PROCEEDINGS OF THE SEVENTH SESSION OF THE COMMITTEE ON NATURAL RESOURCES

WATER RESOURCES SERIES
No. 54

UNITED NATIONS

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Economic and Social Commission for Asia and the Pacific

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FOREWORD

This publication is presented in three parts: part one consists of the report of the seventh session of the Committee on Natural Resources of the Economic and Social Commission for Asia and the Pacific (ESCAP), which was held at Bangkok, Thailand, from 30 September to 6 October 1980; part two contains the working and technical papers presented by the secretariat; and part three contains information and technical papers submitted by Governments.

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.

The views expressed by individual authors are their own and do not necessarily reflect the views of the United Nations.

In the presentation of data in tables in the text, the use of a dash (—) indicates nil or a negligible amount, and the use of leaders (...) indicates that no data were available when the table was being prepared.

National currency equivalents for countries included in the publication

Country	*Currency and abbreviation*	*Unit of currency per United States dollar (period average)*		
		1978	*1979*	*1980 (Jan. – Sept.)*
Australia	Australian dollar ($A)	0.874	0.895	0.885
Bangladesh	Taka	15.016	15.552	15.218
India	Rupee (Rs)	8.193	8.126	7.887
Indonesia	Rupiah (Rp)	442.05	623.05	627.07
Japan	Yen (Y)	210.41	219.41	232.10
Malaysia	Ringgit	2.316	2.188	2.160
Nepal	Nepal rupee (NRs)	12.083	12.000	12.000
New Zealand	New Zealand dollar ($NZ)	0.963	0.971	0.975
Pakistan	Pakistan rupee (PRs)	9.900	9.900	9.900
Papua New Guinea	Kina (K)	0.708	0.712	0.677
Philippines	Peso (P)	7.366	7.378	7.492
Republic of Korea	Won	484.00	484.00	592.80
Singapore	Singapore dollar ($S)	2.274	2.175	2.156
Sri Lanka	Rupee (SRs)	15.608	15.569	16.208
Thailand	Baht	20.336	20.419	20.439

Note: Conversions given show market rate/par or central rate taken as a monthly average in the market of the country.

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Part One

REPORT OF THE SESSION

I. ORGANIZATION OF THE SESSION

1. The Committee on Natural Resources held its seventh session at Bangkok, Thailand, from 30 September to 6 October 1980.

Attendance

2. The session was attended by representatives of the following ESCAP member countries: Australia, Bangladesh, Burma, China, Democratic Kampuchea, France, India, Indonesia, Japan, Malaysia, Mongolia, Nepal, Netherlands, New Zealand, Pakistan, Philippines, Republic of Korea, Samoa, Sri Lanka, Thailand, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, United States of America and Viet Nam. Representatives of the Federal Republic of Germany and Israel also attended, in accordance with paragraph 9 of the terms of reference of ESCAP.

3. Three delegations reaffirmed their position as stated at the thirty-fourth session of the United Nations General Assembly and at the thirty-sixth session of the Commission, concerning the representation of one delegation. The delegation concerned and another delegation protested and rejected that position and reaffirmed the right of that delegation as confirmed by the decision of the General Assembly at its thirty-fourth session and drew attention to the decision taken at the thirty-sixth session of the Commission concerning which there had been no change.

4. The following United Nations bodies and specialized agencies were represented: United Nations Children's Fund (UNICEF), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO), International Labour Organisation (ILO), Food and Agriculture Organization of the United Nations (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO) and World Health Organization (WHO). The Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP), the Interim Committee for Co-ordination of Investigations of the Lower Mekong Basin, the International Commission on Irrigation and Drainage (ICID) and the International Council of Women (ICW) were also represented.

Opening of the session

5. In the absence of the Executive Secretary of ESCAP, the Deputy Executive Secretary opened the session.

6. In his message, the Deputy Executive Secretary pointed out that although water was frequently referred to as man's most valuable resource, society often wasted it, polluted it and treated it as if it were a worthless and abundant commodity. However, with the increasing and competing demands on existing water supplies produced by expanding population and increasing economic activities, society should be made aware of the value of water and of the need to conserve it and use it wisely.

7. The session provided an excellent opportunity to propose and discuss ways of improving policies, both national and regional, dealing with the protection, development and use of water resources to achieve the optimum contribution to the welfare of the people in the ESCAP region. In that connexion, he mentioned the elements of the Commission's regional input into the international development strategy for the 1980s relevant to the deliberations of the Committee. He requested that the Committee keep those elements in mind in reviewing the past, and considering the future, activities of the secretariat in the field of natural resources development.

Election of officers

8. The Committee elected Mr. Sunthorn Ruanglek (Thailand) Chairman, Mr. M. Munir-uz Zaman (Bangladesh) and Mr. I. Samarawickrema (Sri Lanka) Vice-Chairmen and Mr. Mardjono Notodihardjo (Indonesia) Rapporteur. It also elected Mr. S.M.H. Bokhari (Pakistan) Chairman of the Drafting Committee.

Adoption of the agenda

9. The meeting adopted the following agenda:

1. Opening of the session
2. Election of officers
3. Adoption of the agenda
4. Activities of member countries in the appraisal, development and management of water resources
5. Rural community water supply and rural sanitation in relation to over-all management of water resources
6. Integrated optimum development of the deltaic and upland portions of a river basin

7. Industrial water use in relation to the overall management of water resources

8. Activities of ESCAP in the appraisal, development and management of natural resources
   - (a) Water resources
   - (b) Energy resources
   - (c) Mineral resources
   - (d) Remote sensing, surveying and mapping

9. Activities of other international bodies in the appraisal, development and management of water resources

10. Programme of work and priorities in the appraisal, development and management of natural resources, 1980-1981, programme changes; and consideration of the programme of work and priorities, 1982-1983
    - (a) Water resources
    - (b) Energy resources
    - (c) Mineral resources
    - (d) Remote sensing, surveying and mapping

11. Revision of the terms of reference of the Committee on Natural Resources

12. Consideration of the agenda and arrangements for subsequent sessions of the Committee

13. Other matters

14. Adoption of the report

II. ACTIVITIES OF MEMBER COUNTRIES IN THE APPRAISAL, DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

(Agenda item 4)

10. The Committee had before it secretariat background document E/ESCAP/NR.7/1, entitled "Review of water resources development in the region", and nine country papers.

Activities undertaken by countries since 1977

11. In recent years, Australia had placed much emphasis on the development of a national approach to water resource management, identifying important basic principles and goals. It had undertaken a review of the most efficient and rational directions in the collection and analysis of water resources data; a number of representative river basins had been comprehensively covered with a network of measuring devices and studied; problems in the collection of data on water use had received increased attention; much effort had been devoted to studies of flood mitigation options for various localities, to mapping flood-prone areas and to the implementation of flood mitigation strategies; and salinization in certain areas had been recognized as a national problem.

12. Bangladesh had launched the second five-year plan (1980-1985) which envisaged an increase in annual cereal production from 13 to 20 million tons during the plan period, with the improvement and extension of irrigation facilities. The total irrigated area had increased from 1.16 million ha in 1978 to 1.48 million ha in 1980. Most of the flood control, drainage and irrigation projects were labour-intensive, with emphasis on small-scale and quick-yielding schemes.

13. By the end of 1979, China had built 84,000 reservoirs with a total storage capacity of 400 billion m^3. There were 2.1 million power-operated wells for agricultural production and the total irrigated area had reached 47 million ha, covering 48 per cent of the total farmland. The total installed capacity of large and medium-sized hydroelectric power-plants had reached 17 million kW, while more than 90,000 mini-sized hydro plants with a total capacity of 6.3 million kW had been built to serve rural areas. In the past 30 years many large multipurpose projects had been undertaken to harness major rivers, such as the Yangtze, Yellow, Huai and Hai rivers. Embankments with a total length of 168,000 km had been built.

14. Until December 1978, Democratic Kampuchea had carried out the construction of various water projects, covering an area of 2.5 million ha of rice land throughout the country around the Tonle Sap and along the valleys of the Mekong and Bassac rivers. Rural areas were supplied with water, using both surface water and ground water to meet the needs of the population.

15. Viet Nam, Mongolia and the Union of Soviet Socialist Republics protested against the statement made by the delegation referred to in the previous paragraph.

16. China reiterated its consistent position on the issue.

17. From 1977 to 1980, the total irrigation potential in India was increased by 14.23 million ha. For better utilization of irrigation facilities, 43 command area development authorities had been set up, which covered 76 irrigation projects with an area of 15.13 million ha. India had also formulated plans for a national perspective of water resources and for the interbasin transfer of national rivers. The flood damage in 1978 amounted to $US 1,842 million. The expenditure on flood control in 1978/79 and 1979/80 was $US 217.7 million and 195 million respectively. The total length of the dykes in 1978 was 11,870 km.

18. Indonesia had made good progress as a result of the national five-year development plan, reflected by the following figures: irrigation area, 5.29 million ha in 1979; cereals production, 26.96 million tons in 1978; hydroelectric power generating capacity, 510 MW in 1979; urban water supply, 36 per cent of the population in 1979; reasonable access of rural water supply, 18 per cent in 1979. Substantial progress had been made in environmental monitoring, based on the Global Environmental Monitoring/Water Operational Guide of UNEP/UNESCO/WMO.

19. In 1979, Malaysia had initiated a national water resources study which covered all aspects of water resources planning, development and management, and would include an optimum plan for water resources use and development until the year 2000. Since 1977 the main areas of emphasis had been: improvement of water resources assessment; provision of irrigation and drainage facilities; promotion of fish culture; provision of domestic and industrial water supply; provision of flood warning and mitigation projects; development of hydropower through multipurpose dams and mini-hydro plants; provision of sewage systems in urban areas; development of ground water for rural water supply and upland irrigation; reduction of waste in domestic and industrial water use; and training.

20. In Mongolia, there were about 50 operational irrigation systems of various sizes. In recent years extension measures aimed at nature conservation were being implemented, particularly along the major water arteries of the country.

21. In New Zealand, five new irrigation schemes cover-
rural water supply schemes covering an area of 260,400
ing an area of 21,050 ha had been started and 23 new
ha had been initiated in the three-year period 1977-1980. The hydropower generating capacity increased from 3,362 MW to 3,786 MW over the same period. Ten local authority schemes, totalling 119 MW, were under construction by August 1980. Completely satisfactory public water supplies reached about 82 per cent of New Zealand's population. Technical support was extended for: flood forecasting and data collection; long-range forecasting of average annual rainfall; frequency distribution maps of high intensity rainfall; and water quality measures.

22. In Nepal, a large number of irrigation and hydropower projects had been under investigation or had been implemented in recent years. An increase of the irrigation area by 1.5 to 2.0 million ha and also 60 MW of power was contemplated within the next five years. Land slides and soil erosion had become serious problems, especially in the mountainous regions. The Department of Soil and Water Conservation had been established. An afforestation programme had been initiated and engineering measures undertaken to remedy the problems.

23. In an effort to solve major problems in water management, such as salt water intrusion, waste water disposal, etc. the Netherlands had carried out a major policy analysis of the water management of the country. Some measures to solve those problems included: new infrastructural works in the delta; construction of waste water treatment plants financed by taxes on pollution discharges; improved management of existing infrastructure facilities; and new legislation, including pricing and regulations, to allow more rational management of water quality and quantity. The Policy Analysis for the Water Management of the Netherlands (PAWN) was not a single big model, but a set of models and submodels arranged by sectors (agriculture, industry, power, environment and navigation).

24. Pakistan had launched its current five-year plan in 1978, keeping in view the resolutions of the Mar del Plata Action Plan. That Plan had laid maximum emphasis on conservation of developed water resources, elimination of waterlogging and salinity, flood protection, and had provided for the extension of safe drinking supplies to 81.5 per cent of the urban and 35.8 per cent of the rural population. The five-year plan envisaged modernization of water systems and improvements at the farm level to increase the economic efficiency of the developed water resources. As compared with the original provision of PRs 20,410 million for the implementation of the plan, the proportional availability of funds was less during the first three years and the physical targets had been reduced accordingly.

25. By 1976, the Philippines had integrated all its former legislation on water resources into the Philippine Water Code, which declared that all waters belonged to the State and that permits were required for the drilling and abstracting of ground water and surface water. As for water supply, users must own, operate and maintain their own water supply systems. Except for Metropolitan Manila, government agencies had been formed to help the local associations technically, financially and institutionally, but not to main-

tain and operate the systems. Irrigation had been organized on two levels: the National Irrigation Administration had established large systems, while the Farm Systems Development Corporation was helping farmers to run the small systems. The National Water Resources Council was responsible for the integrated and rational development and management of the water resources of the country.

26. The Republic of Korea had drawn up plans for the development of four major river basins serving an area of 62,762 sq km, or 64 per cent of the country's total area. The programme, which cost $US 1.1 billion, included the construction of 13 multipurpose dams, improvement of irrigation for 215,000 ha, water supply to 79 cities, industrial water supply and drainage. The programme was one of the major components of the country's fourth five-year plan (1977-1981). Erosion control and afforestation programmes would also be introduced during the plan period.

27. In Samoa, the major developments in water resources had been in power generation, water supply and sanitation. Water supply service to the public was generally poor and insufficient. With external aid, 30 pumping units had been set up since 1977 in rural areas, serving 25 per cent of the population. The quality of pumped water to households was generally good but salinity was a problem. Surface-water supplies were generally contaminated; the first urban water treatment plant had recently been completed in Apia and could treat 2 million litres per day for 3,000 to 4,000 people.

28. The Government of Sri Lanka had made great efforts in the development of the Mahaweli Ganga basin. The master plan consisted of a system of 15 multipurpose dams and associated trans-basin diversion canals for the provision of improved irrigation facilities to serve 100,000 ha and for the development of 256,000 ha of undeveloped lands in the northern and eastern parts of the country's dry zone. The total proposed installed capacity of the hydro plants amounted to 960 MW. Under an accelerated programme of implementation, many reservoir projects had been investigated and brought to an advanced stage, while construction under the Victoria and Maduru Oya Reservoir projects was started in 1980. In addition, irrigation and drainage programmes in other areas of the country were being actively implemented, with particular emphasis on projects with short gestation periods.

29. The United States had prepared three reports of interest to the Committee. The first report, **Global 2000 Report to the President,** predicted that water shortages would become more severe and water supplies in developing countries increasingly erratic as a result of deforestation. The second report, **The World's Tropical Forests,** discussed the linkage between water resources and deforestation, particularly in developing countries. The third report, **The Nation's Water Resources,** assessed the water resources of the United States from 1975 to 2000, and presented nationally consistent current and projected water use and supply information.

30. In the USSR, during the three-year period 1977-1979, an area of 2.36 million ha of irrigated land and 2.27 million ha of land under drainage had been brought into use. The irrigated and drained lands accounted for 10 per cent of the cultivated land and 32 per cent of agricultural production (in monetary terms) in 1979. Great attention had been given to prevention of water pollution, recycling and reuse of industrial water, construction of water treatment plants and rating of water use. Special attention had also been given to the construction of regional water supply systems from precast reinforced concrete.

31. Viet Nam laid stress on the development of surface- and ground-water resources for industry, agriculture, hydropower generation and rural community water supply. High priority was given to expanding the area under irrigation and drainage in order to increase rice production. Furthermore, the country was trying to reduce the intrusion of saline water in the agricultural areas close to the coast. Other efforts were concentrated on the development of the Red River and Mekong basins, a regional system of flood protection; development of hydropower potential; improvement in the quality of drinking water; development of fish farming; and co-operation in training and technology transfer.

Information and experience on measures taken specifically in response to the Mar del Plata Action Plan and the problems encountered in carrying out the recommendations of the United Nations Water Conference

32. In India, the recommendations of the Conference had been circulated by the Government to the various State Governments in May 1977. The progress on follow-up action had been reviewed at the Conference of State Ministers of Irrigation held in November 1977 and it had been resolved that the various relevant measures suggested in the Mar del Plata Action Plan should be adopted as far as possible in the formulation of master plan and in the operation and maintenance of irrigation systems. In order to achieve more efficient integrated planning and development of water resources, organizations concerned with ground water, minor irrigation works and command area development in the central Government had been amalgamated with the Irrigation Department. Since

the United Nations Water Conference, there had been an increase in the collection of hydrological data and an improvement in data compilation and processing by using modern techniques.

33. In Indonesia, an over-all review of experience on the following topics in response to the Mar del Plata Action Plan was made in March 1979: assessment of water resources; efficiency in water utilization for various purposes; measurement and projections of water demands; policy, planning and management of water resources; environmental monitoring programme, institutional management and education, training and research. The reply to the questionnaire circulated by the Secretary-General of the United Nations in March 1980 had already been submitted.

34. In Malaysia, the following action had been taken: (a) formulation and drafting of a rational water policy, and (b) review and possible revision of the existing institutional structure and legislation on water resources planning, development and management.

35. Nepal had planned to provide drinking water to 20 per cent of the rural population during the period 1981-1985. A Local Development Ministry had been established in order to accelerate the programme.

36. In New Zealand, revision and consolidation of water and soil conservation legislation were in the process of being drafted.

37. The Government of Samoa intended to achieve the objectives of the International Drinking Water Supply and Sanitation Decade by initiating programmes and an action plan in water supply and sanitation, monitoring water quality, promoting public education on usage and protecting catchment areas.

38. In Sri Lanka, the following measures had been taken in response to the Mar del Plata Action Plan; (a) formulation and drafting of a new and comprehensive water resources act which would provide for the establishment of a national water resources council; (b) drafting of a new irrigation law to include up-to-date and more effective provisions for the control and regulation of water use in irrigation schemes; (c) formulation and laying down of appropriate policies for better operation and maintenance of all existing irrigation schemes; (d) initiation of measures for improving the existing standards and procedures for the assessment of water resources; and (e) formulation of a decade plan providing for safe drinking water supplies covering 60 per cent of the rural population, and sanitary methods of excreta disposal covering 50 per cent of the rural population.

Information on opportunities for mutual support in implementing the Mar del Plata Action Plan, with particular reference to technical co-operation among developing countries (TCDC)

39. The Committee considered the opportunities for TCDC as specified in resolution VIII of the Mar del Plata Action Plan.

40. In that regard, Australia expressed its readiness to consider any request for assistance under the TCDC concept with due regard to budgetary constraints, other commitments in the region, the ability to provide the type of assistance requested, and the prevailing government policy. Likewise, Japan declared that it would continue to provide assistance to developing countries in the field of water resources development.

41. Since 1977, India had participated actively in information exchange and expert and consultancy services in the water resources sector. The Water and Power Consultancy Services had also increased their activities in developing countries. The representative of India suggested that under TCDC the initiative had to be taken mainly by the developing countries themselves. International organizations might help considerably in the following ways: (a) by giving preference to the talents and facilities available in developing countries when expert or consultancy services were to be made available to other developing countries; (b) by organizing teams from among senior officials of developing countries to visit projects in other countries of the region and identify and publicize the facilities and expertise available in the region itself; (c) by compiling and periodically updating a register of the facilities and expertise available in the developing countries; and (d) by financing training and study-cum-observation and other programmes, including participation in the proceedings of professional organizations.

42. Recognizing the importance of water resources in the economic development and the life of people in the developing countries, the representative of Indonesia recommended that a regional water resources development centre, similar to the Regional Mineral Resources Development Centre (RMRDC), should be established to promote co-operation in training and advisory services for water resources development among developing countries. It also suggested that copies of the Mar del Plata Action Plan should be widely circulated among the national agencies concerned.

43. The Committee noted with interest examples of TCDC in the water resources field. Technical co-operation between Malaysia and Thailand had been achieved through a joint study of the Golok River

basin. The Government of Samoa was planning to hold a seminar in 1981 on water supply and sanitation for countries in the South Pacific region. In Sri Lanka, engineers from the Department of Irrigation had been sent to the International Rice Research Institute (IRRI) in the Philippines to study rice irrigation and water management, while arrangements had been finalized to send an engineer to the Republic of Korea for a course in water management. It was mentioned that the recent activities in the development of the Mahaweli basin in Sri Lanka would be of interest to other developing countries of the region.

III. RURAL COMMUNITY WATER SUPPLY AND RURAL SANITATION IN RELATION TO OVER-ALL MANAGEMENT OF WATER RESOURCES

(Agenda item 5)

44. The Committee had before it document E/ESCAP/NR.7/2, which contained a background document prepared by WHO and some country papers.

45. The Committee noted with concern the information provided by WHO that while the ESCAP region contained 57 per cent of the total world population, it received only 29 per cent of the total external assistance provided for rural water supply and sanitation. It also noted that the estimated annual investments required to meet assumed achievable targets of 100 per cent for water and only 30 per cent for sanitation for the ESCAP region (excluding China) were $US 1,504 million and 104 million for rural water supply and sanitation respectively. It agreed that the targets of the International Drinking Water Supply and Sanitation Decade could be achieved provided the countries mobilized adequate internal resources as required.

