and Pacific region has several of the world's most important river systems. Seven of Asia's largest river systems, namely the Chang Jiang, Huang He, Mekong, Ayeyarwaddy, Brahmaputra, Ganges and Indus, have a total drainage area of more than 6 million km^2, much of which is heavily populated, particularly along their lower reaches. Therefore, the economic development and the welfare of people in this region are very dependent on the progress made in the development and management of its water resources.

7. The most meaningful measure of freshwater resources is the total annual flow of rivers and the recharge to aquifers, that is the annual average amount of renewable water resources. The total volume of run-off on earth is estimated to be between 41,000 km^3 and 46,000 km^3. The share of the ESCAP region in the global run-off is about 12,500 km^3, comprising between 27 and 30 per cent of the total.

8. In the ESCAP region, with the population estimated at 3,323 million, as of the middle of 1995, an overall average per capita availability of water is estimated at about 3,760 m^3 per year. This amount is less than the relevant estimates for the other regions with the exception of West Asia. Naturally, the per capita availability has been decreasing with the growth of population, which is estimated at 1.6 per cent for the region as a whole, with the highest rates of 2.1 per cent in South Asia and 1.8 per cent in South-East Asia. The estimates for changes in water availability per capita by subregion over the period from 1950 to 2000 are presented in Figure 1, offering a general idea of the order of magnitude of and trends in the availability of renewable water resources in the region.

9. Due to rapidly increasing population, by the year 2000, the per capita water availability would be considerably less compared to that in 1950, almost one fourth in South Asia, one third in north China and Mongolia and forty per cent in south-east China. The most critical ten-fold decrease from 7,500 m^3 in 1950 would be occurring in Central Asia, which now experiences a severe water crisis in the Aral Sea Basin.

10. It should also be noted that users can obtain only a part of the renewable water resources from water bodies, owing to the high variability of streamflow between low water and flood seasons, inaccessibility of some water courses, and the lack of storage sites on many catchments. Since a large part of the run-off, occurring in the form of flood flows of relatively short duration, flows out to sea unarrested, the volume of usable flow is substantially less than the total run-off and the renewable water resource. Moreover, a significant part of water resources is available in remote areas of the region where it is impractical and uneconomic to undertake development activities.

INTRODUCTION

1. The present report is submitted to the Third Session of the Committee on Natural Resources in accordance with Economic and Social Council resolution 1994/308, which stipulated that reports by the regional commissions on progress made and issues arising in the implementations of the Mar del Plata Action Plan and the water-related recommendations of Agenda 21, including case studies available from Governments in their respective regions, would be submitted under agenda item 4(a) of the provisional agenda of the Third Session of the Committee.

2. To the extent that information is available, the report endeavours to provide an overview of developments and trends in Asia and the Pacific in response to the Mar del Plata Action Plan and to the relevant recommendations of UNCED as contained in Chapter 18 of Agenda 21. The report is mostly based on information collected by the secretariat and the data provided by some countries in their country reports in connection with various recent activities organized by ESCAP. Some additional information was obtained from other organizations of the United Nations system.

I. GENERAL OVERVIEW

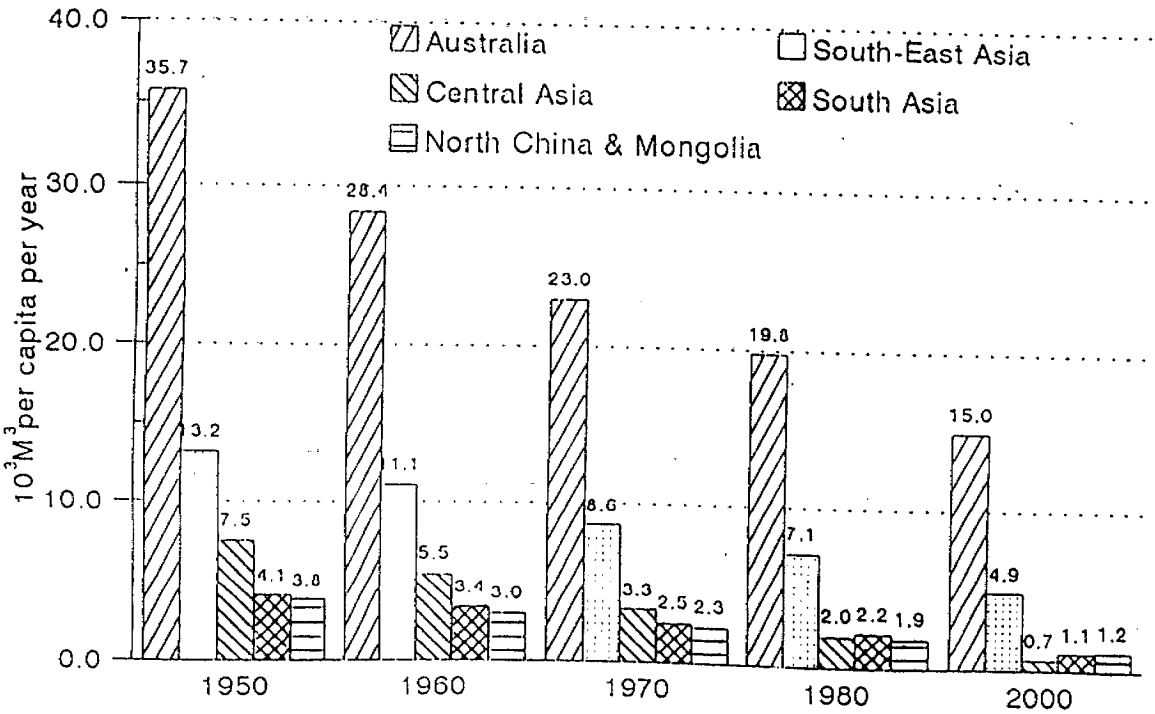
A. Water resources

3. The Asian and Pacific region, as defined at the beginning of 1995, extended over a total area of about 35 million km^2 or 26 per cent of the world's land area. With nearly 60 per cent of the world's population and over 60 per cent of the world's irrigated land, the region is more densely populated and more intensively cultivated than any other region. The region also displays various types of physical features, from arid deserts to the most humid areas of the world.

4. There is an extremely uneven distribution of precipitation over different parts of the region. For example, precipitation is exceptionally abundant on the southern slopes of the Himalayas, on the western slopes of the mountains of India and Indo-China, and on the islands of Indonesia, which receive annually from 1,500 mm to excess of 3,000 mm of rain and in some locations considerably more. On the other hand, almost all the north-western part of the region is extremely dry, with an annual precipitation of less than 200 mm.

5. Moreover, not only is there a sharp difference in the amount of total annual precipitation, but precipitation also varies considerably from one season to another during the year. The rainfall in a large part of the region is characterized by a monsoon climate pattern with very distinctive dry and rainy seasons. During the long dry season, temporary water shortage is experienced in many river basins, while during the rainy season severe floods may cause tremendous damage in the same river basins.

Figure 1: Estimates of water availability in Asia and the Pacific



Source: After Shiklomanov, I.A. The world's water resources. International Symposium to Commemorate the 25 years of IHD/IHP, UNESCO, Paris, 1991

B. Water utilization

11. Although the countries of the Asian and Pacific region have experienced varying rates and patterns of economic development, the region, as a whole, has been the most dynamically developing part of the world with stable overall annual growth rates. This remarkably rapid expansion of many Asian economies accompanied by the population growth has not only raised the standards of living of the people in the region but has also put steadily growing pressure on water resources in many countries in Asia and the Pacific.

12. Water use is increasing rapidly in almost all countries of the region. Rising demand for water from the domestic, industrial and agriculture sectors coupled with the decreased availability of water resources caused by their depletion and degradation has created problems of sustainability of water resources development in many parts of the Asian and Pacific region.

13. The total amount of annual water withdrawal in the ESCAP region is roughly estimated at around 1,500 km^3, or 450 m^3 per capita per year, accounting for about 12 per cent of the regional renewable water resources. It is recognized that availability of water tends to become a limiting factor in national socio-economic development when water withdrawal exceeds 20 per cent of annual total renewable water resources. In several countries, such as Pakistan, Uzbekistan and Turkmenistan, more than half of the total renewable water resources, including transboundary inflows from neighbouring countries, are already withdrawn annually to meet the demands of the national economy. These countries have been experiencing serious difficulties in expanding their sectors of economy that use much of the water, that is irrigated agriculture. In a large number of other countries, the annual amount of water abstraction exceeds 20 per cent of their respective renewable water resources, implying that the scarcity of water may start becoming a limiting factor in national socio-economic development in those countries, as well.

14. In spite of an economic growth throughout the region and sharp rise in urban population, water use in Asia and the Pacific is still dominated by agriculture. About 80-85 per cent of the volume of water abstracted annually in the region is accounted for by mainly irrigated agriculture. Water withdrawal for domestic and industrial uses is currently relatively small in almost all countries of the region with a few exceptions, however, it is rising steadily thus resulting often in conflicts over water allocation with agricultural water uses.

C. State of the aquatic environment

15. In many parts of the ESCAP region, the aquatic environment has been progressively deteriorating mostly owing to over-exploitation of water resources and

their contamination caused by discharges of domestic, municipal, agricultural and industrial effluents without undergoing proper treatment.

16. Since water demand has already surpassed the sustainable yield of existing freshwater sources in many parts of the region, water is often abstracted from such sources at volumes far exceeding their replenishment rates. This is especially relevant to groundwater resources, because the reliance on groundwater has been increasing with the reduction in the potential for developing additional surface water supplies. The remediation of negative impacts of groundwater overpumping such as the lowering of the water table, land subsidence, seawater intrusion into aquifers in coastal zones, deterioration of water quality, etc. usually takes an extended period of time.

17. The heavy pollution load caused by disposal of municipal, agricultural and industrial wastes has exceeded the capacity of a large number of water bodies to accommodate such wastes, and subsequently many rivers have lost their potential as water supply sources for downstream users.

18. In general, the quality of freshwater varies greatly throughout the region. The severity and extent of water quality problems in the ESCAP region is presented in Table 1.

II. REVIEW OF THE PROGRESS

19. The countries of Asia and the Pacific have made great strides in improving the management of their water resources since the adoption of the Mar del Plata Action Plan by the United Nations Water Conference in 1977. The progress achieved in the implementation of the provisions of the Action Plan in the region has been regularly surveyed by the ESCAP secretariat and then analyzed, summarized and reported to the relevant legislative bodies of ESCAP and to the Committee on Natural Resources of ECOSOC.

20. In this section of the report, an additional first attempt has been made to survey also the progress achieved in the implementation of the water-related recommendations of Agenda 21 on freshwater resources, contained in Chapter 18. As only a short period of time has elapsed since UNCED, the implementation levels of the imperatives of Agenda 21 have not yet been comprehensively realized, hence systematized country information on the implementation of Agenda 21 is rather scarce.

A. Integrated water resources development and management

21. The concept of integrated water resources management that implies, as articulated in Agenda 21, a dynamic, interactive, iterative and multisectoral

Table 1. Water quality issues in the ESCAP region

Quality Issues	Indian Subcontinent	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	0-1
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

Source: "Water Quality. Progress in Implementing the Mar del Plata Action Plan and Strategy for the 1990s" 1991. UN Publication.

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.

approach to water resources management and the integration of sectoral water plans and programmes within the framework of national economic and social policy, is gaining recognition within the region. For example, the goal of sustainable development is implicit in the current Eighth Five Year Plan of India (1992-1997), which underlines the significance of ensuring a coordinated and integrated governmental action for conserving nature and ensuring sustainable use of natural resources through a participatory process. In China's Agenda 21, it is recognized that the realization of objectives of other fields of governmental planning becomes increasingly dependent on successful water resources management.

22. In line with the recommendations of the Mar del Plata Action Plan and Agenda 21, most of the countries of the region have adopted or revised their national water policies, reflecting the priority attached to water resources development within the national socio-economic development plans. Thus, in India, the National Water Policy adopted in 1987 aims at planning, developing and conserving the water resources on an integrated and environmentally sound basis, keeping in view the needs of the states concerned. Indonesia undertook a major policy review of its water resources policy during the period of 1991-1994 to meet the needs of development and to accommodate the changing environmental and resource requirements and society's aspirations. The policy review took into consideration the Agenda 21 approach to

deal holistically with water resources management issues and the four main principles of the Dublin Statement. In Pakistan, a comprehensive national water policy is expected to be formulated to provide an appropriate framework for water resources management by 1998.

23. In a number of the countries of the region, national water resources policies have been translated into action programmes or master water plans. The scope of these activities ranges from more sector-oriented plans, such as improvement of water quality, to more comprehensive development plans. Following are some examples from countries in the Asian-Pacific region:

- In Bhutan, a Power System Master Plan (1994) has been formulated to identify a number of possible sites for hydropower plants. These sites have been selected employing technical, economic and environmental criteria.

- In Bangladesh, a National Water Plan II for the period 1990-2010 has been prepared as an updated continuation of the National Water Plan which covered the period between 1985 and 2005. In addition, a Flood Action Plan had been formulated following the catastrophic floods of 1987 and 1988.

- In India, although a comprehensive master plan has not yet been completed, master plans for specific purposes such as irrigation or flood control have been drawn up for a large part of the country. Most of the large states have prospective master plans for irrigation and some for hydropower. Altogether about half of India's land area is covered by master plan activities in one form or another.

- In the Islamic Republic of Iran, the Second Five-Year Socio-Economic and Cultural Development Plan (1995-1999) includes a number of objectives related to the environment and water resources. Also specific targets have been set for various water resources development projects.

- Maldives has developed an action plan in the field of environmental management which gives priority to the development of national policy guidelines concerning wise use of groundwater resources.

- In response to growing concerns over the degradation of the water resources of the country, Pakistan has formulated a water sector investment plan. The main objective of this plan is to identify priorities in the water sectors for investment. The plan also includes such issues as environmental management and public involvement to be dealt with.

24. In several other countries of the region, the preparatory work for the formulation or revision of national action plans has been initiated, often with the assistance from international organizations. In Mongolia, there is the intention to revise the Master Water Plan elaborated in the first half of the 1970s, in order to reflect adequately the new social and economic realities of the country's transition period to a market economy. In Sri Lanka, it is envisaged to formulate an action plan for comprehensive water resources management that will synthesize the results of the subsectoral plans at the national planning level. The action plan is expected to have a positive effect on the quality of investments in irrigation, water supply, power generation and environment protection subsectors, and to strengthen their linkage with national development goals.

25. The concept of management of water resources within a river basin or sub-basin context, facilitating integration of land- and water-related aspects, has been widely applied in the region. In Australia, China and Japan, water management has been already been exercised at the river basin level to a certain extent for a number of rivers of national significance. In India, the national water policy asserts that water resources planning be undertaken for a hydrological unit, such as a drainage basin or sub-basin. In Indonesia, basin institutions for water resources management, including for both planning and operation, have been introduced recently in some river basins, but have yet to become fully functional.