46. The Committee heard with interest accounts of the various activities being carried out in a number of countries in the provision of rural water supply and sanitation facilities in preparation for the Decade.

47. Concern was expressed about the possible detrimental effect of over-abstracting ground water for irrigation purposes, thus lowering the ground water table and rendering ineffective the shallow wells used for the drinking water supply. The dangerous environmental health effects of the extensive development of water resources were also pointed out. Countries were therefore urged to give careful consideration to those matters.

48. The Committee recommended that consideration should also be given to the allocation of water resources through the introduction of appropriate licensing or pricing policies.

49. It noted the magnitude of the rural water supply and sanitation problem, which was quite formidable, and the need to adopt a strategy to provide an adequate coverage of water supply and sanitation of the rural population of the region by 1990.

50. It endorsed the elements of the strategy described in the document. It stressed that one of the principal elements of the strategy was the need to integrate the provision of rural water supply and sanitation in the over-all planning for water resources development of each country. Wherever possible, multipurpose projects should include rural water supply and sanitation along with irrigation, power generation or other uses, rather than leaving the former for subsequent planning and execution. Co-ordination among different agencies at the early planning stage would lead to considerable economies and to a conceptually more satisfactory and optimum solution.

51. Other elements of the strategy should include: adoption of a national policy assigning a high priority to the provision of rural water supply and sanitation; inclusion of rural water supply and sanitation in programmes in integrated rural development; participation of the rural community in the planning, construction and operation and maintenance of the projects; an increased allocation for that sector in the national budget; identification and formulation of suitable projects which could be considered for international funding; an intensive and effective programme of manpower planning and training; co-ordination among the various agencies involved in that activity; appropriate legislation to protect the quality of water resources; health education in generating local interest in water supply and sanitation; application of appropriate criteria and standards to meet the needs of rural communities, or the skills of village people; incorporation of local materials and equipment to the extent possible in the design and construction of the local system; and support for research and development of appropriate technology.

52. The Committee pointed out that only a small fraction of the total amount spent on armaments would be sufficient to finance the total investment requirements for the International Drinking Water Supply and Sanitation Decade the success of which, however, would be achieved only in an atmosphere of peace and détente.

53. The Committee noted with interest the many useful activities of WHO and UNICEF and the important role that they played in the provision of rural water supply and sanitation. It also noted the activities of UNESCO in that field.

IV. INTEGRATED OPTIMUM DEVELOPMENT OF THE DELTAIC AND UPLAND PORTIONS OF A RIVER BASIN

(Agenda item 6)

54. The Committee considered document E/ESCAP/NR.7/3 and commended Professor A. Volker on having prepared an excellent paper which was useful for the guidance of countries.

55. The Committee noted that the main problems usually encountered in the development of the deltaic and upland portions of a river basin to achieve optimum benefits included inaccessibility, water allocation, supply of water and possible regulation from upstream, floods and possible flood control upstream, navigation, protection of water quality, waterlogging, siltation, erosion, soil conservation, storm surges and sait-water intrusion; those were of (sometimes conflicting) interest to both the delta occupants and those in the upstream parts of river basin.

56. The resolution of the major problem of conflicting interests which at the same time would lead to the achievement of optimum benefits called for an integrated approach to the development of the water resources of a river basin by means of which alternative schemes of development would be formulated and their corresponding economic, social and environmental impacts would be evaluated.

57. To ensure the proper and timely implementation of the integrated development of a river basin, it was necessary to establish both an organizational and a legal framework.

58. The Committee pointed out that a river basin could encompass more than one country, in which case its development required co-operation among all the riparian countries. In that connexion reference was made to the recommendations of the United Nations Water Conference concerning co-operation in the field of share water resources, and concern was expressed about the delay in the codification of laws to guide the development of such resources.

59. The Committee expressed the view that master plans which should merely serve as a general framework should take into full consideration the social aspects of development in order to be valid, and must be kept under constant review. Moreover, institutional, administrative, technical and legal constraints must also be taken fully into consideration.

60. The Committee endorsed the following recommendations:

(1) The comprehensive master plans should include the development of the upland and deltaic portions of the basin;

(2) In the formulation of master plans for integrated river basin development, various alternatives should be considered for the allocation of water between interested categories of water users (urban and rural settlements, irrigation, industry, hydropower, navigation, fisheries, salinity control, protection of water quality, etc.), taking into due account the interdependence between water requirements and other interests of the deltaic area and the upland portion of the river basin in connexion with their economic, environmental and social merits;

(3) The master plan, justified from the technical, economic, environmental, social and cultural points of view and adopted by the relevant authorities, should serve as a guide to be used by planners and decision makers in the process of national planning, the phasing of the development of the two portions of the river basin and the selection of priority of hydraulic and other projects, as well as in the elaboration of institutional and legal aspects of integrated water use in the basin;

(4) The master plan should take fully into consideration the flood protection requirements of the river basin;

(5) During the development of a river basin continuous monitoring of the hydrologic and morphologic effects of that development on the various portions of the river basin should be carried out;

(6) ESCAP, in co-operation with other appropriate agencies, should organize a symposium on the mechanisms and effects of salt-water intrusion in surface and ground water and on measures to control such intrusion.

V. INDUSTRIAL WATER USE IN RELATION TO THE OVER-ALL MANAGEMENT OF WATER RESOURCES

(Agenda item 7)

61. The Committee had before it a note by the ESCAP secretariat (E/ESCAP/NR.7/4).

62. A brief review of the characteristics of various competing demands for water indicated that the requirements for community water supply would continue to increase, while those for agriculture, fisheries, salt-water intrusion control and inland navigation would remain more or less constant. Requirements for municipal water supply would not increase very much after a given level of services had been reached. While requirements in the industrial sector could increase, it was in that sector where the greatest scope for flexibility and adjustment existed because of improvements in technology, recycling, salvage of materials and increase in efficiency of water use.

63. The Committee agreed that increasing industrial output need not necessarily require a corresponding increase in the total industrial water requirements, which could be minimized through technological improvements, recirculation, reduction of losses, the formulation of national policy and introduction of legislation encouraging industry to devise and utilize water-saving measures, the employment of economic instruments, including appropriate water-pricing policies, which would encourage industries to adopt more efficient and less wasteful use of water, and the mounting of vigorous publicity and public information programmes to publicize the adoption of water-saving measures by industries.

64. For example, data on industrial water use reported by the Association of Industries in the Netherlands for the period 1957 to 1979 had revealed that while industrial production had increased, the volume of water used by industries had declined, especially between 1968 to 1972. It was estimated that there would be a 22 per cent reduction in 1980. New industrial plants in Japan were being designed to achieve about 95 per cent recirculation, while currently about 70 per cent of the water was being recirculated. The current emphasis in the USSR was on attaining 80 to 90 per cent recirculation of water in industries and zero discharge of pollutants. Effluent from sewerage treatment plants was being used to irrigate farms.

65. A number of countries, for example, Indonesia and Japan, were resorting to the use of ground water for their industrial water needs. However, declining ground-water levels, salt-water intrusion and land subsidence had resulted in some industries shifting to a piped water supply system.

66. It was recommended that prevention and control of water pollution should be made a component of national plans for economic and social development.

VI. ACTIVITIES OF ESCAP IN THE APPRAISAL, DEVELOPMENT AND MANAGEMENT OF NATURAL RESOURCES

(Agenda item 8)

67. The Committee reviewed the activities of the secretariat in the field of natural resources as reported in documents E/ESCAP/NR.7/5-9 and E/ESCAP/NR.7/11-15.

Water resources

68. The Committee noted with interest the progress made in the activities of the secretariat in the field of water resources development, as described in documents E/ESCAP/NR.7/5-9.

69. The Committee endorsed the activities of the secretariat and its efforts to promote regional co-operation and disseminate information in the field of water resources development. It stressed that close co-operation among members of the United Nations system was essential. It was important that the views and needs of regional and subregional bodies organized under the auspices of ESCAP should be considered by the existing mechanisms established to promote regional inter-agency co-operation, such as the Interagency Task Force on Water for Asia and the Pacific.

70. In particular, the work carried out on integrated development, use and management of water was much appreciated. The recommendations of the Seminar on the Improvement of Irrigation Performance at the Project Level, held at Krasnodar, USSR, from 23 August to 5 September 1980 were endorsed.

71. While endorsing in general the criteria for setting water pricing as recommended by the Export Group Meeting on Water Pricing, held at Bangkok from 13 to 19 May 1980, it was pointed out that not all the criteria might be applicable under certain conditions and specific problems faced by some countries.

72. The Committee noted with interest the reports of the Training Course on Flood Loss Prevention and Management, organized at Bangkok from 7 to 18 July 1980, and of the Study Tour on Methods of Flood Control conducted in China from 28 July to 16 August 1980 for the benefit of the Typhoon Committee.

73. It commended the secretariat on its efforts to monitor the implementation by countries of the Mar del Plata Action Plan and suggested that such monitoring should be institutionalized. To implement the recommendations concerning TCDC emphasized in resolution VIII of the Plan, it was suggested that the secretariat should organize groups of experts from the region to visit countries and discuss their problems in water resources development for which solutions might already be available on the basis of the experience of the experts.

74. The Committee expressed concern over the lack of activities organized by the secretariat in the South Pacific island countries in the field of water resources. The hope was expressed that that situation would be improved through the initiation of projects involving the South Pacific members as well as through their increased participation in relevant activities of the secretariat. The Committee endorsed the suggestion that the regional adviser on water resources should visit some of the South Pacific island countries to identify major needs and common problems in the field of water with a view to formulating useful subregional activities which could help in the solution of those problems.

Energy resources

75. The Committee considered document E/ESCAP/NR.7/11, covering activities of ESCAP in the energy field, document E/ESCAP/NR.7/15, the report of the Working Group Meeting on Energy in the South Pacific, and document E/ESCAP/NR.7/24, which contained statistics of energy resources and energy production of countries of the region. The Committee was informed of further progress made since the documents were issued.

76. The Committee noted that in response to an enquiry circulated by the secretariat, a number of replies had been received from member countries indicating the usefulness of the recurrent publication **Electric Power in Asia and the Pacific**, and the Committee was pleased to note that the publication would be continued. However, the Committee suggested that in future consideration should be given to the possibility of expanding the publication to incorporate information pertaining to other sources of energy, provided the secretariat would have sufficient resources to undertake additional work.

77. The Committee expressed interest in the proposed meeting on financing of rural electrification, which had the objective of finding proper solutions to solve the vital problems of financing. It noted, however, that the meeting could be organized only if reports on the current situation of rural electrification were received from a sufficient number of countries, in which case the work programme would have to be revised to include the meeting.

78. The Committee noted that a guidebook on biogas development incorporating information pertaining to Chinese design digesters would be available early in 1981.

79. The Committee expressed the hope that the ESCAP regional preparatory meeting for the United Nations Conference on New and Renewable Sources of Energy, to be convened in December 1980, would provide a good input to the Conference. It also noted that the report of the expert group meeting on fuelwood and charcoal to be organized jointly with FAO in January 1981 would be an additional input to the Conference.

80. The Committee expressed its appreciation of the increasing activities of ESCAP in the South Pacific area. It was grateful that the Working Group Meeting on Energy in the South Pacific had been held at Apia in June 1980 and noted that follow-up action had been taken as follows: (a) analytical papers on the evaluation of the energy situation in the South Pacific had been revised and circulated, (b) the preliminary draft project document on a Pacific regional energy programme had been prepared and distributed, and (c) an information document containing country papers presented at the meeting had been compiled in condensed form for distribution.

81. The Committee expressed its keen interest in the proposed regional energy development programme, but noted that no action would be taken until the UNDP programming mission which was currently visiting member countries of the region had completed its work.

82. The Committee noted with appreciation the support given to ESCAP by UNDP and by donor countries, namely, Australia, Finland, India, Japan and New Zealand, for undertaking various activities in the energy field during the period between the sixth and seventh sessions of the Committee.

83. The Committee appreciated the work of the secretariat. It suggested, however, that consideration should be given to the possibility of taking up other equally important subjects, such as conventional energy resources, energy conservation in the domestic sector and homes, small-scale hydroelectricity and water

desalination with the use of solar energy. The Committee also suggested that co-ordination among offices within the ESCAP secretariat should be improved so as to enable the report of the secretariat on its activities in the field of energy to be more comprehensive and include other planned activities, such as the ESCAP/RCTT Symposium on Solar Science and Technology, held at Bangkok from 25 November to 4 December 1980, and the Intergovernmental Meeting on Agro-industries, with Emphasis on Production of Energy and New Resources held at Tokyo from 21 to 27 October 1980.

84. The Committee was informed that an ASCOPE (ASEAN Council on Petroleum) meeting covering subjects connected with energy would be held at Manila in 1981 by ASEAN countries.

Mineral resources

85. The Committee considered the programme of activities undertaken by the secretariat in the field of geology and mineral resources development as reported in documents E/ESCAP/NR.7/12 and E/ESCAP/NR.7/14.

86. The secretariat was commended on the work carried out and the progress made in connexion with the Regional Mineral Resources Development Centre (RMRDC), the Southeast Asia Tin Research and Development Centre (SEATRADC), the Committees for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP) and in South Pacific Offshore Areas (CCOP/SOPAC), the specialized regional geological maps, the publication of the Mineral Resources Development Series, and the holding of seminars to promote the investigation and development of mineral resources.

87. The Committee was informed of the conclusions and recommendations of the Seminar on Modern Methods of Mineral Prospecting, which was held at Tashkent, USSR, from 20 August to 6 September 1980 with the financial and technical support of the Government of the USSR and UNDP.

88. It considered and endorsed the recommendations of that Seminar concerning the co-operation and assistance of international organizations:

(1) That a similar seminar to review the trends and new methods and techniques being used in mineral exploration and development should be held in about four years;

(2) That specialized training of national professional personnel for periods of three to four months should be provided by the United Nations system;

(3) That ESCAP/UNDP should develop a programme for specialized training of young professional personnel for periods of two or more years in the USSR and/or in other developed countries;

(4) That ESCAP should undertake to translate technical papers from the USSR on geology, geophysics and geochemistry into English and to distribute the information to the member countries;

(5) That regional geological centres and laboratories should be established in the ESCAP region that would be designed to solve some of the more pressing problems faced by the developing countries;

(6) That ESCAP should study in detail the organization of a seminar on drilling. It would be especially important that an appropriate country to organize and host the seminar should be identified and that the programme should be designed for field geologists;

(7) That, in view of the importance of coal as a source of energy for the developing countries, a seminar on exploration, evaluation and development of coal resources should be held, possibly in the USSR, as soon as possible.

89. In that connexion, the Committee noted with appreciation that the USSR was ready to study the possibility of organizing and hosting the next seminar on trends and new methods and techniques used in mineral exploration and development, and the seminar on exploration, evaluation and development of coal resources.

90. The Committee expressed its appreciation of the support given by UNDP to RMRDC, SEATRADC, CCOP and CCOP/SOPAC and strongly urged that continued support be given to those worth-while regional and subregional projects during the next programming cycle (1982-1986).

91. It also expressed appreciation to India for providing the services of a co-ordinator for the preparation of the third edition of the **Oil and Natural Gas Map of Asia** and for the offer to provide the services of an expert to act as co-ordinator for the preparation of the third edition of the regional **Mineral Distribution Map of Asia** in the form of an atlas. It also noted with appreciation that a similar offer had been made by New Zealand to provide assistance in the preparation of the mineral distribution map. Appreciation was expressed to Japan for its preparation of the gravity map of the eastern ESCAP region.

92. The Committee noted with appreciation the statement made by the representative of Japan that his

Government would continue to provide technical and financial co-operation in support of the regional programmes for the development of mineral resources. It endorsed the statement that the activities of bodies concerned with regional mineral development such as RMRDC, CCOP and CCOP/SOPAC should be conducted under the umbrella of ESCAP.

Remote sensing, surveying and mapping

93. The Committee was informed of the programme of activities of the secretariat in the field of remote sensing, surveying and mapping as reported in document E/ESCAP/NR.7/13.

94. It noted that the economies of ESCAP developing countries were primarily based on the development of their natural resources and that those countries urgently needed to speed up the completion of their resource data bases to be able to develop realistic plans for their accelerated economic growth. Remote sensing was therefore particularly important for the developing countries and most of these in the ESCAP region had established national remote sensing programmes and were developing methodologies for mapping natural resources and monitoring environmental changes.

95. The Committee was informed that in pursuance of the request made at the thirty-fifth session of the Commission for UNDP assistance for a three-year regional co-operation programme on remote sensing which would provide a mechanism for information exchange on projects of common interest, as well as sharing of training facilities and the conduct of joint research/pilot projects, a preparatory mission, with UNDP support, was fielded in May-June 1980 to assess and formulate a programme for regional co-operation in the field of remote sensing based on effective involvement and co-operation among national centres and/or services within the region.

96. The mission, comprising one UNDP consultant, one ESCAP consultant (senior remote sensing official from an ESCAP developing country), one representative each of United Nations Headquarters, the ESCAP secretariat and FAO, and a consultant provided by France, visited Thailand, Bangladesh, India, Indonesia, the Philippines, Republic of Korea, Japan, China and Viet Nam to consult with government authorities. In addition, a questionnaire requesting views on the formulation of the regional remote sensing programme was sent to each member and associate member of ESCAP.

97. The mission, after careful analysis of all the information available, prepared its report and a draft project document for a three-year multidisciplinary regional remote sensing programme. The main components of the recommended programme were: information exchange (symposia, newsletter, documentation services); training (workshop/study tour, on-the-job training, short-term/medium-term courses); and joint research and pilot applications projects. It also recommended the establishment of an intergovernmental consultative committee of participating countries to provide policy guidance for the regional programme. The mission report and draft project proposal were being distributed to all ESCAP countries for their consideration. The regional programme was expected to be implemented in 1982.

98. The Committee strongly supported the recommendation of the mission for a multidisciplinary regional remote sensing programme and expressed its appreciation to the secretariat for its endeavour to obtain support from UNDP and donor countries for the regional programme.

99. It endorsed the view that the three-year regional co-operation project to be funded by UNDP would provide a significant contribution towards upgrading remote-sensing capabilities in participating ESCAP countries. Since countries of the region needed further substantial assistance for advanced training and modern remote sensing equipment, the Committee urged prospective donor countries from within and outside the region and some international agencies to inform the secretariat at an early date of the nature of their support.

VII. ACTIVITIES OF OTHER INTERNATIONAL BODIES IN THE APPRAISAL, DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

(Agenda item 9)

100. The Committee had before it documents E/ESCAP/NR.7/1-4 and E/ESCAP/NR.7/11. Those documents gave a detailed description of the activities of some of the international bodies over the past three years. They were supplemented by oral presentations from the international bodies present.

United Nations Environment Programme

101. UNEP had launched a global regional seas programme, which included conservation of coastal areas, mangroves and deltaic areas. Its regional seas action programme consisted of: environmental assessment, en-

vironmental management, consideration of legal factors, and institutional and financial arrangements. UNEP's south Asia co-operative environment programme was concentrating, **inter alia**, on the conservation of montane ecosystems and watersheds, and coastal areas. Furthermore, UNEP had continued to support the efforts of the Mekong secretariat.

United Nations Children's Fund

102. Among the fields in which UNICEF had given support were surveying and programming, training, supply of equipment and materials and other technical support, health education and control of water quality, and the local manufacture of equipment and material. The Committee was informed that the World Bank's Technical Advisory Group, with which UNICEF collaborated, aimed at providing solutions to sanitation problems in urban areas which could not afford a sewage system.

Interim Committee for Co-ordination of Investigations of the Lower Mekong Basin

103. Fourteen hydro projects were already in operation with a total capacity of 230 MW, generating about 1,000 GWh annually, and a total area of about 500,000 ha had been put under irrigation. Recent studies of the Mekong River basin had indicated that a hydropower potential of 42,000 installed capacity and 225,000 GWh was available. The total potential area which could be irrigated in the basin was estimated at 6.4 million ha. Other efforts were aimed at salinity and flood control, navigation improvement, fisheries, environmental social and economic benefits.

International Labour Organisation

104. ILO considered the use of local resources of manpower and material, appropriate technology and local participation extremely important in the planning, development and operation of water resources and facilities. Several studies had been carried out on the subjects of irrigation and drinking water supply in countries of the ESCAP region, particularly emphasizing labour-intensive and indigenous technologies for constructing irrigation works and the use of local materials. Furthermore, ILO support had been given to the training, safety and health of workers, and to emergency employment schemes for seasonally unemployed rural workers.