26. Basin-wide approach might be quite beneficial to the management of a large number of transboundary water systems in the region if the riparians could agree to cooperate for formulation and implementation of development plans. For example, Indicative Plan for the development of land, water and related resources of the Lower Mekong basin was prepared in 1970 by the then Committee for Coordination of Investigations of the Lower Mekong Basin, comprising Cambodia, Lao PDR, Thailand and Viet Nam. The Plan was revised in 1987, and at present a number of specific projects identified in the Plan are being implemented under the auspices of the Mekong River Commission, which was set up in April 1995 as a replacement to the above mentioned Committee.

27. In Central Asia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan reached in 1992 an agreement on joint management of transboundary waters in the the Aral Sea Basin, and established the river basin authorities for the Amu-Darya and the Syr-Darya. Rivers, which are the main tributaries of the Aral Sea . These authorities have been entrusted with the main function of allocation of the scarce water resources available to the riparian countries, also taking into account the need to release a specified amount of water into the Aral Sea.

28. There are several other transboundary rivers in the region, where the respective riparian countries undertake jointly development and management activities in the field of water and water-related resources.

29. The old problem of fragmentation of institutional responsibilities for water resources development, management and conservation among sectoral agencies, central and provincial authorities, which had been a major obstacle to the introduction of integrated water resources management, has been alleviated to acertain extent in several countries of the region by creating some institutional mechanisms for coordination. In China, India, Thailand and some other countries, there are interagency coordination committees and groups composed of high ranking representatives of various agencies and ministries dealing with water resources issues. However, the coordination of activities on water resources development, conservation and protection needs further improvement, particularly at lower administrative levels.

30. This is particularly important in the light of the on-going exercise on decentralization of responsibilities in the water sector, which is taking place in several countries of the region. For example in China, the regional rights in the development and management of water resources will be reinforced, and, when possible, city or province governments will be assigned with the appropriate authority to enable direct management of water resources. In India, multidisciplinary units in charge of preparing comprehensive master water plans have been established in some states. In New Zealand, regional authorities have been entrusted with the power and responsibility under the Resource Management Act of 1991, to carry out or oversee all aspects of water management in their respective regions. In Pakistan, the further decentralization of water resources management will be initiated in accordance with the provisions of the country's Eighth Five Year Plan (1993-1998) by transforming the provincial irrigation departments into provincial irrigation and drainage authorities.

31. Although most countries of the region have adopted water legislation regulating to a certain extent the ownership, use and protection of water resources, there is a need in some countries, especially in the countries with economies in transition, to review the existing water legislation in order to incorporate relevant provisions associated with the economic value of water, rational use of finite water resources, protection of the aquatic environment, etc. For example, in Lao PDR, a Water Law has been drafted recently and submitted for approval to the National Assembly. The proposed law aims to streamline policies on water resources assessment, planning, use, quality and protection, and designates a central administrator for water resources management. In Mongolia, the new Water Law that became effective from 5 June 1995, incorporates water management concepts such as water resources development in the context of sustainability, recognition of EIA procedures and some others. In Central Asian states, water legislation is also being revised substantially.

B. Water resources assessment

31. The importance of assessment of surface water and groundwater resources, including their both quantity and quality, has been clearly recognized in Asia and the Pacific as an essential prerequisite to the sustainable development and integrated management of water resources. The inadequacy of information on quantitative and qualitative aspects of water resources for planning and decision-making has resulted

in several cases in overestimation of the potential usable water sources. This situation subsequently led to mislocation of agricultural and industrial projects which are now unable to operate in full capacity due to the shortage of water supply.

32. Throughout Asia and the Pacific, there is an extremely uneven density of hydrometeorological observation networks, ranging from a dense network in Japan to only a few gauges scattered over the vast areas of Tibet and the Himalayas and to the solitary gauge on a Pacific atoll, that makes proper assessment of water resources a very hard task indeed. On the average, in the developing countries of the region the density of network varies from 2000 km^2 to 5000 km^2 per hydrometeorological station, while in Europe this indicator ranges from 140 km^2 to 400 km^2. This is a vastly different level of coverage.

33. In a large number of the countries in the ESCAP region, available information on water resources is still inadequate to satisfy the data requirements of their development activities. For example, Sri Lanka has indicated that the rapid rate of water resources utilization in the country highlights the need for a complete reappraisal of the available water resources and devising a strategy for their future development and conservation to be formulated in a national water master plan. Viet Nam views the lack of reliable hydrological and hydrometeorological information as one of the obstacles in achieving sustainable and environmentally sound development and management of its water resources. In India, a project is planned to be implemented, with World Bank assistance, for undertaking systematic collection and analysis of hydrological data. Mongolia has indicated the need for immediate action with respect to the development of an adequate information system for both its surface water and groundwater, particularly concerning water quantity and quality.

34. In its Agenda 21, China announced that it will undertake studies on water resources assessment techniques, in its efforts to improve the existing hydrological network and add new monitoring stations for groundwater surveying. China will set up at all levels a water consumption accounting system as part of the state's data system. Furthermore, China will publish "The National Report on Water Resources" annually and carry on studies of advanced technologies for water resources assessment.

35. The assessment of renewable groundwater reserves remains a priority task for small islands and in coastal zones, where freshwater aquifers are vulnerable to salt-water intrusion. Thus, in Maldives, where no national assessment of fresh groundwater resources has been undertaken, the lack of environmental and resource information has been identified as one of the main constraints for rational decision-making.

36. There is a serious need for strengthening of coordinating arrangements in the collection and processing of data on water resources and their use. Some countries have an existing body with comprehensive responsibility for water resources assessment, and some are contemplating the establishment of such a body. However, most countries have chosen to strengthen their existing bodies. For

example, in India, the Ministry of Water Resources has set guidelines to standardize procedures for collecting samples from the rivers. Considering the varying interests and responsibilities of the different agencies, it was decided that work at different locations along rivers could continue to be undertaken by the different agencies, but practices would be made uniform so that data from all agencies could be compiled and published together to provide a complete picture of the river systems.

37. In order to support efforts of the countries concerned in the assessment of their water resources potential for meeting the current and foreseeable water demand, ESCAP has prepared in cooperation with the respective national agencies the relevant studies for China, Japan, Myanmar and Thailand. In addition, a guidebook to water resources and water use in 45 countries in Asia and the Pacific will be released soon by ESCAP. The chapter on Malaysia from the guidebook is attached to this paper as Annex.

C. Protection of water resources, water quality and aquatic resources

38. Many countries in the ESCAP region are threatened by the deterioration of the aquatic environment caused by the disposal of inadequately treated, sometimes untreated at all, domestic sewage and industrial waste waters, polluted run-off from urban areas and cultivated land, and by loss and destruction of catchment areas, deforestation and large-scale reclamation of wetlands. The water quality problems obviously vary in different parts of the region owing to a large variety of climatic, hydrological and hydrogeological conditions throughout Asia and the Pacific and different levels of socio-economic development in the countries of the region.