United Nations Educational, Scientific and Cultural Organization

105. The plan for the second phase of UNESCO's international hydrological programme (1981-1983) gave increased emphasis to education and training and to the dissemination of information relating to water resources management. The regional hydrology programme for 1981 was expected to include two or three training courses in both the south-central Asian region region and the south-east Asian region. UNESCO also planned a number of pilot projects to assist countries in the assessment of their water resources.

World Health Organization

106. WHO activities in the fields of sanitation and water supply had intensified considerably since the United Nations had made preparations to declare 1981-1990 the International Drinking Water Supply and Sanitation Decade. WHO, which was a technical co-operation rather than a funding agency, had provided technical co-operation for promoting and supporting national Decade programmes, which were to become self-sustaining, and had encouraged TCDC and the flow of external funds to support national Decade activities. The water supply and sanitation programmes were carried out together with support programmes for health and hygiene, education and community participation.

International Commission on Irrigation and Drainage

107. The purpose of ICID was to stimulate and promote the development and application of scientific techniques of irrigation, drainage, flood control and river training, taking into consideration engineering, economic and social aspects (as well as environmental aspects). That objective was carried out by ICID through global and regional meetings; interchange of information; studies and experiments; dissemination of publications; and co-operation with international organizations having related objectives.

International Council of Women

108. Women should be involved in training related to the acquisition of water, which was vital for rural life. That included pump repair and other skills for improving the water supply. The Committee was informed that organizations should assist in the training of women to enable them to participate more actively in national development.

109. One delegation pointed out that the reports of the agencies represented had not provided information on follow-up action to the Mar del Plata Action Plan. The hope was expressed that in future such information would be provided.

VIII. PROGRAMME OF WORK AND PRIORITIES IN THE APPRAISAL, DEVELOPMENT AND MANAGEMENT OF NATURAL RESOURCES, 1980-1981, PROGRAMME CHANGES; AND CONSIDERATION OF THE PROGRAMME OF WORK AND PRIORITIES, 1982-1983

(Agenda item 10)

110. The Committee reviewed the programme of work and priorities in the field of natural resources development for 1980-1981 as set out in documents E/ESCAP/NR.7/10 and E/ESCAP/NR.7/16-18. It also considered the draft programme of work and priorities in that sector for 1982-1983, set out in documents E/ESCAP/NR.7/19 and Add.1, E/ESCAP/NR.7/20 and Add.1, E/ESCAP/NR.7/21 and Add.1, and E/ESCAP/NR.7/22 and Add.1.

111. The Committee heard with interest the statement of the UNDP Regional Representative a.i. that UNDP was currently engaged in consultations with the members of the United Nations family, including ESCAP, in preparation for the formulation of the UNDP intercountry programme for the third cycle, 1982-1986. It was pleased to learn that UNDP had a definite commitment to support the proposed regional energy development programme, RAS/80/001.

112. The Committee noted that the availability of resources for the successful implementation of the programme of work was of vital importance. An appeal was made to relevant organizations to provide financial support to those programme.

Water resources

113. The Committee recommended that ESCAP should organize a meeting on water resources development in the first half of 1981 for the benefit of South Pacific island countries to discuss the major needs and problems in the field of water and their possible solutions. The hope was expressed that the organization of such a meeting would be the start of further secretariat activities in the South Pacific in the sphere of water. It was recommended that the 1980-1981 programme of work and priorities in the water sector, as set out in document E/ESCAP/NR.7/10, should be amended accordingly.

114. The Committee endorsed the draft programme of work and priorities for 1982-1983 as set out in document E/ESCAP/NR.7/19 and Add.1, with the addition of a project on water quality management.

115. In endorsing the programme for 1982-1983, the importance of subprogramme 16.02 on policy, planning and management was stressed. In that connexion the USSR reaffirmed its readiness to host a seminar on water resources development planning in 1982 and a study tour on capital investment aspects of water resources development in 1983.

116. Also in connexion with programme 16.02, the United States delegation brought to the attention of the Committee that new techniques were available which could be of assistance to ESCAP in the more effective implementation of its work programme in the water sector.

117. The Committee also pointed out that in the field of irrigation there was still plenty of scope for management reform and system design. It suggested the continuance of case studies in that regard.

118. A note of caution was sounded concerning the application of low-cost technology in the field of water until possible disadvantages had been evaluated by scientific studies. It recommended the continuance of traditional methods which, however, should be made more cost-effective.

119. Some delegations expressed the view that a meeting or seminar on droughts should be held in 1983. However, other delegations considered such a meeting to be unnecessary since at a number of meetings held recently on the same or on related subjects, for example, the International Symposium on Droughts at New Delhi, and the United Nations Conference on Desertification, discussions had been held and recommendations made which were relevant to the drought problem.

120. It was suggested that in drawing up the medium-term plan for 1984-1989, the establishment of a regional water resources development centre should be considered.

Energy resources

121. The Committee considered documents E/ESCAP/NR.7/16 and E/ESCAP/NR.7/20 and Add.1. The work programme for 1982-1983 in document E/ESCAP/NR.7/20 was tentative and might be modified extensively, depending on the outcome of various activities on energy currently being undertaken, as mentioned in the document.

122. The Committee was informed that activity 02.02.01, "Meeting on national energy policies and

energy planning", included in the work programme for 1982-1983, was a modification of an activity of the current work programme, 1980-1981, which had not been implemented in 1980 owing to certain modifications in the priorities within the sector.

123. The Committee stressed the importance of rural electrification development and was informed that the subject could be considered as part of activity 02.02.02 of the current work programme for 1980-1981, through a seminar on planning, management and economics of energy for rural areas. Alternatively, that subject might be dealt with at an **ad hoc** meeting to be proposed as an addition to the work programme, 1982-1983, provided that a sufficient number of member countries of the region would submit to the secretariat, for analysis and evaluation, national reports on management and financing of rural electrification in line with the report of India distributed to the countries late in 1979.

Mineral resources

124. The Committee considered the programme of work and priorities in the appraisal, development, use and management of mineral resources, 1980-1981 (E/ESCAP/NR.7/17) and the draft programme of work, 1982-1983 (E/ESCAP/NR.7/21 and Add.1).

125. It endorsed the amendments to the 1980-1981 programme as set out in document E/ESCAP/NR.7/17, with the addition of the following specific activities:

15.02.09 Support to CCOP

15.02.10 Establishment of a CCOP for the Indian Ocean area

It also endorsed the draft programme of work, 1982-1983, as given in documents E/ESCAP/NR.7/21 and Add.1.

126. In connexion with the seminar on tungsten, the Committee was pleased to note that preparations were under way for holding the seminar in the autumn of 1981 in south China.

Remote sensing, surveying and mapping

127. The Committee considered documents E/ESCAP/NR.7/18 and E/ESCAP/NR.7/22 and Add.1, and endorsed the programme of work and priorities for remote sensing, surveying and mapping, 1980-1981, and the draft programme of work, 1982-1983, as set out in those documents.

128. In connexion with the proposed UNDP regional remote sensing programme, the Committee felt that special attention should be given to the type of training on remote sensing techniques which should really satisfy the needs of the individual member countries. The suitability of the location of ground receiving stations and the availability of satellite imagery were of the utmost importance for the implementation of the programme and should therefore be ensured.

IX. REVISION OF THE TERMS OF REFERENCE OF THE COMMITTEE ON NATURAL RESOURCES

(Agenda item 11)

129. The Committee considered document E/ESCAP/NR.7/23, which contained some suggestions for the revision of its terms of reference. It suggested further minor modifications and recommended the following terms of reference:

"The Committee on Natural Resources shall have the following functions:

"1. To study, review and evaluate progress in natural resources development in the region, in particular in the field of water, energy and mineral resources development;

"2. To discuss in depth technical and other relevant subjects dealing with water, energy and mineral resources;

"3. To consider and recommend policies, strategies, methods and techniques for the proper investigation, development and utilization of water, energy and mineral resources, having due regard to economic, social and environmental considerations, to identify problems impeding the desirable rate of progress in these fields, and to recommend appropriate measures, including required training programmes;

"4. To promote regional and subregional co-operation in water, energy and mineral resources development;

"5. To review and evaluate the activities of the secretariat in the field of water, energy and mineral resources development and to make recommendations for the formulation and implementation of the programme of work in these fields, with particular emphasis on activities in priority areas as defined by the

Commission from time to time, taking into account the work being done in these fields by the United Nations and other relevant organizations;

"6. To perform such other functions and activities as the Commission may request in all matters concerning water, energy and mineral resources development in the region;

"7. To liaise as necessary with, and to take into account the relevant recommendations of, other legislative committees established by the Commission and other relevant bodies.

The Committee shall meet once every year and take up separately, but not exclusively, every third, year, the subjects of energy, water and mineral resources development, and report to the Commission."

130. While agreeing on those terms of reference, the Committee stressed that the principles of integrated land and water management and the relationship between land use and the elements of the hydrological cycle should be taken fully into consideration at all times with a view to optimizing the use of water and associated land resources.

X. CONSIDERATION OF THE AGENDA AND ARRANGEMENTS FOR SUBSEQUENT SESSIONS OF THE COMMITTEE

(Agenda item 12)

131. The eighth session of the Committee scheduled for 1981 would deal mainly with the topic of energy. The Committee was informed that energy would also be a main topic for discussion in the Committee on Development Planning at its third session, scheduled for January 1981. The secretariat therefore decided that the proposed provisional agenda on energy matters for the eighth session of the Committee on Natural Resources would be prepared and submitted for consideration by the Commission at its thirty-seventh session in March 1981.

132. The Committee agreed with that arrangement but suggested that the provisional agenda endorsed by the Commission should be finalized in consultation with the ESCAP member countries.

133. The Committee suggested that consideration should be given to the inclusion of some of the following topics in the agenda for the tenth session:

(1) Multidisciplinary and systems approach for integrated river basin development;

(2) Review of implementation of the Mar del Plata Action Plan;

(3) Assessment and consideration of irrigation efficiency in the irrigated areas of the ESCAP region;

(4) Pollution problems related to the current programmes of low-cost technology applications to water supply and sanitation in the ESCAP region;

(5) Report by the Interagency Task Force on Water for Asia and the Pacific and discussion of the report;

(6) The effects on water allocation and water quality of industrial development in developing countries.

XI. ADOPTION OF THE REPORT

(Agenda item 14)

134. On 6 October 1980, the Committee adopted the report on its seventh session, for consideration by the Commission at its thirty-seventh session.

XII. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

135. The pertinent conclusions and recommendations of the Committee for the attention of the Commission were the following:

The Committee:

(1) Suggested that under TCDC the initiative had to be taken mainly by the developing countries themselves. However, international organizations could help in the following ways:

(a) By giving preference to the talents and facilities available in developing countries when expert or consultancy services were to be made available to other developing countries;

(b) By identifying and publicizing the facilities and expertise available in the region;

(c) By compiling and periodically updating a register of the facilities and expertise available in the developing countries;

(d) By financing training, study tours and participation in professional meetings (paragraph 41).

(2) Agreed that the Decade targets could be achieved provided the countries mobilized adequate internal resources as required (paragraph 45).

(3) Expressed concern about the possible detrimental effect of over-abstracting ground water for irrigation purposes and the dangerous effects of the extensive development of water resources (paragraph 47).

(4) Recommended that consideration be given to the allocation of water resources through the introduction of appropriate licensing or pricing policies (paragraph 48).

(5) Recognized the need to adopt a strategy to provide an adequate coverage of water supply and sanitation of the rural population of the region by 1990 (paragraph 49) and endorsed the elements of such a strategy (paragraphs 50 and 51).

(6) Expressed concern about the delay in the codification of laws to guide the development of shared water resources (paragraph 58).

(7) Endorsed the following recommendations:

(a) The comprehensive master plans should include the development of the upland and deltaic portions of the basin;

(b) In the formulation of master plans for integrated river basin development various alternatives should be considered for the allocation of water between interested categories of water users (urban and rural settlements, irrigation, industry, hydropower, navigation, fisheries, salinity control, protection of water quality, etc.), taking into account the interdependence between water requirements and other interests of the deltaic area and the upland portion of the river basin in connexion with their economic, environmental and social merits;

(c) The master plan, justified from the technical, economic, environmental, social and cultural points of view and adopted by the relevant authorities, should serve as a guide to be used by planners and decision makers in the process of national planning, the phasing of the development of the two portions of the river basin and the selection of priority of hydraulic and other projects, as well as in the elaboration of institutional and legal aspects of integrated water use in the basin;

(d) The master plan should take fully into consideration the flood protection requirements of the river basin;

(e) During the development of a river basin, continuous monitoring of the hydrologic and morphologic effects of that development on the various portions of the river basin should be carried out;

(f) ESCAP, in co-operation with other appropriate agencies, should organize a symposium on the mechanisms and effects of salt-water intrusion in surface and ground water and on measures to control such intrusion (paragraph 60).

(8) Recommended that prevention and control of water pollution should be made a component of national plans for economic and social development (paragraph 66).

(9) Endorsed the activities of the secretariat and its efforts to promote regional co-operation and disseminate information in the field of water resources development and stressed that close co-operation among members of the United Nations system was essential (paragraph 69).

(10) Endorsed the recommendations of the Seminar on the Improvement of Irrigation Performance at the Project Level (paragraph 70).

(11) Endorsed in general the criteria for setting water prices as recommended by the Expert Group Meeting on Water Pricing (paragraph 71).

(12) Suggested that monitoring of the implementation of the Mar del Plata Action Plan should be institutionalized (paragraph 73).

(13) Suggested that the secretariat should organize groups of experts from the region to visit countries and discuss their problems in water resources development (paragraph 73).

(14) Expressed concern over the lack of activities in the South Pacific countries organized by the secretariat in the field of water resources

and suggested that the regional adviser on water resources should visit some of the Pacific island countries to identify major needs and common problems (paragraph 74).

(15) Endorsed the activities of ESCAP in the energy field and the report of the Working Group Meeting on Energy in the South Pacific (paragraph 75).

(16) Suggested that the publication **Electric Power in Asia and the Pacific** should be expanded to incorporate information pertaining to other sources of energy (paragraph 76).

(17) Suggested that consideration should be given to the possibility of taking up such important topics as conventional energy resources, energy conservation in the domestic sector, small-scale hydroelectricity and water desalination using solar energy (paragraph 83).

(18) Noted and endorsed the recommendations of the Seminar on Modern Methods of Mineral Prospecting (paragraph 88).

(19) Expressed its appreciation of the support given by UNDP to RMRDC, SEATRADC, CCOP and CCOP/SOPAC and strongly urged the continuation of that worth-while work during the period 1982-1986 (paragraph 90).

(20) Expressed appreciation to India, Japan and New Zealand for providing staff and services resulting in the preparation of several maps useful for mineral prospecting (paragraph 91).

(21) Noted that the UNDP-supported mission had visited Thailand, Bangladesh, India, Indonesia, the Philippines, the Republic of Korea, Japan, China and Viet Nam regarding remote sensing. After analysis of the information available, the mission prepared a draft project document for a three-year multidisciplinary regional remote sensing programme (paragraphs 96 and 97). The Committee strongly supported the recommendation of the mission for a multidisciplinary regional remote sensing programme (paragraph 98).

(22) Endorsed the view that the three-year regional co-operation project to be funded by UNDP would assist the ESCAP countries in upgrading their remote sensing capabilities and urged prospective donor countries to support that effort also (paragraph 99).

(23) Recommended that ESCAP should organize a meeting on water resources development for the benefit of the South Pacific island countries and that the 1980-1981 programme of work in the water sector should be amended accordingly (paragraph 113).

(24) Endorsed the programme of work and priorities for 1982-1983, including the addition of a project on water quality management (paragraph 114).

(25) In connexion with subprogramme 16.02 on policy, planning and management, noted that the USSR had reaffirmed its readiness to host a seminar on water resources development planning in 1982 and a study tour on capital investment aspects of water resources development in 1983 (paragraph 115).

(26) Suggested that case studies in the field of irrigation water management and system design should continue (paragraph 117).

(27) Suggested that consideration should be given to the establishment of a regional water resources development centre in drawing up the medium-term plan for 1984-1989 (paragraph 120).

(28) Endorsed the amendments to the 1980-1981 programme to include the addition of support to CCOP and the establishment of a CCOP for the Indian Ocean area (paragraph 125).

(29) Endorsed the programme of work and priorities for remote sensing, surveying and mapping, 1980-1981 and the draft programme of work, 1982-1983 (paragraph 127).

(30) Recommended revision of the terms of reference of the Committee on Natural Resources (paragraph 129).

(31) Stressed the need to urge full recognition of the principles of integrated land and water management and the relationship between land use and the elements of the hydrological cycle (paragraph 130).

(32) Agreed that the provisional agenda for the eighth session would be prepared and submitted for the consideration of the Commission at its thirty-seventh session in March 1981 but suggested that the provisional agenda should be finalized in consultation with the ESCAP member countries (paragraphs 131 and 132).

(33) Suggested that in the agenda for the tenth session, consideration should be given to the inclusion of some of the six topics listed in paragraph 133.

Part Two

WORKING PAPERS PRESENTED BY THE SECRETARIAT

I. REVIEW OF WATER RESOURCES DEVELOPMENT IN THE REGION

(E/ESCAP/NR. 7/1)

INTRODUCTION

The last review of water resources development in countries of the region prepared by the secretariat was presented to the Committee on Natural Resources at its first session in November 1974. It included data up to 1972. The present review covers the major sectors of water resources development of the countries, namely, irrigation, hydroelectric power, flood control and urban and rural water supply and covers the period from 1972 to 1978 (or 1977), for which years data are available. The main purpose of this review is to evaluate the progress made in each sector of water resources development in meeting various requirements.

A. IRRIGATION

1. Increase in irrigated area and improvement of service

Table 1 shows the arable land area in 1977 and irrigated area in 1971 and 1977 in 16 developing Asian countries. During the period from 1971 to 1977 the total irrigated area of these 16 countries increased by about 13.2 million ha (or 12.4 per cent), of which 5.7 and 4.1 million ha were in China and India respectively. In Bangladesh, the Philippines, the Republic of Korea, Sri Lanka and Thailand there was a 21 to 30 per cent increase in irrigated area during the six-year period. In Nepal the irrigated area increased by 71 per cent.

There was a high percentage (46 per cent) of arable land under irrigation in east Asia in 1977, while the averages in south-east Asia and south Asia were only 20 and 27 per cent respectively. China, Pakistan, the Republic of Korea and Sri Lanka had about 46 per cent or more of arable land being irrigated in 1977, while Burma, the Lao People's Democratic Republic, Malaysia and Nepal had only 11 per cent or less. This comparison indicates that there was still a great potential for irrigation development in many countries of the region for increasing their foodgrain production.

In most developing countries of the region, government agencies were responsible for the construction of reservoirs, headworks, canals and main distribution systems down to the outlets. The construction of field channels, as well as field drains and land shaping for irrigation, is considered to be the responsibility of the farmers. However, because of the low capability of the farmers to carry out this work, the utilization of water and the efficient operation of irrigation systems has usually been delayed. In recent years, the Governments of many countries have recognized this difficult problem and changed their policies. In some projects the Governments have extended the irrigation construction work, including land shaping and farm roads, down to the farm level. Some countries have also made efforts to co-ordinate assistance to farmers in related aspects, such as the provision of fertilizers, credit and agricultural extension. For example, in India, to ensure better co-ordination among the various disciplines at different levels, 37 command area development authorities covering 47 irrigation projects were set up during the period 1974-1978. These 47 projects cover a total irrigated area of about 14 million ha. In the Philippines, since 1969 the World Bank Group has financed 11 irrigation projects covering a total area of about 400,000 ha to increase rice production. These projects provided improved irrigation and drainage facilities, better road systems for efficiency of operation and the marketing of farm products, and stronger supporting services to assist farmers in adopting new irrigation techniques. The Government of Thailand started the land consolidation and irrigation improvement project in 1971. It consists mainly of land levelling and reshaping, provision of irrigation and drainage facilities at the farm level and the construction of farm roads. By the end of 1977 construction work on 20,923 ha had been completed, and work on 14,685 ha was undertaken in 1978.

2. Production and net imports of foodgrains

In most countries of the region, irrigation development is mainly for the increased production of cereals, namely, paddy or wheat for domestic consumption. Table 2 shows the average annual production of all cereals for the periods 1969-1971 and 1976-1978 in 16 developing countries of the region. Except for the Lao People's Democratic Republic, all the countries made substantial increases in their foodgrain production. A comparison of the average annual production during these two periods shows an increase in cereal production in these 16 countries of 96.9 million tons at an annual rate of increase of 2.9 per cent. In China, Indonesia, Iran, Pakistan, the Philippines and the Republic of Korea, the rate of increase exceeded 3.0 per cent per annum. Undoubtedly the expansion of the irrigated area and the improvement in irrigation water supply played an important role in the increased production of cereals in these countries. However, the increased foodgrain production in these countries did not appear to match their increased requirements since their imports also increased during the period under review.

Table 2 also shows the average annual net imports of foodgrains during the periods 1969-1971 and 1976-1978 in these 16 countries. Among these countries, only three (Burma, Nepal and Thailand) exported foodgrains. The other 13 countries imported a large amount of foodgrains annually. The total net imports of foodgrains of these 16 countries increased from 13.8 million tons per year in 1969-1971 to 20.9 million tons per year in 1976-1978. Pakistan changed from an exporter in 1969-1971 to an importer in 1976-1978. Thailand expanded its exports from 2.8 million tons per year to 4.1 million tons per year.

3. Growth of harvested area and yield of cereal crops

The progress of irrigation development in the countries of the region was also reflected in the increase of the harvested area and yield of cereals, as shown in table 3. The 16 countries expanded their harvested area from 285.8 million ha in 1969-1971 to 307.1 million ha in 1976-1978 at a rate of 1.0 per cent per cent per year. Owing to the conversion of agricultural land to other uses, the harvested area in the Republic of Korea decreased by about 12 per cent (251,000 ha). It is noted that in three countries (Philippines, Sri Lanka and Thailand) there was a substantial increase in harvested area at a rate exceeding 3.0 per cent per year, which is probably due to the expansion of their irrigated areas, as shown in table 1.

The average unit yield of cereals in these 16 countries increased from 1.53 tons per ha in 1969-1971 to 1.74 tons per ha in 1976-1978, with a rate of increase of 1.8 per cent per year, as shown in table 3. There was a large variation in unit yield among these countries. In four countries (Lao People's Democratic Republic, Nepal, Sri Lanka and Thailand), the average unit yield of cereals decreased during the period. In the Republic of Korea the average yield increased by 48 per cent during the same period. Indonesia, Iran and Pakistan made good improvements in this regard. While the average yield of cereal crops was 5 tons per ha in the Republic of Korea and 2 tons per ha or more in China, Indonesia, Malaysia and Viet Nam, it was below 2 tons per ha in the other countries in 1976-1978.

Depending on the condition of water control and the advancement of modern techniques, the degree to which high-yielding varieties of rice were adopted varied greatly among the countries of the region. The Philippines had the highest rate of adoption (68 per cent in 1976-1977), the Republic of Korea reached 44 per cent, and Indonesia, India and Pakistan 30 to 40 per cent, while in the same year only 7 per cent of Burma's rice area and 11 per cent of Thailand's were planted with high-yielding varieties.[1]

B. HYDROELECTRIC POWER

1. Increase of electricity generating capacity

The installed generating capacities of hydro and thermal electricity of 17 countries, including three developed countries or areas in the region, for 1972 and 1978 are listed in table 4. Three of them (Fiji, Hong Kong and Singapore) do not have hydropower.

During the period 1972-1978 the total installed capacity of hydropower in these 17 countries increased by 37 per cent, while the total thermal generating capacity increased by 65 per cent. As shown in table 4, the average annual rates of increase for thermal power are higher than the rates for hydropower in all countries except India, the Republic of Korea and Sri Lanka. For the region as a whole, the share of hydropower continued to decline from 27.7 per cent in 1972 to 24.1 per cent in 1978. This is probably due to the fact that the construction of hydropower plants takes longer and costs more per kilowatt of capacity. In Afghanistan, Nepal, New Zealand and Sri Lanka the total hydro installed capacity exceeded the thermal capacity in 1978.

The electricity generation of hydro and thermal power plants and **per capita** generation in 1978 of these 17 countries are also shown in table 4. The **per capita** electricity generation clearly reflects the stage of industrial development and standard of living in each country. In three developed countries (Australia, Japan and New Zealand), **per capita** electricity generation ranged from 4,857 to 6,933 kWh. In Hong Kong and Singapore it was 1,875 and 2,527 kWh respectively. In other developing countries it varied widely, from 11 kWh in Nepal to 894 kWh in the Republic of Korea.

The total generation of hydropower plants of the 17 countries in 1978 was 160,702.9 million kWh, which was only 18.4 per cent of the total electricity generation of these countries, while the total hydro installed capacity shared 24.1 per cent of the total installed capacity as mentioned above. This indicates that the hydropower plants are generally used to meet the peak load requirements or generate less kWh per kW of installed capacity.

[1] D. Dalrymple, *Development and Spread of High-Yielding Varieties of Wheat and Rice in the Less Developed Nations*, United States Department of Agriculture, Foreign Agricultural Economic Report 95, 1978; and A. Palacpac, *World Rice Statistics*, International Rice Research Institute, 1979.

2. Exploited hydro in relation to total potential

The estimated hydro potentials and the ratios of exploited capacity to total hydro potential of 14 countries or areas are also shown in table 4. In three developed countries, 45 to 63 per cent of the total hydro potential had been exploited by 1978. By contrast, in many developing countries less than 10 per cent of their hydro potential had been developed by 1978. Most of these developing countries are importing fuel oil for their thermal power plants. As the price of oil has been continuously increasing and in order to reduce the foreign currency requirements for the import of fuel and to promote industrial development, it appears that there is a need for developing countries to exert more efforts in the investigation and implementation of economic hydropower projects.

3. Pumped storage project development

India, Japan and the Republic of Korea have built nuclear power plants. By 1978 the total installed capacity of nuclear power in Japan had reached 12,854 MW. For technical and economic reasons the nuclear power units have to run near full capacity continuously. To meet the varied load of the electric power system, hydropower plants can have multiple functions. Not only can they supply electric power, but they can regulate its output to meet the peak load for the economic operation of the system. Pumped storage hydropower plants especially can play a very important role in this respect. In recent years most hydro projects built in Japan have been of the pumped storage type. At the end of September 1978 the total installed capacity of 25 existing pumped storage hydropower plants had reached 8,380 MW, or 31 per cent of the total installed capacity of all hydropower in that country. There were six power plants of this type, with large installed capacity ranging from 500 MW to 1,212 MW. In September 1978, 60 hydro projects with a total installed capacity of 11,507 MW were under construction, of which 13 projects with a total capacity of 10,039 MW were of the pumped storage type.

C. FLOOD CONTROL

1. Cyclone and flood damage

According to statistical data, 32.8 tropical cyclones[2] developed per year on average during the period 1959-1978 in the western North Pacific Ocean, of which 4.8 cyclones were classified as tropical depressions, 10.0 as tropical storms and 18.0 as typhoons.[2] In the typhoon-affected area, China, Hong Kong, Japan, the Philippines and the Republic of Korea are most frequently hit by destructive typhoons, which bring intensive rainfall and floods. In the north Indian Ocean four cyclones developed a year on average during the period 1971-1978. The tropical cyclone causes heavy rainfall, floods and storm surges. Storm surges wipe out and wash away villages and drown thousands of people. In the cyclone-affected area, Bangladesh and India frequently suffer considerable losses.

Table 5 shows the maximum annual cyclone and flood damage and the average annual damage in 14 countries or areas of the ESCAP region for the period under review. The seven countries in the typhoon-affected area sustained an average annual damage of $US 1,901 million, while seven countries in the cyclone-affected area suffered an average annual damage of $US 994 million. In years when more severe typhoons and cyclones strike the countries, much greater damage is inflicted. As shown in table 5, in 1972 Japan sustained flood damage of $US 3,011 million, which was about twice the average annual damage. In that year, 508 persons lost their lives in floods. In the Philippines and the Republic of Korea there were also large numbers of dead and missing when very strong typhoons struck these countries.

In the cyclone-affected area, a large number of lives were lost in Bangladesh and India during the period. The cyclone which hit Andhra Pradesh (India) on 19 November 1977 was the most severe storm of the State in the last 100 years. The storm caused very heavy rain in Prakasam, Guntur, Krishna and east and west Godavari districts. Tidal waves 5 to 6 m high washed away at least 28 villages on the night of 19 November. About 10,000 persons and 250,000 heads of cattle were reported lost.

Because of economic development and increase of population in flood-prone areas, flood damage is liable to increase. The average annual damage in Japan and India during the period 1961-1970 was $US 587 and 207 million respectively.[3] By comparison, the average annual damage in these two countries for the period 1972-1978 had increased to $US 1,690 and 857 million respectively.

2. Flood control measures and annual expenditure

In most countries of the region the dike is the principal measure of flood control. As shown in table 5, all countries or areas for which data are available extended the length of their flood dikes during the period under review. In Indonesia the length of flood dikes had increased from 1,500 km in 1970 to 4,036 km in 1978.

By 1978 there were seven countries in the region which had established flood forecasting and warning

[2] ESCAP, *Water Resources Journal*, June 1980.

[3] "Second ten-year review of water resources development in the ESCAP region (1960–1970)", *Water Resources Journal*, September 1973.

systems in order to mitigate flood damage. Australia had 120 river basins with flood forecasting systems, while India and New Zealand had 55 and 50 basins respectively with flood forecasting in 1978.

Among the seven countries for which data are available, Japan spent the largest amount on flood control works, which is about three times its average annual damage. India, Indonesia, the Philippines and the Republic of Korea also spent a significant amount to protect their people and property from flood inundation.

D. URBAN AND RURAL WATER SUPPLY

1. Population served

The relevant data[4] on the urban and rural population served in 1975 and 1980 in 15 developing countries in the region are listed in table 6. The computed growth rates of the population served from 1975 to 1980 of the countries for which data are available are shown in table 7, which indicates that Fiji, Indonesia, Nepal, the Philippines and Samoa made good progress in expanding their services, with growth rates exceeding 5 per cent per year during the period 1975-1980.

The status of water supply services in 1980 varies greatly among these countries. In all of them, the percentage of urban population served is higher than that of the rural population, which had reasonable access to safe water or service. Table 6 indicates that in Singapore 99.5 per cent of population was served in 1980, while in Afghanistan and Maldives only 20 and 12 per cent respectively of the urban population were served in 1980. A high percentage of the urban population was also served in some other countries, such as peninsular Malaysia, Nepal, the Philippines and the countries of Oceania.

The percentages of the rural population having reasonable access to safe water were much lower. There were six countries where less than 20 per cent of the rural population had reasonable access to safe water in 1980. In Afghanistan and Maldives, only 8 and 0.5 per cent respectively of the rural population had reasonable access to safe water. The statistical data clearly indicate that rural water supply needs much improvement in many developing countries of the region.

2. Level of service of urban water supply

Some information on the level of service of urban water supply in the countries is included in table 7. Afghanistan, Nepal and Pakistan, the supply of water in most urban water supply systems was intermittent. These systems supplied water only 2 to 10 hours a day.

In many countries of the region more than 60 per cent of the population served in the urban area obtained water from public standposts in 1980, as shown in table 7. For these countries the distribution systems have to be greatly expanded to enable more people to be served with house connexions.

There is no information on the adequacy of the water supply services to meet the requirements of customers. In arid and semi-arid regions and small island countries, such as Maldives and many countries in the South Pacific, the scarcity of water available from surface and ground-water sources poses a serious problem. As shown in table 7, the average consumption of water in Afghanistan was only 10 to 40 litres **per capita** per day, which is far below the normal requirement of urban residents.

3. Constraints and difficult problems in urban and rural water supply development

Habitat: United Nations Conference on Human Settlements, held at Vancouver in 1976, urged the adoption of water programmes for urban and rural areas, with realistic standards for quality and quantity, to be implemented by 1990, if possible. The target of the International Drinking Water Supply and Sanitation Decade is "water for all" by the end of the Decade. The targets set by some countries are shown in table 6. It would require considerable effort and investment by the countries to achieve these targets, considering the constraints and problems which they face.

The constraint most frequently encountered by the developing countries mentioned in the country reports is the shortage of engineers, skilled technicians and experienced managers for the planning, construction, operation and maintenance of water supply systems. In the rural areas, it is even more difficult to recruit qualified personnel.

The second most important constraint in developing countries of the region is the shortage of construction materials and equipment, such as pipes and fittings. The manufacturing sector in these developing countries has not yet developed to the stage where it could supply the requirements of the water supply sector. To import these materials and equipment requires a large amount of foreign currency, which is in short supply in most developing countries.

There are many other constraints, such as lack of data for the assessment of ground water, lack of co-

[4] Country reports for the International Drinking Water Supply and Sanitation Decade.

ordination among agencies, inefficient administration, etc.

It is also noted that the water supply sector is highly subsidized by the Governments in most developing countries of the region. Subsidization by the Government is often detrimental for the efficient operation of the system and is a large drain on the financial resources of the Government. In many countries the users of public standposts do not pay for the water and the capital cost of rural water supply systems is fully subsidized by the Government.

If the Decade targets are to be achieved, serious consideration needs to be given to the removal of these constraints and the solution of these problems.

Table 1. Irrigated area in 1977 and estimated increase in irrigated area from 1971 to 1977, for selected countries in the ESCAP region

	1977 arable land area (1 000 ha)	*Irrigated area (1 000 ha)*		*Increase*		*Irrigated area as percentage of arable land area in 1977*
		1971	*1977*	*1 000 ha*	*Percentage*	
1. *East Asia*						
China	105 550	43 000[a]	48 700	5 700	13.3	46
Republic of Korea	2 067	868	1 082	214	24.7	52
Subtotal	(107 617)		(49 782)			(46)
2. *South-east Asia*						
Burma	9 514	890	1 000	110	12.4	11
Indonesia	15 000	4 490	4 900	410	9.1	33
Lao People's Democratic Republic .	950	19	11	– 8	—	1
Malaysia	3 150	256	335	79	30.9	11
Philippines	5 250	920[a]	1 113	193	21.0	21
Thailand	15 750	2 106	2 576	470	22.3	16
Viet Nam	5 250	980	980	0	—	19
Subtotal	(54 864)		(10 915)			(20)
3. *South Asia*						
Afghanistan	7 910	2 360	2 480	120	5.1	31
Bangladesh	8 913	1 047	1 300	253	24.2	15
India	165 300	31 100	35 200	4 100	13.2	21
Iran	15 330	5 251	5 840	589	11.2	38
Nepal	2 300	117	200	83	71.0	9
Pakistan	20 040	12 986	13 800	814	6.3	69
Sri Lanka	1 009	439	540	101	23.0	54
Subtotal	(220 802)		(59 360)			(27)
Total	383 283	106 829	120 057	13 228	12.4	31

Source of arable land area and irrigated area: FAO, *Production Yearbook*, 1978.

Note: [a] As at 1972.

Table 2. Annual production and net imports of foodgrains of 16 developing countries in the ESCAP region

	Annual production of all cereals (1 000 tons)				*Average annual net imports (1 000 tons)*		
			Difference				
	1969-1971	*1976-1978*	*Amount*	*Annual rate of increase (percentage)*	*1969-1971*	*1976-1978*	*Difference*
	1	*2*	*3*	*4*	*5*	*6*	*7*
1. *East Asia*							
China	209 839	258 780	48 941	3.1	4 637	7 831	+3 194
Republic of Korea	7 507	9 424	1 917	3.3	2 625	3 421	+796
2. *South-east Asia*							
Burma	8 276	9 953	1 677	2.6	-643	-556	+87
Indonesia	21 711	27 399	5 688	3.4	1 260	2 609	+1 349
Lao People's Democratic Republic .	986	865	-31	—	67	114	+47
Malaysia	1 704	1 846	142	1.1	847	1 191	+344
Philippines	7 141	9 779	2 638	4.6	745	864	+119
Thailand	15 561	18 056	2 495	2.1	-2 798	-4 075	-1 277
Viet Nam	10 031	11 449	1 418	1.9	1 146	1 499	+353
3. *South Asia*							
Afghanistan	3 615	4 385	770	2.8	66	68	+2
Bangladesh	16 727	19 115	2 388	1.9	1 292	1 819	+527
India	111 146	134 253	23 107	2.7	3 617	2 348	-1 269
Iran	6 092	8 495	2 403	4.9	446	2 376	+1 930
Nepal	3 475	3 657	182	0.7	-248	-120	+128
Pakistan	11 668	14 714	3 046	3.4	-218	343	+561
Sri Lanka	1 495	1 654	159	1.5	954	1 138	+184
Total	436 884	533 824	96 940	2.9	13 795	20 870	+7 075

Sources of columns (1), (2), (5) and (6): FAO, computer printouts, March 1980.

Table 3. Growth rates in harvested area and yield of all cereals

	Harvested area of all cereals, 1 000 ha				*Unit yield of all cereals, tons per ha*			
	1969-1971	*1976-1978*	*Increase*	*Annual rate (percentage)*	*1969-1971*	*1976-1978*	*Increase*	*Annual rate (percentage)*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. *East Asia*								
China	114 744	127 936	13 192	1.6	1.83	2.02	0.19	1.4
Republic of Korea	2 148	1 897	-251	-1.9	3.50	4.98	1.48	5.2
2. *South-east Asia*								
Burma	5 140	5 266	126	0.4	1.61	1.89	0.28	2.3
Indonesia	10 825	11 123	298	0.4	2.01	2.46	0.45	2.9
Lao People's Democratic Republic .	680	703	23	0.5	13.2	1.23	-0.09	—
Malaysia	716	698	-18	—	2.39	2.64	0.25	1.4
Philippines	5 513	6 872	1 359	3.2	1.30	1.42	0.12	1.3
Thailand	7 743	9 682	1 939	3.2	2.01	1.96	-0.15	-1.1
Viet Nam	5 160	5 615	455	1.2	1.94	2.04	0.10	0.7
3. *South Asia*								
Afghanistan	3 193	3 391	198	0.9	1.13	1.29	0.16	1.9
Bangladesh	10 074	10 252	178	0.3	1.66	1.86	0.20	1.6
India	100 308	103 054	2 746	0.4	1.11	1.30	0.19	2.3
Iran	7 318	7 435	117	0.2	0.83	1.14	0.31	4.6
Nepal	1 981	2 200	219	1.5	1.75	1.66	-0.09	-0.8
Pakistan	9 673	10 125	452	0.7	1.21	1.45	0.24	2.6
Sri Lanka	622	824	202	4.1	2.40	1.99	-0.41	-2.8
Total	285 838	307 073	21 235	1.0	1.53	1.74	0.21	1.8

Sources of columns (1), (2), (5) and (6): FAO, computer printouts, March 1980.

Table 4. Increase in electric power generating capacity

	Installed generating capacity[a] in 1972 (MW)			*Installed generating capacity[a] in 1978 (MW)*			*Average annual growth rate of generating capacity, 1972-1978 (percentage)*		*Generation in 1978 (millions of kWh)*			*Per capita generation in 1978 (kWh)*	*Estimated hydro potential (MW)*	*Ratio of exploited capacity to total potential (percentage)*
	Hydro 1	*Thermal[b] 2*	*Total 3*	*Hydro 4*	*Thermal[b] 5*	*Total 6*	*Hydro 7*	*Thermal 8*	*Hydro 9*	*Thermal[b] 10*	*Total 11*	*12*	*13*	*14*
1. *East Asia*														
Hong Kong	—	1 835.4	1 835.4	—	2 920.3[c]	2 920.3[c]	—	12.3	—	8 333.1	8 333.1[c]	1 875.1[c]	—	—
Japan	20 734.0	64 562.0	85 296.0	27 316.0	103 901.0	131 217.0	4.7	8.3	74 647.0	484 804.0	559 451.0	4 857.0	51 499	53
Republic of Korea . .	341.1	3 874.3	4 215.4	712.0	6 950.0	7 662.0	13.0	10.2	1 808.0	31 511.0	33 319.0	894.0	2 301	31
2. *South-east Asia*														
Indonesia	308.9	480.1[d]	789.0	636.4	1 863.4[d]	2 499.8	12.8	15.4	1 298.7	3 422.1	4 720.8	33.3	31 500	2
Malaysia	293.2	726.7	1 019.9	354.8	1 661.8	2 016.6	3.2	14.7	751.0	7 030.6	7 781.6	586.9	1 958[e]	18
Philippines . . .	849.0	1 600.0	2 449.0	748.0	2 875.0	3 623.0	—	10.3	2 750.0	13 290.0	16 040.0	346.2	7 903	9
Singapore	—	729.0	729.0	—	1 610.0	1 610.0	—	14.1	—	5 898.0	5 898.0	2 526.6	—	—
Thailand	516.0	1 123.4	1 639.4	910.0	2 421.2	3 331.2	9.9	13.6	2 109.5	11 094.4	13 203.9	292.0	22 344[f]	4
3. *South Asia*														
Afghanistan	191.5	76.3	267.8	258.7	137.2	395.9	5.1	10.3	589.6	250.5	840.1	54.0	5 000	5
India	6 787.0	11 172.0	17 959.0	10 023.0[g]	16 152.0[g]	26 175.0[g]	8.1	7.7	38 019.0[g]	60 909.0[g]	98 928.0[g]	157.3[g]	42 096	24
Iran	804.0	2 100.0	2 904.0	1 804.0	6 785.0	8 589.0	14.4	21.6	6 249.0	13 598.0	19 847.0	561.0	14 000	13
Nepal	32.9	20.2	53.1	36.3[c]	26.0[c]	62.3[c]	2.4	6.6	128.1[c]	13.6[c]	141.7[c]	11.1[c]	83 000	.04
Sri Lanka	192.0	70.0	262.0	331.0	70.0	401.0	9.5	—	1 365.9	19.1	1 385.0	97.2	1 540	21
4. *Oceania*														
Australia	4 467.5	11 903.5	16 371.0	6 113.1	17 547.7	23 660.8	5.4	6.7	14 770.7	64 379.0	79 149.7	5 558.6	9 765	63
Fiji	—	52.8	52.8	—	103.6[c]	103.6[c]	—	18.3	—	261.8[c]	261.8[c]	445.2[c]	—	—
New Zealand . . .	3 270.6	822.5	4 093.1	3 766.0	1 857.0	5 623.0	2.4	14.5	16 209.0	5 484.0	21 693.1	6 933.0	8 435	45
Samoa	1.3	4.2	5.5	1.3	9.0	10.3	—	13.5	7.4	17.4	24.8	161.0	13.8	9
Total	38 789.0	101 152.4	139 941.4	53 010.6	166 890.2	219 900.8	5.4	8.7	160 702.9	710 315.6	871 018.5			

Source of columns (1), (2), (4), (5), (9), (10), (12), and (13): United Nations, *Electric Power in Asia and the Pacific, 1973* and *1978* (manuscript).