39. Although almost all countries in the region are conscious of the degradation and depletion of their water resources, efforts to protect the quality of the aquatic environment have often lagged behind the pace of population growth and development. National legislation for protecting water resources, water quality and aquatic ecosystems has been available in many countries, but not adequate in some countries, such as Kiribati, Mongolia, Nepal, Niue, Papua New Guinea and Uzbekistan. Moreover, in some other countries, for example, Vanuatu and Tuvalu, such legislation does not yet exist. Institutional frameworks for the protection of the aquatic environment are not available in many countries, and there is no adequate coordination of activities among the agencies concerned with water resources protection in a large number of the countries.

40. In several countries of the region, large-scale and ambitious programmes and action plans have been initiated to rehabilitate degraded waterstreams and depleted aquifers. Thus, in India, the National River Action Plan has been conceived with a view to carrying out pollution abatement works in 14 grossly polluted stretches in nine of 17 major rivers in the country and 14 less polluted stretches in the remaining 8 rivers. Other activities initiated in India for the improvement of water quality include Ganga Action Plan and Scheme of Common Effluent Treatment Plants. In Central Asia, five co-basin countries have approved a long-term programme, supported by the

international community, with the objective to stabilize the environment and improve management of the transboundary water resources of the Aral Sea basin. In accordance with China's Agenda 21, the government will undertake action for the protection of water sources and the aquatic environment to reverse the deterioration and exhaustion of water resources.

41. It is widely accepted in the region that in order to protect the aquatic environment and to increase the availability of freshwater of good quality, the pollution load on water resources should be drastically reduced by proper wastewater treatment, reuse and recycling of domestic sewage and industrial wastewater, introduction of appropriate low-waste water-saving technologies, and strict water quality control on industrial and municipal effluent. However, the enforcement of legal and economic measures, such as permits and regulations relating to wastewater disposal or effluent fees, is not often sufficient throughout the region.

D. Drinking water supply and sanitation

42. Safe water supplies and environmental sanitation are vital for improving living standards and health, alleviating poverty and protecting the environment. Therefore, the water supply and sanitation sector is normally given a high priority in their development efforts by national governments throughout the region.

43. As a result of the large population shifts from rural to urban areas, the priority for the 1990s in the water sector in much of the region is to improve water supply and sanitation in the urban areas of Asia. This includes not only drinking water supply for urban residents, but also water supply for industry, municipal uses and disposal of wastes. 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.

44. One of the concomitant features found in many rapidly expanding cities in the Asian and Pacific region is the tremendous increase in the number of the urban poor, who live mostly in slums and squatter settlements. These areas often do not have the basic necessities of proper water supply and sanitation facilities, and the urban poor suffer the most from the lack of a healthy environment within their homes and their neighbourhoods. Infant and child mortality rates may be considerably higher than the city average and there is a comparable difference in all other aspects of health and social well-being.

45. The lack of an adequate water supply also affects the economic welfare of the poor since people often have to pay for water provided by vendors at prices which may be substantially more than what is paid by customers served by a piped water system in a nearby area.

E. Water and sustainable urban development

46. Industrialization coupled with the growth of urban centres has been a major driving force behind national economic development in the developing countries of Asia and the Pacific. However, industrialization and urbanization have placed 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.

47. 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 remedy the polluting effects of wastewater discharges. However, with the fast growth of urban centres over the last decades, overuse of water resources, stemming 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 contributed to water resources depletion and degradation in a number of river basins in Asia. In 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 at these areas.

48. 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 are starting to reconsider and modify accordingly their current approaches to the formulation and implementation of water resources policies and action programmes.

49. It is becoming increasingly apparent that many of the problems facing urban areas in the water management sector are often basin-wide as the principal source of surface water supply may be located far upstream in the same river basin. Moreover, 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.

F. Water for sustainable food production and rural development

50. In Asia and the Pacific, the sustainability of food production is increasingly dependent on sound and efficient use of water for irrigated agriculture. Approximately one third of the cultivated land in the region is under irrigation. As of 1992, the total irrigated area in Asia and the Pacific was about 150 million ha accounting for nearly 60 per cent of the world's total. Irrigated area in the region has been expanding steadily with an average annual growth rate of 1.1 per cent. It is expected that this rate will continue until the year 2000, whereas the annual population growth rate in the ESCAP region is estimated at 1.6 per cent. Therefore, to meet the growing demand for food, the production efficiency of the existing irrigation lands should be increased mainly through more rational use of land and water resources.

51. In all countries of the region except Singapore, the bulk of water is withdrawn for agriculture, mostly for irrigation. The share of water abstracted for agriculture varies from about 95 per cent of the total water withdrawal in the still predominantly agricultural economies of Bangladesh, Cambodia, Nepal Pakistan and Sri Lanka to around 64 per cent in the industrialized economies of Japan and the Republic of Korea. In China and India, around 84 per cent of total water abstraction is for agriculture.

52. However, the efficiency of irrigation water use is low throughout the region. It is estimated that in most irrigation schemes only about 40 per cent of the water taken into major canals reaches the fields and, owing to incorrect water application practices in the fields, the losses are further increased, in many places leading to waterlogging and salinization of valuable cropland.

53. Therefore, countries of the region are increasingly putting emphasis on improving the efficiency of irrigation water use through modernization of technologies and improvement of existing methods employed in irrigation schemes and rehabilitation of waterlogged and salinized irrigation lands. Expected water savings resulting from a reduction in demand by agriculture could be reallocated to non-agricultural uses which persistently require a larger share of water.

54. For example, in India, the National Water Board of the Ministry of Water Resources has recently finalized the draft of an irrigation management policy for consideration and recommendation by the National Water Resources Council. The policy aims at improving water application efficiency through the use of modern technologies such as drip/sprinkler irrigation and better on-farm irrigation methods. For ensuring improved irrigation efficiency, the need for maintaining irrigation systems at the optimum level has been emphasized, through provision of adequate finances and through changes in the financial arrangements including the linking of finances with irrigation revenues.

55. China, in order to increase its annual food production, has plans to modernize existing irrigation systems, improve water conservation and reclaim waterlogged lands.

56. In Pakistan, where about 10 per cent of the best agricultural land is already affected by salinity, Phase I of the National Drainage Programme (1996-2002) will be launched from 1 January 1996 in order to more effectively combat the problems of waterlogging and salinization on a basin-wide scale. The programme accords priority for improvement of existing drainage systems and better operation and maintenance in the future.

G. Impacts of climate change on water resources

57. It is anticipated that among the most adverse potential impacts of climate change may be its possible effects on the hydrological cycle and freshwater resources and through these on socio-economic activities. The economies of many countries in Asia could be very vulnerable to climate change, because a large percentage of their gross national product still comes from climate-sensitive and water-dependent agriculture.

58. Higher temperatures and reduced precipitation may lead to decreased water supplies and increased water demands, thus putting additional strains on the already fragile balance between water supply and demand in a number of countries. Even in areas where climate change may induce higher precipitation, the rainfall increase may also cause more severe flooding and associated harmful consequences.

59. In its Agenda 21, China announces that it has plans to complete a water survey system which employs new techniques to appraise the effects of climatic changes on flood occurrence and concentration, the economy and environment. Furthermore, China has also plans to formulate appropriate strategies for the forecast and control of the influence of climatic changes on water resources, and adopt effective measures to reduce the negative effects. At the same time, China aims to study the potential influence that the climatic changes may have over regions with high drought and flood occurrences.

60. Any appreciable rise in sea level would pose a definite threat of inundation in low-lying coastal areas in Bangladesh, China, Pakistan, Thailand, Viet Nam and some other countries with flat coastal lands. Small islands are particularly vulnerable to the anticipated sea level rise. For example, in Maldives, 80 per cent of the land area has an elevation of less than one metre above sea level. Hence the government is understandably very concerned about the potential impacts of the climate change on the sea level rise.