Notes:

[a] Public electric utilities and self-generating industries.

[b] Including steam, diesel, gas turbine and nuclear power generating units.

[c] As at 1976.

[d] Public electric utilities only.

[e] Peninsular Malaysia only.

[f] Including 13,761 MW of international rivers.

[g] As at 1977.

Table 5. Flood damage and flood control measures in countries or areas of the ESCAP region

	Maximum annual flood damage during 1972-1979				*Average annual damage, 1972-1979 (millions of US dollars)*	*Length of dikes (km)*		*Number of basins with flood forecasting systems in 1978*	*Annual expenditure on flood control works, 1978 (millions of US dollars)*
	Year	*Loss of life and missing*	*Area inundated and/or damaged (km²)*	*Damage*[a] *(millions of US dollars)*		*1970*	*1978*		
Typhoon-affected area									
Hong Kong	1972	209	—	14	4	28	. . .	—	. . .
Japan	1972	508	9 470	3 011	1 690	16 600	18 269	17	4 887
Malaysia	1978	—	242	2	1	. . .	406	5	4.6
Philippines	1972	884[c]	. . .	227	105	598	630	1	44
Republic of Korea	1972	682	153	114[b]	66	4 900	6 070	1	93
Thailand	1978	106	. . .	169	35	1 207	. . .	—	. . .
Viet Nam	1977	—	695	135	. . .	. . .	. . .	—	. . .
Subtotal					(1 901)				
Cyclone-affected area									
Australia	1974	50	. . .	416	82	. . .	. . .	120	. . .
Bangladesh	1974	2 225	. . .	380	. . .	. . .	4 469[d]	—	. . .
Burma	1975	—	. . .	129	42	. . .	. . .	—	. . .
India	1977	10 000	79 000	1 294	857	7 000	10 834	55	164[e]
Indonesia	1976	95	. . .	3	. . .	1 500	4 036[d]	—	150
New Zealand	1976	—	. . .	31	13	2 510	3 000	50	6.6
Sri Lanka	1978	1 000	. . .	88	. . .	119	. . .	—	. . .
Subtotal					(994)				
Total					2 895				

Sources: ESCAP, *Water Resources Journal,* June issues from 1973 to 1980; and country replies to secretariat's questionnaire for 1976, 1977 and 1978.

Notes:

[a] In 1975 prices.

[b] The damage in 1979 was $US 217 million, and there were 390 dead and missing.

[c] In 1978, 1,057 dead and missing.

[d] As at 1976.

[e] Total plan outlay for flood control Rs 6,750 million for period 1978–1963.

Table 6. Urban and rural water supply

	Total population in 1975		Total population in 1980		Population served in 1975				Population served in 1980				Population expected to be served in 1980			
					Urban		Rural		Urban		Rural		Urban		Rural	
	Urban (thousands)	Rural (thousands)	Urban (thousands)	Rural (thousands)	Number (thousands)	Percentage	Number (thousands)	Percentage	Number (thousands)	Percentage	Number (thousands)	Percentage	Number (thousands)	Percentage	Number (thousands)	Percentage
1. *South-east Asia*																
Burma	7 197	23 077	8 407	25 122	2 159	30	3 000	13	2 564	30.5	4 120	16.4	...	56	...	...
Indonesia . . .	25 700	106 700	29 200[a]	114 400[a]	9 000	35	6 400	6	10 500[a]	36	20 597[a]	18	27 000	75	57 500	42
Malaysia (Peninsular)	...	...	4 441[b]	6 536[b]	...	...	...	...	3 917[b]	88.2	2 618[b]	40.1	...	100	...	100
Philippines . . .	12 970	30 600	17 900	30 700	8 300	64	10 100	33	13 100	73	14 100	46	...	85–88[c]	...	80[c]
Singapore	...	...	2 390	—	...	...	—	—	2 378	99.5	—	—	...	...	...	...
Thailand	6 900	34 970	...	37 000	1 640	24	...	...	...	...	11 100	30	...	...	...	...
2. *South Asia*																
Afghanistan . . .	...	...	2 290[d]	11 040[d]	...	...	...	...	460	20	880	8	1 700[e]	55[e]	...	...
Maldives	...	...	33	125	...	...	...	...	4	12	0.7	0.5	...	...	...	...
Nepal	623	12 105	820	13 589	450	72	542	4	680	83	904	6.6	1 314	100	11 378	66
Pakistan	...	...	23 051	59 620	...	...	...	...	15 681	68	10 300	17.3	35 332	100	48 870	66
Sri Lanka . . .	3 079	10 550	3 313	...	1 447	47	1 477	14	1 590	48	...	...	3 922	100	8 101	60
3. *Oceania*																
Fiji	190	392	230	415	152	80	235	60	193	84	307	74	...	...	...	...
Samoa	36	110	48	129	32	90	66	60	43	95	110	85	...	...	...	...
Solomon Islands . .	...	...	20.7	190	...	...	...	...	19.6	95	45.6	24	...	...	...	...
Tonga	...	...	...	95.6[f]	...	...	...	...	...	...	76.4[f]	79.9	...	...	...	...

Sources: Country reports for preparation for the International Drinking Water Supply and Sanitation Decade, 1980.

Notes:

[a] As at 1979.
[b] As at 1978.
[c] As at 1987.
[d] As at 1979, excluding 2,250,000 nomads.
[e] By the end of 1988.
[f] Including urban and rural population.

Table 7. Growth rate of population served by, and level of service of, urban water supply in 1980

	Growth rate of served population, 1975-1980 (percentage)		Level of service of urban water supply in 1980		
	Urban	Rural	Continuous or intermittent supply of water	Percentage of population served with house connexion	Average consumption (litres per capita per day)
1. *South-east Asia*					
Burma	3.5	6.5	...	16	...
Indonesia	4.0	34.0	...	53	...
Philippines	9.6	7.0	...	31	...
2. *South Asia*					
Afghanistan	...	...	Intermittent	...	10–40
Nepal	8.6	10.8	Intermittent	34	40–50
Pakistan	...	...	Intermittent	30	114
Sri Lanka	1.9	...	...	56	...
3. *Oceania*					
Fiji	4.9	5.5	...	100	140–300
Samoa	6.0	10.8	...	100	...
Solomon Islands	...	...	...	95	...

Source of information on level of service: Country reports for the International Drinking Water Supply and Sanitation Decade, 1980.

II. RURAL COMMUNITY WATER SUPPLY AND RURAL SANITATION IN RELATION TO OVER-ALL MANAGEMENT OF WATER RESOURCES

(E/ESCAP/NR. 7/2)

Note by the secretariat

The following report, prepared by the World Health Organization on rural community water supply and rural sanitation in relation to over-all management of water resources, is well researched and places in proper perspective the magnitude of the rural water supply and sanitation problem and its relation to the over-all management of water resources.

It is pointed out that water resources development, including the provision of water supply, has an important environmental health impact. This is particularly true in the provision of water supply facilities. While such facilities improve the health of the population by providing reasonable access to safe water, the same facilities could also actually cause some problems if the waste water were not properly disposed of. A number of environmental problems arising from water resources development with particular reference to the rural community are mentioned.

The main problems, however, may be succintly stated as (a) competition for the allocation of the available water resources among competing demands and (b) the host of problems associated with the provision of rural water supplies, the major ones being inadequate financial and manpower resources, lack of a data base, improper maintenance of existing facilities, institutional problems, lack of public participation and health education programmes designed to overcome old social customs and habits in order to make the facilities acceptable to the rural population, and low priority assigned to the sector in national economic and social development plans.

The core of the strategy recommended to overcome the above problems is the adoption of a minimum needs small-scale project approach for rural areas, together with the use of appropriate technology in the functional and structural design of the projects. The simplicity and low cost of such projects would also minimize maintenance problems. The problem of competing demand for water of the various sectors can be minimized through the establishment of national water resources data systems to provide an adequate data base for the appraisal of the water resources in each country.

* This paper was prepared by the South-East Asia Regional Office of the World Health Organization, New Delhi, with the assistance of Professor M. B. Pescod, University of Newcastle-upon-Tyne, United Kingdom, who acted as a short-term consultant.

INTRODUCTION

It is indeed a matter of regret, and perhaps a reflection on our priorities in planning, that even today a large portion of the world's population does not have reasonable access to such basic amenities as a safe water supply and proper disposal of excreta and domestic wastes. Often this is because not enough attention has been paid to the needs of rural water supply and sanitation in the over-all management of water resources programmes in the developing countries.

By integrating rural needs into their over-all plans and by concurrently incorporating environmental and health aspects in their planning process, water resources planners will contribute successfully to an acceleration in the pace of rural water supply and sanitation programmes and to a reduction in water-borne and water-related diseases.

The report of the 1976 ESCAP Regional Preparatory Meeting for the United Nations Water Conference included a section on rural community water supplies as a special issue of great significance in the ESCAP region. In 1977 the United Nations Water Conference in Mar del Plata, Argentina, stressed the need for the systematic planning of the distribution of water among various users and the co-ordination of community water supply and waste disposal planning with over-all economic development. The Conference's Action Plan for Community Water Supply and Sanitation called for improved co-ordination at the country level and regular consultation among the Governments, international organizations and non-governmental organizations concerned.

The Mar del Plata resolution on community water supply recommended, **inter alia,** that "national development policies and plans should give priority to the supplying of drinking water for the entire population and to the final disposal of waste water", and Governments were asked to "adopt programmes with realistic standards for quality and quantity to provide water for urban and rural areas by 1990, if possible". A recommendation was made and latter endorsed by the United Nations General Assembly to designate the period 1981-1990 as the International Drinking Water Supply and Sanitation Decade. Noting these recommendations the Thirtieth World Health Assembly in 1977 urged member States:

(1) To appraise as a matter of urgency the status of their community water supply, sanitation facilities and services and their control;

(2) To formulate within the context of national development policies and plans, by 1980, programmes with the objectives of improving and extending those facilities and services to all people by 1990, namely within the International Drinking Water Supply and Sanitation Decade; and

(3) To ensure that people consume water of good quality by periodic inspections of water sources and treatment and distribution facilities, by improving public education programmes on the hygiene of water and wastes, and by strengthening the role of health agencies in this respect.

A. MAGNITUDE OF THE RURAL WATER SUPPLY AND SANITATION PROBLEM

1. Demographic information

About one half of the world's population of more than 4000 million live in Asia and the Pacific region and make up two-thirds of the world's developing country population. Member countries of the WHO south-east Asia region[1], with a total estimated population of 1,082 million in 1980, account for roughly one third of the population in developing countries. In this same region, the rural population, which was about 685 million in 1970 (81.3 per cent of the total population) is expected to reach 845 million (78.1 per cent) by 1980. Approximately 518 million people live in absolute poverty[2] in south, east and south-east Asia and this makes up 89 per cent of the world's poverty population. The number of absolute poor has increased since 1970 because of high population growth rates and the failure of policies to redistribute income adequately or raise the productivity of those afflicted by the course of poverty.

The large proportion of the total population living in rural areas (ranging from 72.9 to 94.3 per cent for countries in the south-east Asia region), combined with the large number of communities and high population densities in many countries, make rural community water supply and sanitation a formidable task in the region.

2. Targets for rural community water supply and sanitation

The WHO mid-decade review of 1976 considered the progress achieved in different regions and, in keeping with such rates of progress, proposed regional targets for 1980 and required investment levels. These

[1] Bangladesh, Burma, Democratic People's Republic of Korea, India, Indonesia, Maldives, Mongolia, Nepal, Sri Lanka and Thailand.

[2] "Absolute poor" includes those people who *per capita* income is below the level at which, in that country, it is possible to secure the minimum requirements of life, i.e., essentially nutrition, clothing and shelter.

Table 8. Rural population coverage and targets — WHO south-east Asia region

Decade	Year	Est. rural population (millions)	% rural population covered or targeted	
			Water supply	Sanitation
Second UN Development Decade (1971–1980)	1970 (covered)	676	9	4
	1975 (covered)	750	19	6
	1980 (target)	835	35 (35)	15 (60)
International Drinking Water Supply and Sanitation Decade (1981–1990)	1990 (target)	922	100	50

Note: ( ) values shown in brackets refer to WHO western Pacific region.

proposals were approved by the 29th World Health Assembly in 1976 and included a 1980 target for the WHO south-east Asia region of 35 per cent coverage of the rural population with reasonable access to safe water supply and 15 per cent coverage with rural sanitation (see table 8). Equivalent target figures for the western Pacific region of WHO were 35 per cent and 60 per cent coverage, respectively.

Following the United Nations Water Conference, WHO in co-operation with the World Bank carried out a rapid assessment exercise and prepared rapid assessment reports of member States in 1978. These reports included anticipated coverage of rural water supply and sanitation and indicated that many countries were not contemplating achieving full coverage of the population with either service by 1990.

A recent regional consultation meeting of WHO south-east Asia region member States held in New Delhi reconsidered these rapid assessment report projections and revised 1990 targets were proposed for the region. It was agreed that all countries should try to achieve 100 per cent coverage of the population with a minimum service level of access to safe water, although it was realized that certain areas with specific problems might not be served. A maximum feasible level of 50 per cent coverage of the rural population with sanitation was also agreed to, but general feeling was that this could be achieved only if radical organizational changes were made to deliver the service. Table 9 indicates country requirements for improved sector performance in 22 countries of the ESCAP region.

3. Present levels of service vis-a-vis targets

For rural communities in Asia and the Pacific, the criterion of minimum service level is "reasonable access to safe water", which generally implies that the housewife or members of the household do not have to spend a disproportionate part of the day in fetching water for the family. The source of supply might be a treated surface water or, perhaps more likely, an untreated but uncontaminated water, such as that from protected boreholes, springs and sanitary wells. Tables 7 and 10 show the position in the WHO south-east Asia region and countries of the ESCAP region, from the data available.

The levels of service mentioned in tables 7 and 9 do not necessarily imply levels of utilization, particularly when poor and inappropriate design has led to social unacceptability. As rural communities are increasingly served with water supply, consideration will have to be given to general sanitation in villages.

4. Investment needs to achieve targets

To achieve the 1990 global targets set for the International Drinking Water Supply and Sanitation Decade it was estimated[3] that the then level of investment for the rural phase alone (estimated at $US 1,545 million during 1975-1980) would have to be increased 3.9 times for rural water supply and 4.0 times for excreta disposal (at 1977 price levels), assuming the same levels of service and methods of implementation as in the past. The oil crisis is likely to add significantly to the costs of achieving the 1990 targets and will probably strain the ability of governments to divert national resources to the sector in those developing countries which have to import oil. If the unserved population is to be reached and the sector is not to take up a disproportionate share of the national development budget in developing countries of the region, political commitment and new approaches will be required in the planning and implementation of rural water supply and sanitation programmes.

[3] Report on Community Water Supplies, prepared by WHO in collaboration with the World Bank for the United Nations Water Conference, Mar del Plata, March 1977, E/CONF.70/14, 19 January 1977.

Table 9. International Drinking Water Supply and Sanitation Decade (1981-1990): country requirements for improved sector performance in the ESCAP region

Country	WHO/RO	CGC	GNP/QOLI/PCRP	Sector planning	Sector finance		Project development				Sector management			
					TA+CA	ICG/TAR	Proj. Id.	Proj. Prep.	SOSI		Institutional		O & M	Manpower Dev.
									GW	SW	Reorg.	Coord.		
Afghanistan	EM	1A	190/ –/87	X	X	X	X	X				X	X	X
Bangladesh	SEARO	1A	90/18/91	X(r)san	X	X		X(L)			X		X	X
Burma	SEARO	1A	140/57/75	X(r)san	X	X	X(L)		X	X	X	X		X
Fiji	WP	3C	1 210/79/67	X	X	X		Xsan	X			X	X	X
India	SEARO	1A	150/31/79	X(r)san	X(CA)	X			X		X	X	X	X(r)
Indonesia	SEARO	1A	300/48/82	X(r)san	X	X	X(L)	X(L)	X		X	X	X	X
Iran	EM	3B	2 160/37/55	Xsan		X								X
Malaysia	WP	2C	930/73/70	X(r)san	X	X		Xsan	X			X	X	X
Maldives	SEARO	1A	90/NA/80	Xsan	X	X		X(IP)					X	X
Mongolia	SEARO	2A	830/NA/52	X	X		X							X
Nepal	SEARO	1A	110/27/96	X	X	X		X(IP)			X	X	X	X
Pakistan	EM	1A	190/28/74	X(r)san	X	X		X(L)					X	X
Papua New Guinea	WP	2B	490/42/87	X(r)san	X		X(r)san	X(r)san				X		X
Philippines	WP	2B	450/69/66		X	X		X	WPC			X(IP)	X	X(IP)
Republic of Korea	WP	2C	820/80/40		Xsan	X		Xsan					X	X
Samoa	WP	1B	280/ – /80	X(r)san	X	X			WRM			X	X	X
Singapore[a]	WP	3C	2 880/93/ 0											
Solomon Islands	WP	1B	250/ – /90	X	X	X			X			X(IP)	X	X
Sri Lanka	SEARO	1A	200/79/76		X	X	X	X			X		X	X
Thailand	SEARO	2A	420/67/86		X	X		X			X	X		
Tonga	WP	—	—	X(r)san	X		Xsan	Xsan	X					
Viet Nam	WP	1A	160/ – /80	X	X			X	X	X			X	

[a] Government fully capable of resolving any sector problems.

Legend:

WHO/RO	World Health Organization/Regional Office	GW	Ground water
SEARO	Southeast Asia Regional Office	SW	Surface water
WP	Western Pacific	Reorg.	Reorganization
EM	EMRO, Eastern Mediterranean, Alexandria	Coord.	Coordination and improvement
CGC	Country group classification. See table, national and sector data relevant to Decade planning	O&M	Operation and maintenance
		Manpower dev.	Staffing and training of sector personnel (all levels)
GNP/QOLI/PCRP	*Per capita* gross national product/quality of life index/percentage rural population	(IP)	In progress
		(P)	Planned
Sector planning	Policies, priorities, targets and programming	(r)	Rural area
TA	Technical assistance	san	Sanitation
CA	Capital assistance	WRM	Water resources management
ICG/TAR	Internal cash generation/tariffs	(L)	Large projects
Proj.Id.	Project identification	WPC	Water pollution control
Proj-Prep.	Project preparation	X	Country requirement
SOSI	Source of supply investigation		

Table 10. Rural water supply and sanitation coverage in 22 countries of the ESCAP region

Country	Population (million)	Rural population (percentage of total)	Percentage of rural population covered[a] Safe water	Sanitation
Afghanistan[b]	15.5	71	8	Very low
Bangladesh	81.2	91	50	Very low
Burma	31.5	75	14	5
Fiji	0.6	67	62	93[c]
India	631.7	79	10	8
Indonesia	133.5	82	6	20
Iran	34.8	55	33	NA
Malaysia	13.0	70	49	63
Maldives	0.1	80	5.3	Very low
Mongolia	1.5	52	NA	NA
Nepal	13.3	96	5	Very low
Pakistan	74.9	74	17	2
Papua New Guinea	2.9	87	10	10[c]
Philippines	44.5	66	34	33
Republic of Korea	36.4	40	36	NA
Samoa	0.2	80	23	95
Singapore	2.3	0	—	—
Solomon Islands	0.2	90	24	20
Sri Lanka	14.1	76	13	56
Thailand	43.8	86	12	30
Tonga	0.11	50	77	100
Viet Nam	50.6	80	20	NA

Source: National sector and data sheets of countries of the ESCAP region.