III. CAPACITY BUILDING AND MOBILIZATION OF RESOURCES

61. In Asia and the Pacific, the most critical issues for the implementation of Agenda 21 in part related to all the programme areas of Chapter 18 are (i) the inadequacy of existing institutions, in terms of their responsibilities, budgeting, staff training and coordination arrangements, to the requirements stemmed from the relevant provisions of Chapter 18, and (ii) the shortage of human and financial resources needed for achieving the goals of Agenda 21 in the freshwater sector.

62. Although, in a large number of countries of the region some institutional and legal reforms are in progress as presented in section II of the report, more drastic action might be needed soon to ensure integrated management and efficient protection of water resources considering the decreasing per capita availability of water and increasing competition of various users over scarce resource. The delegation of water management functions to lower levels in the process of decentralization leads to the necessity of involving millions of people in water management and protection activities. In response, some countries, such as China, India, Indonesia, Pakistan and Thailand, are undertaking vigorous capacity building programmes in the water sector.

63. In addition, the importance of increasing public awareness about water resources is gaining recognition in the region. Thus, in Japan, the public awareness of the high value of water resources has been promoted by governmental agencies. For example, the National Land Agency organizes various activities and initiates public campaigns aimed at enhancing the public's understanding of the limited availability of water resources and the importance of sustainable water resources development. One of the most prominent campaigns is the Water Week beginning on 1 August of each year which is proclaimed as the National Water Day. In India, Water Resources Day has been celebrated every year during April or May since 1986. Moreover, World Day for Water has been increasingly observed throughout the region on 22 March of each year since 1993. Awareness building activities carried out in connection with this Day are targeted at all groups of urban and rural population. The relevant information has been disseminated through leaflets, newspaper articles and radio and TV programmes.

64. The bulk of funds required for the implementation of the activities proposed in Chapter 18 is expected to come from the national Governments. However, it is obvious that the governmental funds allocated for water resources development, management and protection activities are not sufficient in many countries. Therefore, more attention needs be be given to the improvement of economic efficiency of water supply and irrigation projects, mobilization of resources of the private sector and involvement of communities.

65. For example, economic efficiency of water supply and irrigation projects can be improved by rehabilitating defective systems, reducing wastage and unaccounted for water, recycling and reusing wastewater and improving operation and maintenance. In several large cities in the region, such as Bangkok, Hanoi and Manila, urgent

measures have been undertaken to improve the efficiency of urban water services by mainly reducing the losses from the water supply systems.

66. An important resource, particularly in low-income settlements, is the contribution from local communities. By involving benefiting communities in the development of water supply, sanitation and water pollution prevention facilities and subsequent maintenance and operation of new facilities, the required investments can be reduced substantially. Some experience in motivating communities to take care of the development and management of local water supply and sanitation projects has been gained in China, India, Pakistan and several other countries of the region.

67. The involvement of private companies could reduce the financial burden borne by the governments in the freshwater sector. However, the transition from the government-run services to the private sector involvement might be a lengthy and complicated process, which needs to be planned and executed taking into account the prevailing socio-economic conditions in a particular country. Furthermore, in some countries, particularly in the countries with economies in transition, the local private sector is too weak to be interested in long-term commitments with relatively low rates of capital return. In such cases, foreign companies might be interested in investing in some water supply projects. Some French and British companies have been investing in water supply projects in China, Malaysia and Viet Nam.

Conclusions and recommendations

1. The comprehensive evaluation of the progress in the implementation of the Mar del Plata Action Plan and the water-related recommendations of Agenda 21 has been impeded by the scarcity and fragmentation of the information on relevant activities being undertaken by the countries of the Asian and Pacific region. In order to facilitate the monitoring of the implementation of Agenda 21 in the freshwater sector at the national, regional and global levels, a questionnaire might be prepared for collecting the relevant information from the Governments concerned. The proposed questionnaire can be made compatible with the 1983 questionnaire on the progress in the implementation of the Mar del Plata Action Plan in order to enable the Governments and the United Nations to review on a continuing and comparable basis the overall progress made in the implementation of both the Mar del Plata Action Plan and the water-related provisions of Agenda 21.

2. The awareness about the provisions and objectives of Agenda 21 in the freshwater sector is still inadequate among the governmental officials, the private sector and general public. Therefore, the further promotion of awareness about the water-related recommendations of Agenda 21, particularly at the subregional and national levels, is indispensable for the successful translation of those recommendations into appropriate action.

3. The programmes and activities of the countries concerned in capacity building in the freshwater sector in line with the pertinent recommendations of Agenda 21

need to be supported by the international community in a better concerted way. This is particularly relevant to the countries in transition to the market economy, many of which have only recently become exposed to the assistance from international and bilateral sources.

4. Review and revision of policies, action programmes and plans in the water sector should be carried out on a regular basis in the light of the requirements of Agenda 21 in order to reflect timely and adequately the recent socio-economic changes and current trends in the respective countries and to adjust them accordingly.

5. Urgent action towards the conservation of water resources, heavily polluted and depleted in a large number of areas throughout the region, should be taken in order to achieve sustainable water resources development. Within the framework of integrated water resources management, strong emphasis should be given to measures to increase the efficiency of water use, which is low in various sectors of the economy, particularly in irrigated agriculture, in many countries of the region, through demand management.

6. In order to reduce demand for water, a number of technical and regulatory measures could be introduced, including reduction of water losses, introduction and encouragement of use of water-saving appliances and water reuse. In addition, economic instruments such as charges, subsidies, taxes, fines and penalties should be applied more widely in the countries in Asia and the Pacific.

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Appendix

COUNTRY CASE STUDY

Water Resources and Water use in Malaysia

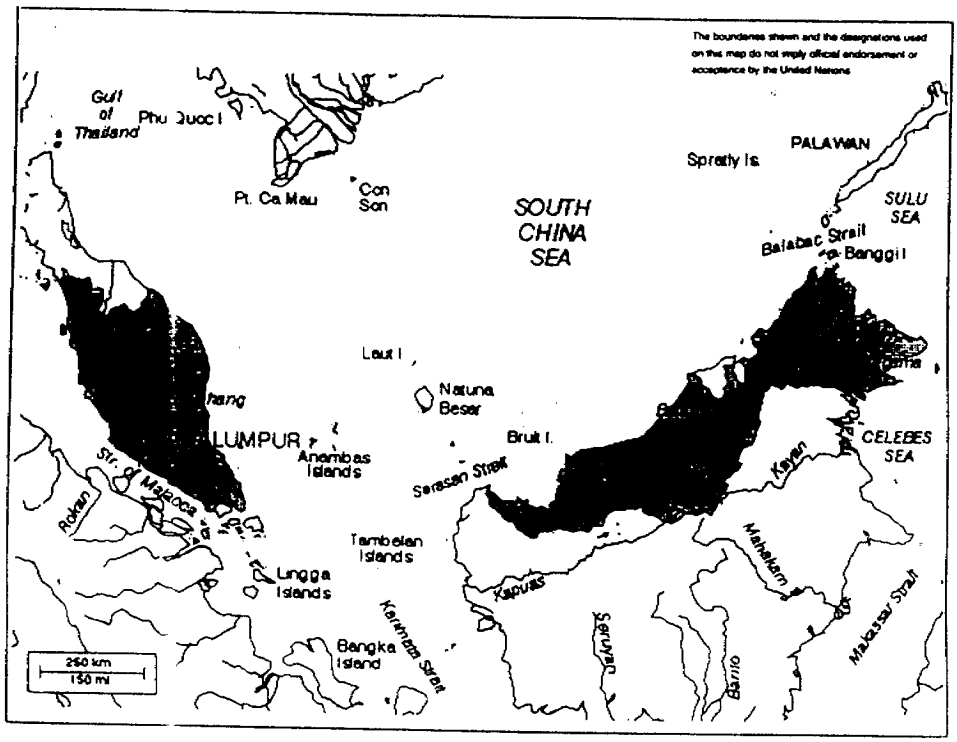

Figure 1. Regional drainage pattern and major surface water features of Malaysia

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This chapter on Malaysia was taken from the ESCAP publication "Guidebook to Water Resources, Use and Management in Asia and the Pacific", Volume One: Water Resources and Water Use, Water Resources Series No. 74, Sales No. E.96.II.F.15, New York, United Nations, 1996.

MALAYSIA

A. GENERAL

1. Physiography

Malaysia is a federation of 11 states in the Malay Peninsula and the states of Sarawak and Sabah on Borneo Island.

Highlands cover a large part of the Malay Peninsula, and more than half of the territory is more than 1,500 m high. Peninsular Malaysia is dominated by a mountainous core, which consists of a series of roughly parallel mountain ranges trending north-south. The most prominent is the Main Range, which extends for more than 400 km. Flat pieces of land are not extensive, and are restricted to between the mountainous core and the coast on either side of the peninsula. The coastal plain is more extensive along the western half of the peninsula, and averages about 50 km in width. Coastal plains on the eastern side are narrower and less continuous. The greatest width of the eastern plain is generally more swampy. The eastern plains are usually sandy, and in places are characterized by the presence of beach ridges. [1]

About 60 per cent of Sabah, on the Borneo Island, consists of mountainous terrains and highlands. Lowlands occur along the coast and major river valleys. The western part of Sabah is dominated by the north-east trending Crocker Range, which encompasses the Mount Kinbulu with an elevation of 4,094 metres. In the south-central part and in part of east Sabah the area is dominated by a series of circular to sub-circular basins ranging from 15 to 50 km across. The greater part of the east coast, including the Bangkoka, Sandakan and Dent peninsulas, consists of low-lying plains and coastal swamps with occasional high ridges. The south-east part of Sabah, comprising the Semporna peninsula, is generally rugged and consists of steep volcanic hills. [1]

Sarawak consists of about 60 per cent of moderately undulating areas. Along the coast, low-lying swamps prevail. Away from the coast most of the areas show a gradual increase in height on the approach to the Sarawak-Indonesian border. In places, mountains rise to more than 2,500 m above sea level. [1]

2. Climate

Peninsular Malaysia is subjected to maritime influence and to the interplay of the prevailing wind systems originating from the Indian Ocean and the South China Sea. It has an equatorial climate with monsoonal influence, and is characterized by constant high temperatures, high rainfall and high humidity. The climate of Sabah and Sarawak is generally of the tropical humid type. [1]

The annual rainfall is high over the entire peninsula, averaging 2,500 mm. The east coast has an average of 3,000 mm, while the driest locality receives about 1,600 mm per year. While there is no specific dry season, the rainfall varies sufficiently at different periods in the year to justify a classification of the rainfall regime into seasons of lesser or greater rainfall. [1]

Rainfall in Sabah ranges from 4,000 mm in the coastal area to 1,500 mm per year in the interior. Sabah experiences two rainy seasons: the south-west monsoon brings rain mainly to the west coast between October and March, and the south-east monsoon brings rain to the east coast from May to August. [1]

The climate of Sarawak is characterized by regular heavy rainfall throughout the year. The mean annual rainfall in Sarawak varies from 3,050 to 4,050 mm. Most of the rainfall occurs during the north-east monsoon, which begins in October and lasts until February. During the south-west monsoon that lasts from April to August, the state receives relatively little rain. [1]

B. WATER RESOURCES

1. Surface water

(a) Rivers and Lakes

Peninsular Malaysia is drained by a dense network of rivers and streams. The year-round precipitation supports a perennial stream flow in most of the rivers. The longest river is the Pahang river, which follows a course of 434 km before reaching the South China Sea. It drains a catchment area of some 29,000 km^2. Other major rivers that also drain into the South China Sea are the Kelantan river, Trengganu river, Dungun river, Enadu river and Sedili river. The major rivers on the west coast drain into the Straits of Malacca, and these include Muda river, Perak river, Kelang river and the Muar river. In general the main streams and the major tributaries are more or less parallel or transverse to the structural grain of the country. [1]

Major rivers in East Malaysia tend to be larger than in Peninsular Malaysia, up to 51,000 km^2 (Rajang river). [2]

Sabah includes a number of permanent rivers. The largest and longest river, the Kinabatangan, follows a course of 550 km before reaching the sea. The second largest river is the Segama, which also drains the east coast just south of the Kinabatangan drainage area. Other major rivers on the east coast are the Labuk, Tungud, Sugut and Paitan, which drain the north-east part of Sabah, and Tingkayu, Kalabukan, Kalumpang and Serudang, which drain the south-east part. Major rivers on the west coast are Padas, Papar, Moyog, Tuaran and Kadamian. [1]

Rivers in Sarawak flow mainly to the north-west. In many cases, meandering rivers flowing through coastal plains have ox-bow lakes. [1]

There are about 150 river systems in Malaysia. They are small when compared to the other large rivers of the world. By virtue of its topography, the streams flowing in the upper reaches of the Malaysian rivers are swift and become slow in the lower reaches. The very gentle gradient in the west coast of Peninsular Malaysia have resulted in large extensions of tidal flats and swamps. [3] A good example of one of the swamp lakes is lake Tasek Bera in Pahang State. The surface area of this lake is 61.5 km^2. While the lake's maximum depth is 7 metres, its average depth is only 2 to 2.5 metres. [4]

Monsoonal floods occur almost every year. However, its severity, location and time of occurrences varies from year to year. The west coast of Peninsular Malaysia experiences flash floods during the inter-monsoon period when convectional storm activities are common. [3]

(b) Inland navigable waterways

Total extent: 7,296 km [5]

(c) Dams, Reservoirs and Hydropower

Number of dams higher than 15 m, by period of completion:

Until 1950:	1
1951-1977:	10
1978-1982:	1

Source: [6]

As of 1988, Malaysia had 36 dams with heights of more than 15 metres.

Large dams over 15 m in height:	36
Large dams over 30 m in height:	19
Large dams under construction:	2

Source: [5]

In 1992, there were two dams with heights of over 15 metres under construction.