[a] Derived from WHO/World Bank sector, rapid assessment and other reports prepared at different times.

[b] Figures from country report.

[c] Stated figure may be an overestimate according to ESCAP national and sector data sheets.

B. WATER RESOURCES DEVELOPMENT AND RURAL WATER SUPPLY AND SANITATION

1. The need for a new strategy

The development of water resources, involving as it does the development of irrigation systems, power generation, urban and rural water supply, flood control and drainage, has often concentrated more heavily on irrigation, power generation and urban water supply, for which volumetric flow requirements (and consequently capital investment requirements) have been very large indeed, compared to rural drinking water supply requirements; it has been assumed that the relatively small drinking water supply needs of the rural communities in the region served would somehow be easily met from the large flows brought into the ESCAP region.

Unfortunately, this approach has not proved satistory, since it has tended to neglect water quality, water-related diseases, environmental sanitation and, above all, the entire environmental impact of water resources development projects on health and the ecosystem. It is, therefore, suggested that a new strategy be called for, in which all aspects of the problem are integrated into a balanced and systematic consideration of the whole. Such a strategy involves water resources planning at both the macro- and micro-levels, co-ordination of the inter-sectoral aspects, and includes an environmental impact assessment. The rural community, generally the weakest and most defenceless sector of human society, must not be forgotten, as that community is the subject and object of all rural development projects. In fact, much economy can be achieved by undertaking wherever possible multi-purpose projects which include rural water supply and sanitation along with irrigation, power generation or other uses, rather than leaving the former to later planning and execution, all too often by another agency. Co-ordination between different agencies at the early planning stage could lead to considerable economies and to a conceptually more satisfactory and optimum solution.

Since expenditure on water resources comprises a sizable proportion (generally between one sixth and one half) of the total development expenditure in developing countries of the ESCAP region, it provides a convenient entry point through which to channel resources.

Large- and medium-scale dam construction has been a feature of water resources development throughout the region. Unfortunately, this type of scheme has benefitted relatively few people in rural areas, although the fortunate few have had their incomes and land value increased through complete government subsidy.[4] Thus, even in rural areas, these larger schemes have been inequitable in the distribution of benefits but in addition, particularly when power production has been an important component, major benefits have been derived by urban dwellers.

Another serious shortcoming of irrigation dams has been the lack of planning for the farmer's end of the water delivery system. Poor planning has resulted in canal distribution systems being incomplete and, even where they have been built, no provisions were made for operation and maintenance. Consequently, many of the potential benefits have never been realized and large rural populations remain in abject poverty. Even when large numbers of people had to be resettled as a result of a reservoir inundating a broad area, the evidence suggests that no attempt was made, at least in earlier projects, to provide new settlements with safe water and suitable sanitation facilities.

[4] There are of course a few exceptions to this general trend, such as the irrigation works works in Tamil Nadu State, India, where the over-all shortage of water resources has resulted in the development of a large number of minor irrigation works in which the domestic drinking water needs of communities are incorporated.

One of the most imaginative water resource developments in the world is the lower Mekong River basin development scheme within the ESCAP region. The Committee for Co-ordination of Investigations of the lower Mekong Basin (now the Mekong Interim Committee) has, over the years, endeavoured to promote improvements in environmental health facilities in the basin through studies of existing services and advice on the best use of available resources for the phased development of water supplies, sewerage and drainage, refuse disposal and rural sanitation. Its impact in rural areas has, however, been somewhat limited, as indicated by the statistics on coverage of rural water supply and sanitation in riparian countries of the Lower Mekong.

In recent years there has been a tendency to encourage a change in emphasis in water resources development from large-scale projects to small projects designed to satisfy the basic requirements of all rural communities in a region. Apart from the experience in Tamil Nadu, India, cited earlier, a promising strategy for the development of small-scale rural water resources has recently been delineated for north-east Thailand in a study undertaken for the Water Resources Planning Sub-Committee of the National Economic and Social Development Board.[5]

A preliminary survey indicated that large schemes had provided irrigation water to only about 3 per cent of the population in north-east Thailand but, by improving the distribution systems, they could reasonably be extended to cover 8.9 per cent of farmer families. Reliable rivers in the region could provide pumped irrigation for a further 10 per cent of the population, leaving another 80 per cent still to be supplied from other sources. For all areas inaccessible to large reservoirs or reliable rivers, small water projects of different types have been recommended for development over the next five years to provide a minimum supply of water for minimal supplementary irrigation of crops, minimal dry season watering of garden plots, watering of animals and domestic water needs. A "bottom-up" approach for project development and a large measure of villager participation and self-help is anticipated in planning and implementation of the programme. From the point of view of the Decade objectives, advantage must be taken during the implementation of such schemes to incorporate, at the very least, simple systems to ensure safe water for domestic use and sanitary excreta disposal.

2. Integrated rural development

Wherever a particular project of integrated rural development is being planned, the water supply and sanitation component should be an integral part.

To rely on rural development to achieve the Decade targets would, however, imply total integrated rural development for all by the year 1990, which is just not possible. The problems of planning large-scale programmes of total rural development are too numerous to contemplate, but this approach can be followed in many a rural area where integrated development is already being planned.

Being agriculturally based, rural communities without access to water resources will be unable to produce sufficient food to maintain a reasonable caloric intake and health will be poor. Providing for their basic needs in irrigation and animal watering as well as safe water and excreta disposal should go a long way towards promoting the health of rural people and improving their quality of life. Social productivity and economic growth rely on a sound health base which in turn is dependent on water resources development and primary health care facilities in rural areas.

Too often, large irrigation and hydropower schemes have brought improved agricultural productivity in rural communities within their influence but no improvement, and perhaps a deterioration, in environmental health. A recent study carried out for the Mekong Committee as part of the Nam Pong Environmental Management Research Project (supported by the Ford Foundation) looked into the state of health of rural communities in the area of the Nam Pong scheme in north-east Thailand, completed more than ten years before. It was found that the most common complaints of villagers in resettlement, irrigation, lake-side and traditional communities were gastro-intestinal disturbances, fever and respiratory tract infections. Parasitic infections were high, with **Giardia lamblia** and **Entamoeba coli** predominating among protozoal infections and hookworm and **Opisthorchis viverrini** (liver fluke) being common helminthic infections in all groups of people.

The health implications of water resources development are not limited to the spread of gastro-intestinal infections; many more communicable diseases might be promoted by poor project planning. A 1979 World Bank Report[6] presented a convenient classification of water-related diseases, together with useful information on modes of transmission and possible control measures which will be of use to water resource planners. It is essential that the adverse health impacts of water resources projects, of any scale, should be assessed and counteracted before implementation. Effective sanitation is an important barrier to disease transmission and should not be seen as of secondary importance to water supply; the two are interdepen-

[5] Asian Institute of Technology, *Water for the North-east: A Strategy for the Development of Small-Scale Water Resources*, vol. 1, Main Report (Bangkok, 1978).

[6] World Bank, *Appropriate Technology for Water Supply and Sanitation — Health Aspects of Excreta and Wastewater Management*, 4 vols. (1979).

dent and should be developed together in rural communities.

In recent years, international and bilateral agencies have insisted on some assessment of environmental impact before agreeing to loans for water resources schemes. Environmental health has always been an important component of assessments carried out in the ESCAP region. Such assessments would also include beneficial impacts of a project, but rarely has the provision of rural water supply and sanitation been an essential component of such benefits. Even where resettlement of people living in an area to be inundated has been given important consideration, safe water supply and sanitation for them in their new location have often been neglected, as was the case with the Nam Pong project in Thailand. Water resource planners could give significant impetus to national programmes for meeting Decade targets if rural water supply and sanitation were made required objectives in all water resources projects wherever feasible.

C. INTERACTION BETWEEN HEALTH, WATER RESOURCES MANAGEMENT, RURAL WATER SUPPLY AND SANITATION

1. Environmental health impact of water resources development

In its final recommendations, the United Nations Water Conference draws pointed attention to the need to include consideration of diseases associated with water as an integral part of water assessments and consideration of the interrelationships of water quality, quantity and related land use (Recommendation A-3(e)).

Water resources development primarily affects land use patterns, leading to a series of consequences such as the following, all of which affect man's health, his socio-economic well-being and the natural ecosystem as a whole. Thus, water resources development generally tends to increase:

(a) Economic activity and the inflow of migrant labour;

(b) The density and spread of habitation (and consequently poorer sanitation);

(c) Agricultural and industrial pollution of surface and ground waters downstream;

(d) Difficulty in meeting drinking water quality standards;

(e) The incidence of water-borne and parasitic diseases in the region (e.g. malaria, schistosomiasis);

(f) The rate of deterioration of soil drainage and other characteristics;

(g) The eutrophic state of receiving water bodies.

It is essential to include a careful assessment of all the above impacts in a scientific planning procedure for water resources development. Consequently, the above mentioned impacts are discussed below with special reference to the rural community.

2. Economic activity and inflow of migrant labour

Large-scale irrigation and hydropower projects usually involve migrant labour during the construction period and might attract people from different regions for the employment opportunities arising after implementation. These immigrating populations frequently bring with them types of disease which are not indigenous to the area and are themselves exposed to infections which they have not previously experienced. If the associated health problems (for example, malaria) are not anticipated and provisions made for safe water supplies and sanitation as well as health care, the consequences can be very serious.

3. Density and spread of habitation

Increased employment opportunities and inflow of labour lead to increased density and spread of habitation, which in turn require that new sources of drinking water supply be sought and improvements in distribution of these supplies be undertaken. Concomitant problems with waste-water disposal and general rural sanitation invariably arise, demanding proper location and construction of sanitary facilities. Better protection of ground and surface waters is necessary, since poorer sanitation is to be expected in a community whose density and spread have rapidly increased.

Defecation in open fields, in the bush or directly into streams are common practices throughout the ESCAP region where proper sanitary disposal devices are not available. This causes high pathogen levels in surface waters, particularly just after rainfall when the first flush carries the bulk of the contamination. Improper construction and poor location of borehole and pit latrines as well as poor protection of wells will result in ground water being contaminated with pathogenic organisms in spite of the original high quality of the water in many aquifers. Surface springs must also be adequately protected if they are to provide a safe supply for rural communities. Thus, even the simplest water systems need careful planning if they are to meet the quality requirements of the Decade at low cost. Local protection of ground-water sources is frequently effective but surface waters will generally require some form of treatment, since controlling their contamination by human, animal, agricultural and industrial wastes is not practicable.

4. Agricultural and industrial pollution

Increasing and poorly-controlled use of herbicides, pesticides and fertilizers are causing the concentrations of these substances to build up in rivers, ponds and reservoirs throughout the ESCAP region. Some of the compounds used might be persistent, toxic or bio-accumulative and give rise to primary and secondary effects which might seriously limit use of the water for potable purposes. The provision of water to rural communities might well aggravate the situation if increased agricultural output is achieved through increased use of chemicals. Unless the farmer is instructed in the proper application o fthese materials and adopts proper management practices, excess amounts will show up in surface waters and, inevitably, in his drinking water.

Industrial development is often considered to be an urban phenomenon but, with increasing growth of agro-industry in Asia and the Pacific, the tendency is to locate processing plants where the produce is grown. Uncontrolled growth of agro-industry in rural areas and free discharge of highly-polluting wastes have resulted in serious deterioration of the quality of many surface waters, making them unsuitable as a source of drinking water. Rural communities have lost their traditional water supplies through the development of sugar cane processing, tapioca flour manufacture and palm oil refining on rivers whose water is necessary as process water, for cooling and for the reception of wastes. In some cases, where profit margins are low, the imposition of stringent pollution control on agro-industry would force plants to close down, with consequent loss of employment and social upset in rural areas.

5. Drinking water quality requirements

Once a reliable source or combination of sources has been identified to provide the quantity of water required for the needs of a rural community, the quality of the supply for domestic use must be considered. Even though the provision of sufficient water for household needs is known to improve environmental health conditions, but its quality also has a profound effect on the well-being of people. The World Health Organization, the World Bank and other agencies are at present supporting studies on the health impact of water supplies, but even without such confirmatory data, the objectives of the Decade clearly demand a safe supply. In rural areas where water sources might be limited, "safe" will normally mean bacteriologically and parasitologically safe and free from toxic materials.[7] It will not imply achievement of all water quality standards recommended, for example, in the WHO International Standards for Drinking Water.

The quality of raw water will vary, depending on the source, and often little choice will be possible in rural areas. Ground water will usually provide the best quality of raw water when it is available, but poor sanitation will be a hazard wherever dug (or shallow) wells are common. Ground water is, however, likely to contain dissolved impurities and chemicals leached from the soil (for example, fluorides, iron, manganese, etc.). Bangladesh is a case in point, where in certain areas ground water is readily available but is of unacceptable quality owing to these chemicals. The intensive use of fertilizers may also increase the nitrate concentration of ground waters and make them undesirable for drinking purposes. Rainwater is generally the only source of drinking water in the absence of other sources in rural areas of developing countries (for example, in Maldives and south Thailand), but its storage often causes problems and results in contamination. Surface water sources, such as rivers and ponds, are likely to be highly contaminated wherever rural population densities are high, agricultural run-off occurs and industries release wastes but it is impossible and uneconomical to attempt to maintain drinking water quality in such water resources. The system required to produce safe water will generally increase in technical complexity and cost as the quality of the source decreases.

The surveillance of water quality is one of the objectives of the International Drinking Water Supply and Sanitation Decade and increasing importance is expected to be placed on the maintenance of a safe supply. It is no longer considered acceptable to install systems which merely have the capability of producing safe water; they must be monitored regularly to be proved effective.

6. Possibility of water-related parasitic diseases

Large-scale water resources projects can disturb the natural balance of the ecosystem and have been known to lead to unexpected problems with water-related parasitic diseases arising from, for example, mosquito breeding in poorly drained areas and shallow

[7] Under the minimum requirements for water quality, one should include aesthetic acceptability to the people (consumers). This is important because even if a water supply provided is bacteriologically and chemically safe, but is aesthetically unacceptable (for example, it it is too hard, foul smelling, highly coloured, too hot, etc.) the people will not use the water and revert to water sources which are more acceptable but polluted.

water fringes around impoundments, leading to malaria, filariasis, and even yellow fever and dengue in certain regions.

The present resurgence of malaria in south Turkey is a case in point, where large-scale agricultural activity in irrigated but poorly drained soils has aggravated the situation and the ultimate solution is not the use of more insecticides (the mosquitoes are already resistant to most types of insecticides) but proper drainage to remove breeding grounds. Similar conditions exist in other countries.

Other water-related parasitic diseases which have spread rapidly on introduction of large-scale water resources development are schistosomiasis and onchocerciasis. Considerable precautions in planning and implementation are required to prevent such diseases from occurring.

7. Deterioration of soil characteristics

The water resources developer interested in irrigation projects is generally all too familiar with the ill effects of water-logged soils and alkaline conditions on crop yields and soil characteristics, and it is, therefore, not necessary to discuss this question further. One need only remember that any harm to the rural community's means of livelihood will have a direct effect on its health and well-being, and on future land-use patterns.

8. The trophic status of receiving water bodies

Rivers and canals often carry considerable amounts of nutrients (carbon, nitrogen and phosphorus) which drain into them from the natural surface run-off over their catchments. The nutrients washed into the rivers and canals depend upon the nature of the catchment area, and on urban and industrial developments within it, namely, on the land-use pattern.

The greater the concentration of the nutrients, the higher is the algal productivity and the "trophic state" of the receiving water and, as is well known, eutrophic conditions are undesirable and should be avoided to allow use of the water for community drinking water supplies without excessive treatment and to preserve the water resource itself for future generations.

Thus, water resources development is likely to have many environmental effects including health, social, ecological, cultural and aesthetic impacts. Most of these impacts again have an indirect effect on human health.

D. RURAL WATER SUPPLY AND SANITATION PROGRAMME PLANNING AND FUNDING

1. Basic policy

Developing countries in Asia and the Pacific region will meet the Decade targets for rural water supply and sanitation only if national policy decisions are taken to divert additional resources to the sector through a reordering of priorities. The political will to achieve such a restructuring of national policy can come only from the top.

Once the political backing for a national policy has been provided, a strategy for planning and implementation of rural programmes must be developed. The most that can be attempted, assuming a fair amount of self-help, is the provision of very simple sanitary services to all rural communities over the Decade. The possibility of including rural water supply and sanitation in programmes of water resources development or integrated rural development as discussed earlier should certainly be considered in formulating a national strategy. Each country will have its own approach to rural development, depending on local geographical, climatic and socio-economic conditions, and it is essential that suitable criteria for the identification of new projects be evolved carefully so that the programme most acceptable to the rural population is implemented in a manner consistent with local expectations and resources.

Integrated rural development and water resources development both provide sensible approaches through which self-help might easily be organized. The district development worker, if properly trained and technically supported, can be the focus of plan implementation. The health worker should also be included in plans to provide water supply and sanitation as part of primary health care. Health education, both for the worker as well as the general public, will usually be a very important input into rural sanitation programmes.

Planning "from the top" has rarely succeeded and it is essential that the recipient communities and local administrations be involved in projects from the early stages of planning, since they are the ones most likely to perceive their real needs in an integrated rural development programme. To a certain extent a reversal of the planning process is called for so as to leave the basic decision-making process in the hands of the rural communities, once the development strategy has been tentatively formulated.

2. Past funding

Rural water supply has been accepted as a social investment without financial returns in most countries of the ESCAP region. In a few countries, a measure of consumer participation has been realized. For example, in Thailand contributions ranging from 20 to 44 per cent of the capital costs were made (mostly in cash) and in India more costly piped systems were based on consumer cost-sharing in cash, materials and/ or labour, depending on ability and local conditions. Rural sanitation has yet to be accepted as a high priority in most developing countries of Asia and the Pacific, except for Sri Lanka and Thailand where community involvement has demonstrated an encouraging result. Economic criteria previously applied to loans by external funding agencies hindered the flow of external aid to rural water supply and sanitation, and internal funding was not adequate for the massive programme of work facing most developing countries of the region as a result of past neglect.

3. Economic appraisal

Conventional economic evaluation terms such as benefit-cost and credit-worthiness are irrelevant in the context of providing basic rural sanitary services when human dignity and quality of life are at stake. It is encouraging that the earlier rigidity of national planning and international lending has given way to much greater flexibility in approaching rural community water supply and sanitation and the commitment of countries in the region to the objectives of the Decade should allow the acceleration of rural programmes.

4. Ability and willingness to pay

Any serious attempt to provide safe water and sanitation to all rural people in any developing country in Asia and the Pacific over the next decade must depend, in part, on the willingness of consumers to pay. Their ability to pay will vary, however, from country to country and from community to community. In some countries of the region this willingness to pay has been demonstrated, in others the approach has had only marginal success, or there has been no attempt to introduce it. The self-help approach is essential to success and countries must accept it and plan for its incorporation in programmes of rural water supply and sanitation.

5. Internal resources

The increased rate of investments required to meet the Decade targets for rural water supply and sanitation on a global scale has been mentioned. Even with increased external funding and consumer contributions, national commitments to the sector will have to increase dramatically over current levels in all countries of the ESCAP region. A high sectoral priority in national plans signifies a country's recognition of its importance and is the first step towards augmenting funds for the programme.

India may be taken as an example of increasing commitment to the sector in successive national plans, as indicated in table 11. With the earlier low percentage allocations in a country with such a large population, it is not surprising that a huge backlog of rural water supply and sanitation service has accumulated. In fact, most of the sector allocations have been invested in water supply on a "worst-first" approach, almost to the exclusion of rural sanitation. Bangladesh has achieved remarkable progress in rural water supply with a rural sector allocation of about 0.5 per cent of the total public sector outlay in the first five-year plan (July 1973 - June 1978), but also with massive UNICEF assistance. Again no progress has been made with rural sanitation. In Thailand, rural water supply schemes have qualified for an 80 per cent grant in aid from the Government and a 20 per cent loan for villages with populations of less than 500 and about a 56 per cent grant and an 44 per cent loan for villages with populations of 500 to 5,000. The loan part of the funding is advanced by the Government, usually on a ten-year term, or met by the beneficiaries themseleves or by contributions from international and bilateral agencies. By comparison, the successful rural sanitation programme in Thailand has been essentially self-financed.

The form of government funding of rural projects will naturally vary from country to country but it will always be necessary to mobilize the reserve of internal funding capacity in the consumer's willingness and ability to pay for services. Programme planning must aim at maximizing all indigenous resources to reduce the unit cost of basic sanitary services for rural communities.