Table 1. Major dams with hydro plants

Name	Year completed	River or Basin	Rated capacity now (MW)	Rated capacity planned (MW)	Maximum reservoir capacity (Mm^3)
Kenyir	1985	Trengganu	400	400	13,600
Kuala Yong (Pergau)	1996	Pergau		600	62.5

Source: [7]

Hydropower potential

Gross theoretical hydropower potential (GWh/year):
Peninsular Malaysia: 41,400
Sabah: 11,700
Sarawak: 190,000

Source: [7]

Hydropower Development

Total installed capacity (MW):
Peninsular Malaysia: 1,248 (1991)
Sarawak: 108 (1993)

Source: [7]

Total annual generation (GWh/year):
Peninsular Malaysia: 4,300 (1991)
Sarawak: 614 (1993)
S

Source: [7]

Percentage of electricity generation by hydro (%):
Peninsular Malaysia: 22
Sarawak: 30

Source: [7]

Small Hydropower

Gross theoretical small hydropower potential (GWh/year):
Peninsular Malaysia: 1,062.5
Sabah: 3,530 (preliminary figure)

Source: [7]

Exploitable small hydropower potential (GWh/year):
Peninsular Malaysia: 1,038.5
Sabah: 2,000 (preliminary figure)

Source: [7]

Small hydropower plants in operation:
Peninsular Malaysia: No: 2
Capacity (MW): 9.7
Sarawak: No: 0
Capacity (MW): 0

Source: [7]

Mini and Micro hydropower plants in operation:
Peninsular Malaysia: No: 0
Capacity (MW): 0
Sarawak: No: 7
Capacity (MW): 2.35

Source: [7]

2. Groundwater

(a) Peninsular Malaysia

Groundwater prospects may be broadly grouped into four main categories:

(i) The most promising aquifers are found in Quaternary alluvium, which may yield 25 m^3 per hour if sand or gravel horizons are present. However, in many cases the yield per well exceeds 100 m^3 per hour, as was proven in the alluvium in Kelantan and Trenggau. The alluvial aquifers on the east coast are generally extensive, both laterally and vertically, and are considered to have the highest potential for groundwater development. [1]

(ii) Carbonate rocks may also constitute important aquifers. However, their distribution is more localized. They are restricted mainly to Perlis, north Kedah, Perak, Selangor, and parts of Kelantan. Most of the productive wells are located in the karstified carbonate rocks, in particular in the Permian limestones in Perlis, where yields up to and over 65 m^3 per hour have been exploited. [1]

(iii) Areas that are underlain by complex sedimentary and volcanic rocks are of limited groundwater potential. They are important only locally in that they provide small amounts of groundwater for domestic purposes. [1]

(iv) Granitic rocks outcrop widely. In general they are of limited potential for groundwater development. Some groundwater, however, can be exploited from the weathered or fractured zones. [1]

(b) **Sabah**

The only aquifers of importance are the sandstones in the Upper Miocene sedimentary basins. The sandstone aquifers are extensive and thick and consistent in dip and strike. Individual sandstone beds could be up to 50 m thick and cover several square kilometres. The aquifers are overlain by impermeable shale or mudstone. [1]

(c) **Sarawak** (Government information)

Groundwater prospects may be broadly grouped into three categories:

(i) **Surficial Aquifers:**

These refer to those aquifers occurring within 30 m of the ground surface in areas underlain by the unconsolidated Holocene (Recent) and Pleistocene sediments of the coastal plain. They consist of shallow coastal sands, peat and the sand and gravel facies of marine and riverine alluvium.

The shallow coastal sands are generally barrier sands and some tidal channel sands that fringe a significant stretch of the coastline. These are important sources of water for the coastal communities. The development of the shallow sand aquifers takes into account that they are, in most cases, surrounded and underlain by saline water.

The marine alluvial sands are commonly found in the coastal plains. In many cases they form the "second" aquifers in the coastal fringes and are generally confined. The riverine alluvium are extensive in the upper reaches of the deltas; the sands and gravels in this alluvium are in direct contact with the rivers and are suitable for bank-infiltration schemes for drawing large volumes of water for urban supplies.

Peat underlies about 2 million hectares of the coastal plain, and more than 50 per cent of these peat have thickness greater than 3 m. It holds a very large volume of water in storage, estimated at greater than $2.24 \times 10^{10} m^3$. The ground-water from the peat sustains the rivers and streams flowing out of the peat swamps during the dry seasons, and these are important sources of water for the more than 20 coastal water supplies that caters for nearly 100,000 people.

(ii) **Deep Aquifers in Sedimentary Basins:**

Several major sedimentary basins with groundwater potential occur in Sarawak and notable among these are the rock formations in northeast Sarawak. The formations include the Tukau, Lambir, Miri, Liang and Belait Formations. The

flow characteristics in these formations are dominated by porous flow. Groundwater is presently withdrawn from the Tukau Formation as a supplementary source for the Miri Water Supply. A typical well located in the sandy facies of this formation yields up to 3,000 kilolitres per day of water; the wells located in the clay (tidal) facies yield between 1,000-2,000 kilolitres per day.

The noteworthy sedimentary formation with dominant porous flow in central Sarawak is the sandy facies of the Nyalau formation in the Nanga Merit region. In west Sarawak, thick friable sandstone layers have been encountered in the Silantek Formation and these have in some instances been exploited for groundwater.

Deep aquifers are also found in Quaternary sediments in the coastal plains of Sarawak. The hydrogeology of these sediments is complex and based on the exploratory boreholes drilled, some to depths of 160 m at Kuala Baram, Kuala Tatau, Balingian, Mukah, Oya, the Rajang Delta and Asajaya, the probability of locating extensive freshwater aquifers in these sediments in the near-shore areas is limited.

(iii) **Fractured Rock Aquifers:**

Fractured rocks occupy more than half the state of Sarawak. The aquifers in these rocks are seldom extensive and normally only locally important. Their yields, except in limestone areas, are also usually smaller than the other aquifer types. Many wells are tapping water from the fractured rocks; in the Kayan Sandstone at Matang the wells have yields ranging from 150-250 m^3 per day. The wells in the indurated shale-sandstone sequences of the Pedawan Formation have yields of between 35-360 m^3 per day. Those boreholes penetrating the limestone lenses of this formation have significantly larger yields. One of the characteristic structural features of the rocks of the Serin Arkose Member of the Sadong Formation is the fine, closely-spaced joints. Wells located in this rock formation have consistently yielded volumes between 210-345 m^3 per day.

Fractured rock aquifers offer further scope for the development of groundwater in Sarawak, especially low to moderate yields for domestic, agricultural and industrial water requirements in the rural areas.

C. WATER QUALITY AND WATER POLLUTION

1. Surface water quality

Water quality is deteriorating badly in many rivers because of economic development, logging, urban effluent, etc. [2]

Generally the quality of rivers in Malaysia has been good, except where they pass near populated areas where they get polluted. Contributing factors to raw water pollution in Malaysia have been identified as follows:

From the point of view of raw water quality, the principal contributory factors to pollution of the water have been mainly due to:

(i) Soil erosion and stream siltation during changes in land use, caused by deforestation for agriculture/oil palm development, has created tremendous ecological changes in the rivers basins' water quality and also the depletion of dry-weather flows;

(ii) Development of agro-based industries, e.g. palm oil mills, rubber factories etc., has caused discharge of effluents. Although governed by legislation, this has contributed to degradation of streams, e.g. low dissolved oxygen, high dissolved solids from palm oil wastes, pesticides and herbicides dus to pest control usage in the plantations, nutrients from fertilizers and oil/grease from palm oil wastes;

(iii) Development of townships with no proper sullage and sewage treatment, although most of the new townships are provided with pour-flush latrines/septic tanks, but with no adequate soakaway pits. This has caused discharge of waste water flows high in BOD and suspended solids. [8]

The licencing of prescribed premises (mills and raw natural rubber factories) has proved in significantly reducing BOD load over the past 16 years since the regulations came into force. The percentage of BOD load reduction increased from 70 to 99 per cent from 1978 to 1982 and it is maintained from 1982 onwards at approximately 99 per cent. To date only 10 per cent of total organic pollution could be attributed to both agro-based and manufacturing industries and 90 per cent is from the domestic and animal wastes. In terms of actual loading, it has been estimated that on the average the agro-based industries are generating some 28 tonnes per day of BOD load. (Government information)