Table 11. India's national plan outlays and rural water supply and sanitation allocations

National plan		*Plan outlay (million Rs)*[a]	*Allocation to rural water supply and sanitation*	
			(million Rs)	*Percentage of plan outlay*
First	(1951–1956)	19 600	60	0.3
Second	(1956–1961)	46 000	280	0.6
Third	(1961–1966)	85 765	670	0.7
Annual	(1966–1968)	67 565	313	0.5
Fourth	(1969–1974)	159 022	1 645	1.0
Fifth	(1974–1979)	392 875	3 780	2.3

[a] $US 1.00 = Rs. 7.80.

6. External aid

In recent years, there has been a significant change of direction in the application of external aid. Developed countries and international agencies have now given priority to the poorest (least developed) countries and the most deprived (low-income) groups of people, although countries of the WHO south-east Asia region in which live 41 per cent of the total global target population to be served received only 2 per cent of the total global external aid to the sector. Rural areas of developing countries in Asia and the Pacific are in a strong position to make out a case for increased aid. Provided programmes are well planned, with maximum mobilization of available internal resources, bilateral and international agencies are keen to provide external funds for critical phases of programme implementation. The co-operative action among the United Nations agencies to promote activities for the International Drinking Water Supply and Sanitation Decade should provide impetus to the identification and formulation of suitable projects and should result in better co-ordination of bilateral aid.

7. Water resources budget allocations

The national budget allocations for irrigation and hydropower development far exceed those for rural water supply and sanitation. The fact that these water resource developments arise in rural areas suggests the possibility of incorporating community water supply and sanitation into these programmes and diverting a proportion of the major funds to the sector. Particularly if small-scale projects are being planned to provide basic water needs to all rural communities, it is a small step taken at minimum marginal cost to ensure that the supply for domestic use is safe. It would not be inappropriate to include the promotion of rural sanitation as part of rural development and to allocate some part of the water resources budget for this purpose.

E. MANAGEMENT OF RURAL WATER SUPPLY AND SANITATION PROGRAMMES

1. Manpower planning and development

In most developing countries of the Asia and the Pacific region, there has been no commitment on the part of governments to training for rural service, and shortages of manpower exist at every level. In some countries (such as Indonesia), professional engineers are in short supply, while in some others there is a lack of trained technicians. All countries seem to have the problem of limited managerial abilities among the professionals employed in water supply and sanitation agencies. This is crucial since on account of their relative simplicity, rural water supply and sanitation schemes do not require superior engineering skills, but rather management capabilities resulting from their scattered nature.

In an intersectoral approach, the training of rural development and primary health care workers with an understanding of environmental sanitation needs should not be overlooked. Similarly, water supply and sanitation personnel should have a broader understanding of health in relation to agricultural and other rural activities if they are to work as members of an intersectoral team at the rural level.

2. Organizational requirements

Implementation of national programmes for rural water supply and sanitation in most countries of the region is assigned to many government departments, sometimes in different ministries, and this causes serious puroblems, particularly when they are operating without the framework of a national plan. The activities of those concerned should be properly co-ordinated, and there should be adequate vertical linkages between central planners, regional and local administrations and villagers during the planning and implementation of rural programmes.

The importance of a local support structure involved in project management must be stressed. Many rural water supply and sanitation projects in the region have failed shortly after completion in the absence of any planning for operation and maintenance. Technical advice, operator training, water quality monitoring, maintenance servicing and financial administration must be provided at the local level if the original investment is not to be wasted.

3. Legislation

There are few laws governing the use and abuse of water resources in many developing countries of the region. Abstractions of water for private use are generally made without permission and waste discharges released with impunity. Some countries are revising legislation related to water resources as national policy is being formulated. Nevertheless, legislation is no impediment to rural water supply and sanitation programmes but could be beneficial in establishing regional agencies to administer them or co-ordinate existing agencies.

4. Public participation and health education

The case for public participation in programmes is clear, both in terms of financial viability and social acceptability. Villagers must be involved in projects from their inception, through the planning and design stages, to their operation and maintenance. It is essential, however, to select the right type of rural community representation. Since trust is an essential factor in collaboration, the local committees representing communities must have the full support of the people.

Health education is very important in generating local interest in water supply and sanitation. Village level workers should play a leading role in motivating villagers and educating them with regard to the benefits of a safe water supply, sanitation and home hygiene. To do this they must be properly trained.

Overcoming the farmer's objection to paying for what he considers a natural right is likely to be a problem in many developing countries of the region, particularly against a background of complete government support for past schemes. It is, nevertheless, essential for the aims of the Decade to have rural dwellers contribute increasing amounts to support their own projects.

Where cash earnings are very low, the only possible inputs will be in the form of labour and materials, but it is surprising how even people near the absolute poverty level can be encouraged to finance projects which they are convinced will improve their quality of life.

In general, self-help schemes relating to rural sanitation have been more successful than those concerned with water supply in many countries. Thailand has had remarkable success with rural sanitation projects in recent years and they have been almost exclusively self-financed by villagers. Programmes relying on a significant component of public participation are being introduced in some countries and the approach is generally accepted.

5. Finance management

Wherever the funds originate, whether they be external or internal, they must be channelled to the point of implementation of projects. This will normally be through the provincial or state administration and they should be equipped to manage both government subsidies and villager contributions in constructing, operating and maintaining projects. The technical and managerial skills necessary to ensure the efficient utilization of all resources must be present at this level of administration, not only in central government departments.

F. APPROPRIATE TECHNOLOGY

Developing countries of the region generally have a good idea of their total water resources but have difficulty in determining how much is available for development because of lack of hydrogeological data. Even simple flow measurements may be lacking and sometimes the amounts consumed are not known. Water-use data covering both quantity and quality are necessary for sound planning. There is little information on rural water use, particularly private use, and what is available is spread among the many regional and central Government agencies responsible for different uses. Lack of licensing legislation contributes to the poor control, and therefore to the slim data base, of water use. Before proceeding with a large-scale programme of rural water supply and sanitation, a regional survey of water resources and water use will always be necessary. In some countries there is special need for funding of water resource studies, especially ground-water studies, in order to be able to plan better rural water supply projects.

1. Design, criteria and standards

Design criteria have a great effect on the **per capita** costs of water supply and sanitation and it is essential for all components of a system to be examined for possible savings if budget allocations are to cover the largest number of people possible. Inappropriate criteria and standards have frequently been adopted in design and systems have not always matched the needs of rural communities, the realities of rural duty or the skills of village people.

A basic variable influencing design is the quantity of water which should be supplied to rural communities. *World Health Statistics*[8] in 1973 gave rural water consumption in developing countries of the region and this varied from a minimum of 10 litres/day in Bangladesh to a maximum of 110 litres/day in the Philippines. At that time, all countries expected levels of consumption to increase in the future, even though full coverage of the population had not been achieved. The water resources development report for north-east Thailand[9] suggested a minimum of 1000 m^3 of water storage per farming family of six to provide for supplementary irrigation of crops, dry-season garden watering, animal and domestic needs for a six-month dry season. Only part of this, between 27 and 216 m^3/family, was considered to be for domestic use and would therefore require special handling to ensure a safe supply.

Some countries of Asia and the Pacific have prepared or are preparing design criteria and guidelines to assist technical personnel in making suitable designs for rural water supply and sanitation projects. This is important because a rural project has its special aspects and is not just an urban project on a smaller scale.

Appropriate technological approaches must be taken to optimize the functional and structural design of rural systems. Unfortunately, Asian and Pacific designers have had little guidance on the effectiveness of simple systems, either in the literature or from their typically high-technology study programmes. Consequently, they have been unwilling to accept the respon-

[8] World Health Organization, *World Health Statistics*, vol. 26, No. 11 (1973), pp. 720–783.

[9] Asian Institute of Technology, *op. cit.*

sibility for introducing innovative designs which had not been proved, particularly when international loan agencies wwere not encouraging such approaches. There is evident that these attitudes are changing in the region as pilot schemes involving low-cost approaches are being introduced.

2. Operation and maintenance

Design and construction costs of rural water supply schemes have usually been provided by central governments in the region but operation and maintenance costs have frequently been left to local authorities. They have had inadequate resources to cover these costs, often imposed without much prior involvement, and water rates have seldom been set to cover charges and loan obligations. Between design and operation there have been wide gaps in knowledge, expertise and communication resulting in loss of functional efficiency of system elements, neglect of preventive maintenance and general loss of benefits to rural communities.

A survey carried out in north-east Thailand[10] in 1971 showed that in their early stages of implementation, 69 out of 79 rural water supply systems investigated had had operating difficulties. Among the more frequent problems were: (a) continuing difficulty in collecting money from consumers because of broken taps, great distance to public standpipes and low incomes; (b) operator salaries too low to support family; (c) pumps or public standpipes broken and fuel not available; (d) inadequate tanks or water sources; (e) insufficient pipe to extend the distribution system; (f) lack of knowledge about system operation and chemical use; and (g) lack of assistance from the central water supply authority. This case study typifies conditions elsewhere in the region, which generally suffers from the failure of rural water supply and sanitation investments to provide the full measure of financial, economic and social benefits.

Simple rural excreta disposal systems should cause no problems in operation but will frequently be abandoned through lack of maintenance. Being individual on-site systems, there is no need for local authority involvement in maintenance but rural people must be educated on their use and maintenance.

The local support system necessary for a successful rural programme of water supply and sanitation should include a technical advisory service, a maintenance training scheme, a spare-parts inventory and an administrative structure allowing collection of payments, regular supply of materials, etc. Maximum use should always be made of village labour but the local authority must accept responsibility for its management. To do this satisfactorily, local authorities and villagers must be involved in planning and constructing acceptable systems for rural communities and a manpower training programme should include special emphasis on operation and maintenance of completed schemes.

3. Materials and equipment

Many countries in the region face shortages of materials and have little local manufacturing capability. Rural water supply and sanitation systems are prone to breakdown of equipment and appurtenances and there is a great need for the development of sturdy, reliable and cheap items (for example, hand pumps) which can be manufactured locally. Import substitution is an essential aspect of developing country programmes and local materials readily handled by rural people should be incorporated into designs whenever possible. The adoption of a limited number of standard items for use in standard designs should be an objective in programme planning to reduce the diversity of spare-parts inventories and minimize the possibility of long periods of breakdown. Mass production of essential parts of standard equipment should be encouraged as national policy.

4. Research and development

An important part of research and development is exchange of information among developing countries. Support of the United Nations system for technical co-operation among developing countries will provide a strong incentive for the exchange of experience and product designs in the Asia and Pacific region. Many developments in the region are worth trying in other countries and this can be realized if information transfer is effective and professionals are receptive.

G. STRATEGY FOR THE ESCAP REGION

1. Constraints on progress

An increasing awareness of the need for economic growth and improved quality of life in rural communities has not yet been translated into policy decisions related to implementation of water supply and sanitation programmes in most countries of the ESCAP region. Furthermore, planning has often been imposed "from the top" without sufficiently involving the recipient communities and local administrations in the decision-making process and giving due cognizance to the need for integrated rural development, since after all it is the local community that can best perceive its needs. Even where rural water supply or sanitation programmes have been planned, implementation has

[10] R. J. Frankel, "An evaluation of the effectiveness of the community potable water project in north-east Thailand", *Research Report,* Asian Institute of Technology, Bangkok (1973).

suffered from vagaries in funding. Shortage of internal financing has generally been considered the major constraint on progress in rural water supply and sanitation but the ability of existing agencies to handle increased budgets to meet an accelerated programme is seriously questioned. The flow of external aid has been restricted somewhat in the past by financing patterns and funding methods, but more often than not, it has been restricted by the lack of well planned projects to support.

Institutional problems and administrative shortcomings are considered to be extremely important in limiting the expansion of national programmes and the successful continuation of completed projects. Technological constraints do not appear to be retarding progress but appropriate technological improvements could be expected to have a considerable impact on the economics of rural schemes.

Manpower shortages are another major impediment in many developing countries of the region. At the professional level, study programmes in national institutions do not respond to the needs of rural development and qualified staff have a strong urban orientation, which makes them unwilling to serve in rural areas as well as unsuitable for such duty. There is a noticeable lack of training programmes for subprofessional personnel in all countries, and local support systems are consequently inadequate.

Most programmes have failed to respond to the social and economic needs of rural communities, and lack of health education has limited the benefits of completed projects. The consumer's willingness and ability to pay have rarely been assessed, and villagers have had little involvement in the planning or implementation of projects, denying programmes a degree of consumer participation and cost-sharing.

2. Programme planning and implementation

Planning to meet the targets of the International Drinking Water Supply and Sanitation Decade should now be well developed in all countries of the region because implementation is scheduled to be undertaken in the period 1981-1990. Concerted action might have been delayed in some countries until policy has been formulated in a new national plan but decisions on organizational patterns, administrative responsibilities and financial support will have already been taken. It is to be hoped that internal programme planning will not limit the flow of internal and external financing which must by now have been allocated to rural water supply and sanitation. If necessary reforms have not yet been decided upon and supported by the political hierarchy, the Decade will start with a "whimper" instead of a "bang". Past strengths will be built on in many countries but poor performance areas should have been identified and plans made to overcome obstructions to progress. Most important in this respect, consumer participation will have to be incorporated into both planning and implementation of projects and national strategies to achieve this should have evolved.

The delivery of an adequate supply of water to all rural communities is, no doubt, the responsibility of water resource planners at the macro-level. But, the planners will have to concern themselves equally with the micro-level if their schemes are to be satisfactory on all counts. Past schemes have rarely achieved a sizable coverage of rural populations and new programme planning should attempt to reach all rural people at a basic level. In many countries of the ESCAP region it will be desirable to undertaken a fresh review of the criteria for the identification of new projects and fixing priorities. In some cases the technical planners and designers themselves will need to be retrained to gain some expertise in the preparation and evaluation of projects with special reference to rural water supply and sanitation.

In formulating national strategies for accelerating the pace of rural water supply and sanitation programmes, it will be well to keep in mind that only a minimum needs approach and mobilization of local resources with a significant self-help component will make it possible to provide the basic requirements of rural communities at minimum cost and time. Additionally, the rural programmes will benefit from being included as an integral part of large-scale water resources development and comprehensive rural development projects, taking into account their over-all environmental impact. The environmental health impact will have to be given greater consideration in the planning stages if satisfactory programmes are to develop and tragedies are to be avoided.

3. Resources mobilization

Although external funding can be only marginal, greater co-ordination among international and bilateral agencies will allow maximum benefits to be realized in its application. This can be achieved through actual projects, assistance in manpower training, the provision of critical equipment, and the stimulation of local capability in manufacture; continued capital and technical assistance will also need to be provided to many countries of the ESCAP region from external sources. The pace of a country's programme will, however, depend primarily on the extent to which funds and services are mobilized from internal resources. The generation of additional funds by increasing taxation, through loans from banking and commercial institutions, through income redistribution among communities, through rational tariff structures, through cross-subsidies and other feasible measures contingent upon local conditions, will always be a matter within the exclusive judgement of an individual country.

Mobilization of manpower can be defined precisely when the physical dimensions and strategy of a programme have been decided. Few countries are self-sufficient in the supply of trained manpower at all levels required for rural water supply and sanitation programmes. In particular, local support staff is often inadequate and if they are to be trained adequately to be able to perceive the link between health and water and its various uses in domestic, agricultural and other rural activities, and guide the communities in environmental sanitation, the demands to meet their training requirements will indeed be great. Training centres will be necessary, especially for sub-professionals, and short-term training for mid-level skills will have to be expanded to accommodate rural development and health workers as well as water agency staff. Better operation and maintenance of completed schemes will have to be emphasized in designing new training programmes.

The requirements for material resources will depend on the level of sophistication of programmes and the planning approach adopted. Foreign exchange will often be necessary to meet urgent short-term imports and longer-term investment for local manufacture, and this will call for judicious advance planning. The ability of a country to attract foreign loans will depend on its ability to underwrite those portions of sectoral investment which are not self-financing, as a social policy. An improving water resources situation in rural areas will bring about speedier growth of the economy and an increasing ability to pay for services on the part of rural communities. Collective action by all agencies involved in water resources and rural water supply and sanitation provision will be profitable in terms of the economic mobilization of material resources.

4. Management reform

No other aspect of rural water supply and sanitation in the region has been more influential in limiting the benefits of past investments in the sector than defects in management structure. Operation and maintenance of completed schemes have rarely received the attention they deserve and failures are traceable to the lack of planning of institutional frameworks, administrative procedures and technical and financial mechanisms as well as to the neglect of public relations and other social factors.

All countries will have to devote special attention to the managerial reforms which are necessary to ensure the continued viability of all projects during planning and after their construction is completed. State, provincial and local authorities will have to provide the levels of management essential for success and resources will have to be made available to them. Future investments must continue to yield optimum benefits throughout the design life of projects if there is to be any hope of serving all people by 1990.

5. International co-operation

A much greater proportion of the global external aid than in the past needs to be directed towards assisting countries in the Asia and Pacific region to formulate and implement national programmes for water supply and sanitation to meet Decade targets. An awareness of the magnitude of the problem and direction on feasible approaches have been provided by international organizations acting for multilateral and bilateral aid-providing agencies. Better co-ordination of external inputs is required.

The United Nations and its specialized agencies are playing a leading role in extending water supply and sanitation systems throughout the region. The co-ordinating role for such activity has been assigned to UNDP, with the Resident Representative acting as the focus for international co-operation at the national level. WHO continues to provide the technical service for all programmes of environmental health and often through it external aid is channelled to rural water supply and sanitation. With its declared objective of "Health for all by the year 2000", WHO is committed to supporting primary health care programmes in which rural water supply and sanitation form an integral part. UNICEF is increasing its traditional involvement in rural water supply and sanitation. In the ESCAP region there is also an inter-agency task force for water for Asia and the Pacific, which is a co-ordinating body among United Nations agencies, used to exchange information and follow up on the United Nations Water Conference.

The ESCAP Committee on Natural Resources could assist in achieving the regional objectives of the Drinking Water Supply and Sanitation Decade by endorsing the principle of including provisions for rural water supply and sanitation wherever feasible in water resources development projects and integrated rural development projects. Acceptance of the small-scale water project approach for rural areas would be an important step towards this objective. Resolutions detailing positive recommendations on how best to support these broad proposals would embody many of the essential themes of the United Nations Water Conference on the use of water resources.

III. INTEGRATED OPTIMUM DEVELOPMENT OF THE DELTAIC AND UPLAND PORTIONS OF A RIVER BASIN

(E/ESCAP/NR. 7/3)

Note by the secretariat

The first Regional Technical Conference on Flood Control held in 1951 emphasized that flood control was fundamentally a part of unified river basin development, from which it could not be divorced. At subsequent regional conferences on water resources, full consideration was given to the various aspects of planning for water resources development in river basins, such as flood control, irrigation, power generation and soil conservation. In the relevant studies, the river basin was considered in general and emphasis was laid on the methodology of planning and on concrete questions of technical engineering.

It was soon realized that special attention had to be paid to the downstream parts of a river basin, in particular to the deltaic areas, because of the special hydrological problems encountered there and because of the high economic significance of the large deltas in the ESCAP region. As early as 1960, at the Fourth Regional Conference on Water Resources, the problem of floods in deltaic areas was discussed in depth and it was decided to hold a symposium on flood control and reclamation, including utilization and development of deltaic areas.

The first symposium on deltas, held in 1963, considered the natural framework, the stage of development and the possibilities and problems of further development with respect to flood control, water management, soil improvement, agricultural practices and rural structure in deltaic areas of the ESCAP region. This was followed by a second delta symposium in 1969 which examined in greater detail: (a) water management with emphasis on salinity control and drainage, including flood control; (b) planning and design of tidal embankments; and (c) reclamation of marshes, lagoons and tidal land. Finally, a third delta symposium was organized in 1977 which concentrated on the development of deltaic areas in semi-arid and arid regions and on the development of marshes, lagoons and tidal land in humid tropical areas.

Discussions at these symposia indicated that deltas possess a high potential for intensive economic development, in many cases exceeding that of the upstream portions of the river basin. However, certain problems must be solved in order to realize the full benefits from such potential. Some of these problems concern supply of water and possible regulation from upstream, the size of the river floods and possible flood control upstream, the quality of the water and soil conservation upstream. Indeed, there exists an intimate relationship between the interests of the delta occupants and those in the upstream parts of the river basin in the sense that it is the delta which is the dependent party. In some respects, those interests are conflicting; the major problem, therefore, is to resolve such conflicting interests in a manner which would yield the optimum benefits from the development of the whole river basin.

The following paper provides a good summary of the main problems usually encountered in the development of the deltaic and upland portions of a river basin to achieve optimum benefits. It correctly points out that piecemeal and independent development of parts of a river basin will lead not only to difficult problems but to a reduction of the potential optimum benefits which can be obtained from the basin. What is called for, therefore, is an integrated approach to the development of the water resources of a river basin by means of which alternative schemes of development would be formulated and their corresponding economic, social and environmental impacts evaluated. Possibly, with the use of systems analysis, the appropriate development scheme can be selected on the basis of certain objective criteria.