2. Groundwater quality

In Peninsular Malaysia, the quality of the groundwater is largely dependent on the geological environment in which it is found. Shallow groundwater is widely used by the rural population, and is chemically acceptable for most uses except on occasions when the iron content may be higher than desirable. On the other hand, some local bacteriological pollution may be present. Deeper groundwater, while presumably free from bacteriological contamination, usually has a high iron content also. Water from sedimentary terrain is usually safe for drinking after minimal treatment. Groundwater from granitic areas is usually suitable for various uses. [1]

The groundwater in Sabah, from Sandakan and Labuan is of good quality, clear and odourless. Solids are mainly inorganic salts (sodium chloride). Some faecal pollutants are encountered in Sandakan.[9]

In Sarawak, the groundwater in the surficial aquifers generally requires treatment to remove iron and manganese except along some narrow strips of higher beach ridges. The quality of the groundwater is also influenced by connate waters and by the inflow of water from the adjacent formations, principally the peat and the underlying marine clays, which contribute to the increased colour, salinity and odour of the groundwater. In the case where water is drawn directly from the peat aquifer, the water generally requires treatment to remove the colour, iron and acidity.

The quality of water in the Tukau Formation is of low salinity and neat neutral pH; the values of iron and manganese are, however, slightly elevated. Similar quality water can be expected from the other deep sedimentary rock formatins in northeast, central and west Sarawak. The deep aquifers in the Quaternary sediments in the coastal fringes are characterised by moderate to high salinity water with high iron and manganese values.

The quality of water from the fractured rock aquifers are good except that the iron values are just slightly higher than the WHO maximum permissible level.

In most cases groundwater used for the major municipal water supply schemes is of acceptable quality, and the raw water is amenable to conventional treatment processes. [10]

While deeper aquifers are relatively safe from contamination from human activities, the shallow aquifers are more vulnerable, particularly in well fields within areas of high population density and industrial development. in the past there have been isolated reports of groundwater degradation due to indiscriminate industrial effluent discharge in which shallow wells were affected. However, such cases are not very common and usually of a localized nature. [10]

Groundwater deterioration owing to human activities remains at a manageable level at present. However, because of increasing urbanization and industrialization, as well as intensified agricultural practices and increased groundwater abstraction rates to meet higher demand, the problems of water quality degradation can be expected to rise. Particularly vulnerable will be areas with shallow unconfined aquifers such as in the Kota Bharu area, or in the heavily industrialized Klang Valley in Selangor at Peninsular Malaysia. [10]

D. WATER AVAILABILITY PATTERNS

Malaysia receives an annual average of more than 2,500 mm rainfall, mainly due to the Southwest and Northeast monsoons. The country is therefore rich in water resources when compared to other regions of the world. The above average annual rainfall, when translated into volumetric quantities on the total land area of the country, leads to a total of water resources of some 990 km^3 per year. Out of the above total resources, it is estimated that some 360 km^3 (or 36 per cent) return to the atmosphere as a result of evapotranspiration, 566 km^3 (or 57 per cent) appear as surface runoff, while the remaining 64 km^3 (or 7 per cent) contribute to the recharging of the aquifers. [11]

Annual Renewable Water Resources

Annual internal renewable water resources:	566.0 km^3	[12]
Exploitable groundwater potential:	23.2 km^3/year	[4]
Annual renewable water resources per capita (1990):	31,851 m^3/year	[12]

E. WATER USE PATTERNS

1. Water Use by User Sector:

Annual water withdrawal (1990):	Total:	11.6 km^3 [12], [11]
	Per capita:	653 m^3 [12]
	Domestic:	10 per cent [12]
	Industry:	13 per cent [12]
	Agriculture:	77 per cent [12]

(a) Domestic Water Use

Public water supply serves the majority of the population. Urban systems are often overloaded, and rural supplies experience difficulty in access to water sources. [2]

Water supply and sanitation

Table 2. Urban and rural water supply

Coverage	1980		1990	
	Urban	Rural	Urban	Rural
Population covered (thousands)	4,130	4,370	7,025	7,090
Percentage of Total	90	49	96	66

Source: [13] and [14]

Table 3. Urban and rural sanitation

Coverage	1980		1990	
	Urban	Rural	Urban	Rural
Population covered (thousands)	4,595	4,850	6,857	10,019
Percentage of Total	100	55	94	94

Source: [13] and [14]

Urban water supply and use:

Water supplied by water utilities:

City:	Kuala Lumpur	Penang
Population:	1,145,075 (1991)	1,200,000 (1992)
Population served:	1,145,075	1,232,042
Av. daily production:	360,000	500,000 m^3/d
Groundwater:	0 per cent	0 per cent
Surface water:	100 per cent	100 per cent
Annual water use:	131.4	182.5 Mm^3
Per capita consumption:	222 l/c/d	203 l/c/d
Domestic:	32 per cent	50 per cent
Industrial/Commercial:	21 per cent	28 per cent
Other:	10 per cent	0 per cent
Unaccounted for water:	37 per cent	22 per cent

Source: [15]

(b) Agricultural Water Use

Almost all of the irrigation schemes utilize surface water. Use of groundwater is negligible. [16]

Irrigated area (1,000 ha):

Year:	1970	1975	1980	1985	1990
Irrigated land:	262	308	320	334	342

Source: [5], [17]

Average annual growth of irrigated land (1980-1990) was 0.7 per cent.

2. Water Use by Source

Groundwater supply: 25 per cent
Surface water supply: 75 per cent

Source: [10]

(a) Surface water

The existing piped water supply schemes are, with a few exceptions, using surface water sources. [1] Almost all of the irrigated lands utilize surface water sources. Similarly, industry uses more surface water than groundwater.

(b) Groundwater

Groundwater utilization:

Domestic and/or Municipal:	60 - 65 per cent
Irrigation:	5 per cent
Industry:	30 - 35 per cent

Sources: [4], [10], [16]

In Peninsular Malaysia, groundwater is utilized mainly for domestic supplies, with lesser amounts developed for industrial needs. Groundwater is not used significantly for agriculture. [1]

Groundwater is developed for domestic purposes mainly in rural areas, largely from driven or dug wells. More than half of the rural population rely on shallow wells for their water supply. [1]

Municipal water supply systems in several large towns in Kelantan, namely Kota Bharu, Tumpat, Pengkalan Cepa, Tanjong Mas and Bachok are dependent on groundwater sources. In Sabah, the major towns, Sandakan and Labuan, depend partly on groundwater. Several industries in these two towns draw their supplies from groundwater sources. In Sarawak, the use of groundwater is not very extensive.

Groundwater is also being used for agricultural purposes. The Department of Irrigation and Drainage has initiated several schemes in Kelantan in which groundwater is used conjunctively for irrigation purposes. Groundwater has also been used on a limited scale for aquaculture. [10]

Industrial use of groundwater is concentrated mainly in the major industrialized zones, such as the Klang Valley, in Selangor. [10]

F. WATER DEMAND PROJECTIONS

The total water requirement for the year 2000 was estimated as 14.2 km^3, considering a 2.3 per cent increase in population per year, on the average 11 per cent increase per year in industrial water demand, and 0.7 per cent in irrigation water demand between 1990-2000. The domestic/ municipal demand would be 10 per cent, industry 22 per cent, and irrigation 67 per cent of the total water demand in the year 2000. [9], [17], [18], [19]

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