INTRODUCTION

1. Natural characteristics of the deltaic and upland portions of a river basin

When going down from the highest points of a river basin to the place where the river debouches into the receiving basin, a more or less gradual change of the natural features is encountered in such matters as topography, the pattern and configuration of the river channels, the river flow and the nature of the soils of the hills and the river valleys. In this respect, the dominant feature is a decrease in the downstream direction of the relief of the lands and also of the slope of the river channel.

An essential feature from the point of view of hydraulics which is closely associated with the gradual change in channel slope is the pattern of the river channels (fig. 1). While in the upper and middle

* This paper was prepared by Professor A. Volker, Rijkswaterstaat (State Public Works), The Hague, Netherlands, at the request of the ESCAP secretariat.

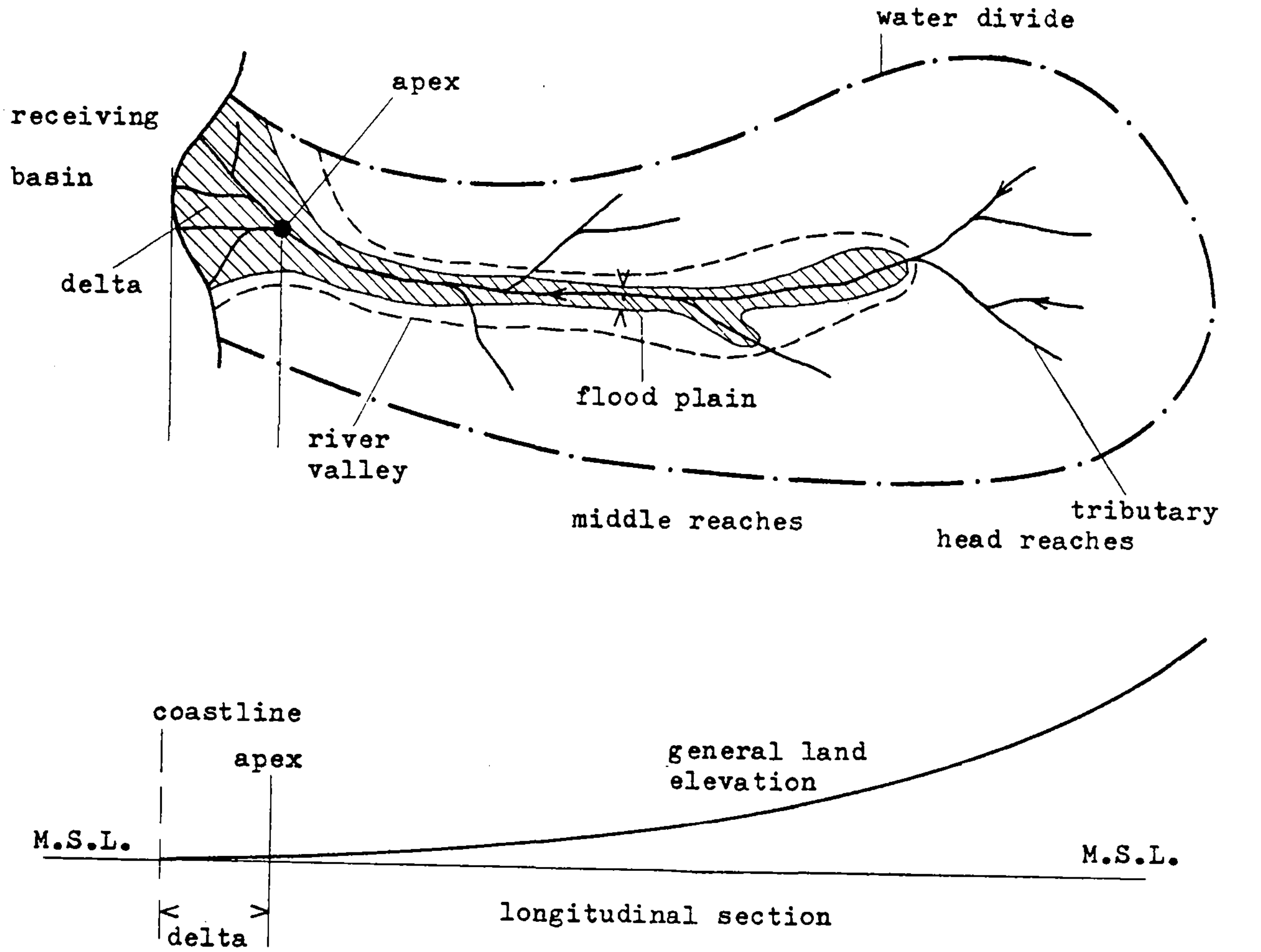

Figure 1. Pattern of channels in a river basin

reaches the main stem is augmented by tributaries, the river, approaching the flat coastal strip, splits up into a number of branches or distributaries. The point where this occurs is called the apex and the delta has been defined as that part of the downstream reach of a river with the adjacent land areas deposited by the river which is situated downstream from the apex. This definition will also be used in this report.

The ability to form a channel and to split up into branches has not yet been explained on physical grounds. It must be related in some way to the fundamental law of the conveyance of water and sediments with a minimum amount of energy but a quantification cannot be made. The fact remains, however, and has dictated to a large extent the development pattern of human society.

In the deltaic portion of a river, land and channel slopes are extremely small. For the gross slope, defined as the ratio between the land elevation at the apex above mean sea level (MSL) and the distance from this point to the coastline, figures are found ranging between 5×10^{-4} (0.5 m per km) and 1×10^{-5} (0.01 m per km). Figures for some of the large deltas in the ESCAP region are given below.

Indus	1×10^{-4}
Irrawaddy	5×10^{-5}
Mekong	3×10^{-5}
Pearl River	3×10^{-5}
Red River	9×10^{-5}

Natural levees and backswamps are features common to the river valleys and deltas. They develop during flood periods when the river water overtops the banks and sediments are deposited on the land. In deltas, in general, the height of the crest of the natural levees decreases from the apex in the downstream direction and the texture of the soil changes from sandy to finer material. In the river valleys which border on hills, there may also be former river terraces and the soils are generally lighter than in the deltas (fig. 2).

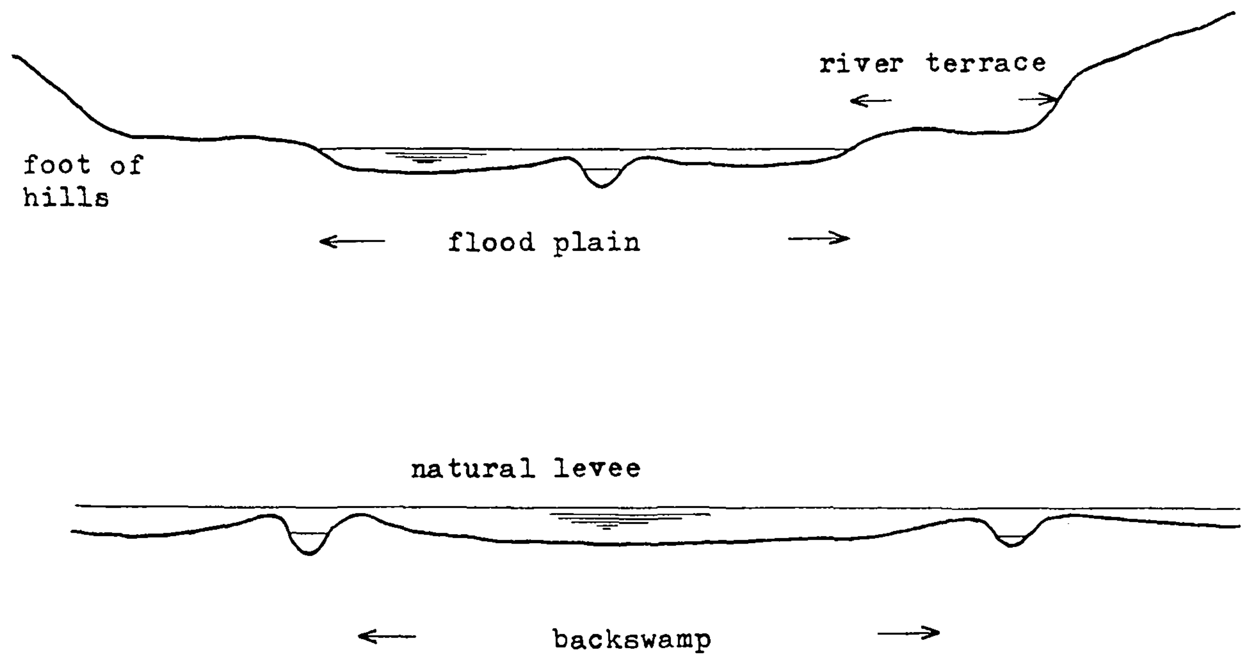

Figure 2. Topography of the river valley and the deltaic portion of a river basin

The hydrologic régime of deltaic areas differs in many respects from that of the upstream portions of a river basin. In the latter case the river level and the discharge in a given gauging station are governed by the rainfall on the watershed upstream of that station and the central problem in "general hydrology" is to estimate the runoff from the rainfall. In a delta the water levels and the discharges are governed by the boundary conditions at the two ends: the water level and the discharge (the "upland discharge") at the apex and the water levels of the recipient basin. The rainfall on the delta plays a minor role. Figure 3 illustrates the propagation of the astronomical tides in a delta for low and high upland discharges.

In many deltas embankments have been built to protect the land areas against flooding by rivers and the sea. In this way, the hydrologic régime of the land areas can be made to a large extent independent of the régime in the delta channels. "Polders" are embanked areas in which the surface- and groundwater levels are controlled to an economically feasible extent.

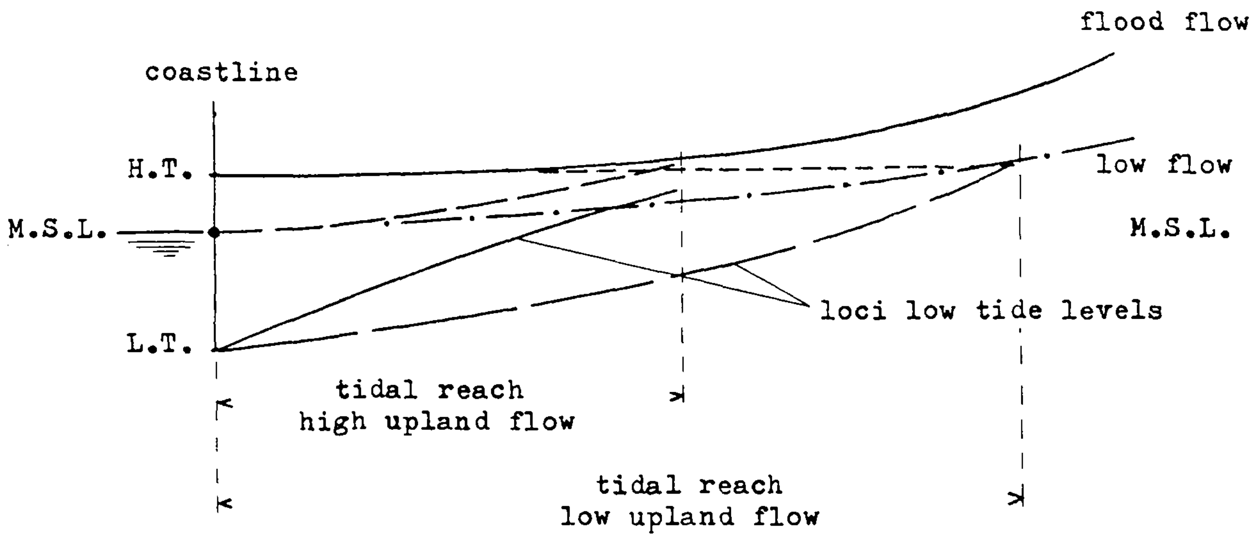

Figure 3. Water levels in a delta as governed by the upland discharge and the tidal levels

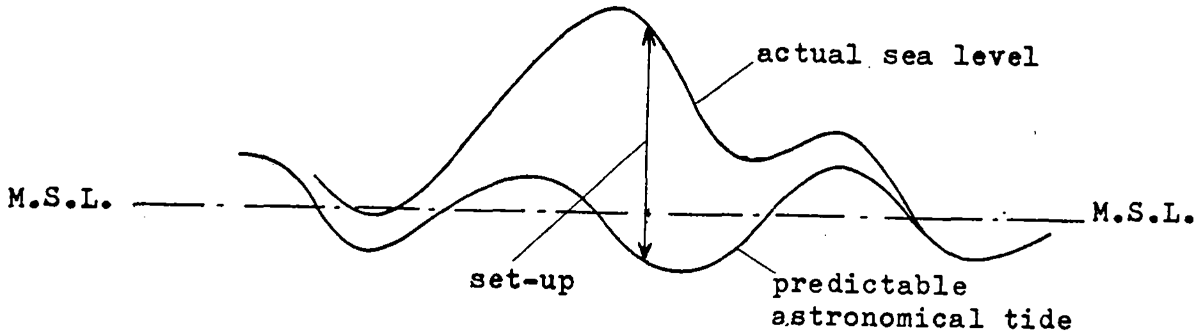

Figure 4. Storm surge: superposition of the set-up caused by the wind on the astronomical tide

The deltas along the northern coasts of the Bay of Bengal and the Pacific coasts of Japan are exposed to storm surges caused by cyclones or typhoons. Owing to landward winds, a high water level is generated which is superimposed on the astronomical tides (fig. 4). In this way, abnormally high sea levels are generated which form a threat to the low-lying coastal areas, especially when there is simultaneous occurrence of river floods.

Delta channels debouching into seas and oceans are exposed to intrusion of sea water. Depending on the upland discharge, the water in the river channels may be saline or brackish many tens of kilometres upstream of the coastline. This feature, which is very important for the environmental conditions in the delta, will be considered in greater detail in section B in relation to the hydrology of the river basin.

2. Characteristics of deltas in the ESCAP region in relation to the river basin

Some of the largest river basins and deltas in the world are found in the ESCAP region. One such delta in India and Bangladesh is commanded jointly by the Ganges, the Brahmaputra and the Meghna rivers. The total catchment area of these rivers is around 1.5 million km^2 and the average annual flow 34,500 m^3/sec. If the area south of the Ganges, Padma, Meghna and east of the Bagharhati Hooghly is considered as the present delta, the area is around 50,000 km^2. Including the upstream areas presenting characteristics as "former deltas", the figure would be more than 100,000 km^2.

Other large deltas in the ESCAP region are formed by the Indus River in Pakistan, the Godavari, Krishna and Cauvery rivers in India, the Irrawaddy River in Burma, the Chao Phya River in Thailand, the Mekong River and the Red River in Viet Nam and the Huang Ho (Yellow), the Yangtsekiang and Pearl rivers in China. In addition, there are numerous smaller rivers and deltas.

Practically all deltas in the ESCAP region are densely populated, with demographic densities ranging from 250 to 500 per km^2. They are highly productive and are often designated as the "rice bowls" of the countries in which they are situated. In many deltas, especially the small deltas of Japan, industrial development has taken place.

The deltas in the ESCAP region exhibit a great diversity with respect to the hydrometeorologic conditions and the degree of hydraulic and economic development. Table 12 shows the typical features of deltaic areas.

While the delta of the Indus River is situated in an arid zone, the other large deltas mentioned above are situated in the humid tropical zone or in the subtropical zone. As stated earlier, some of the deltas are exposed to storm surges.

With respect to the water resources development of the deltas in the ESCAP region (degree of protection against river and sea floods, drainage and irrigation of the land areas, supply of fresh water etc.), considerable variations exist among the various deltas. This is partly due to the differences in hydro-meteorological conditions and partly to the economic development of the river basin and the country of which they form a part. Whereas in all deltas coastal embankments have been built to protect the coastal zone against flooding with sea water at high tide, the protection against river floods differs from one delta to another.

Most of the deltas of the ESCAP region possess many possibilities for further exploitation of their great natural potential. In this respect, the hydrologic development of the upper portions of the river basin plays an important role. It is the object of this paper to highlight the salient aspects of this relation.

Table 12. Typical features of deltaic areas

Specific natural feature	Advantage	Inherent drawback	Remedy
1. Deltais areas are level areas (flat, horizontal)	Depth of surface and ground water can be controlled	Exposed to flooding by the rivers and the sea	Flood control upstream and flood protection on location
2. Since they are at the down-stream end, water is supplied from the entire catchment	Relative abundance of water	Effect of water abstraction and water pollution upstream	Storage in the delta
3. Soils are generally fine-grained (heavy)	Good water retention capacity; water storage in the soil	Soils may be difficult to till and to drain	Subsurface field drains with shallow spacing
4. Ground-water table is high at shallow depth below surface	Water supply to the root zone by capillarity	Depth may be too shallow; water-logging and possible soil salinization	Horizontal and vertical drainage
5. Network of water courses is always filled with water	Easy communications in early stages of development	In later stages the river channels form obstructions in the road systems	Infrastructure of integrated systems of road and water transport
6. Deltas are the outfalls of the hinterland to the sea	Large ports and cities: Rotterdam, Tokyo, Calcutta, Cairo etc.	Silting up of harbours; bad foundation conditions	Periodical dredging necessary; pile foundations

3. Nature of the development problems of the deltaic and upland portions of a river basin

Historically, man did not wait until full hydraulic and economic development of the upstream portions of the river basin had taken place before occupying the deltaic areas. There is archeological evidence that in the third to sixth centuries the north-western part of the present Mekong delta (between Rach Gia Long Xuyen) was occupied and provided with canals forming a part of the Funan Empire. The reclamation of other parts of this delta, however, was postponed until the end of the nineteenth century aid took place from the east. The older deltaic areas of the Ganges-Brahmaputra-Meghna system were already cultivated in the fourteenth century and reclamation of the recent delta started towards the end of the eighteenth century, following the natural extension of the delta. It seems that the natural advantages of deltas were recognized in a rather early stage of history and a concentration of the population in these areas occurred to an even greater extent than upstream.

In the early stages of occupancy, man settled on the natural levees of the present and former river channels, where the depth of flooding is small and crops other than paddy can be grown. If higher productivity, higher cropping intensity and crop diversification are to be achieved, the need for better water control, better accessibility and settlement in the backswamps will arise.

The hydrologic aspect of the development problems of the deltaic and upland portions of a river basin is related to the effect of changes in the hydrologic régime of the river basin on the conditions in the delta. These changes may be in the field of erosion control (terracing, silt arresters, reforestation), reservoirs for various purposes (flood control, power, irrigation, water supply etc.), diking of flood plains, withdrawal of water, disposal of polluted effluents etc. As will be shown in sections B and C, these changes directly affect the conditions downstream, such as the size of the floods, the saline water intrusion, the minimum flow and water quality and other environmental features.

Changes in the hydrologic régime of the upstream portion of a river basin may be beneficial or detrimental for the conditions in the delta. In the latter case, as experience has shown, there have been many attempts to find legal grounds for prohibitive regulations or claims for indemnification. In this respect, the legislation in most countries is very sketchy and virtually non-existent in the international community.

Master plans aiming at a balanced development of the upper portions of river basins are becoming a common practice in many ESCAP countries. There are fewer plans for a balanced development of the deltaic areas, although for deltaic areas where hydraulic works in one part of the delta may have repercussions on the hydrologic conditions in other parts, the need is even greater. In all deltas actual development has so far been piecemeal.

An example of an attempt to arrive at an integrated optimum development of the upper portions and the deltaic portion of a river basin is illustrated by the studies of the Mekong Committee. Although a final master plan has not yet been agreed upon, the studies carried out so far on the general development of the river basin and on the agricultural potential and requirements with respect to the hydrological conditions upstream of the delta have provided the basic data to formulate a plan which from a general economic point of view could be considered as the optimum one.

A. ECONOMIC FRAMEWORK

1. Economic significance of deltas compared with the other parts of a river basin

Deltaic areas possess a number of natural advantages for economic development which are not found or do not occur to the same extent in the other portions of the river basin. These advantages, however, art partly offset by inherent drawbacks (table 12).

The generally heavy soils in deltaic areas have a high water retention capacity and also in many cases a high natural fertility. They may, however, be difficult to till and to drain.

The lands in deltaic areas are virtually level lands. This makes it possible, in principle, to control the depth of the surface water above the surface in the case of rice production and the depth of the ground water below the surface in case of a dry root crop. In the latter case, the ground-water table may be too high and a subsurface drainage system is required to adjust the depth. The absence of natural gradients makes it difficult to install an adequate drainage system and the same applies to irrigation facilities.

Since deltaic areas are situated at the downstream ends of the river basin, they receive in the natural state a maximum supply of water. However, deltaic areas also receive flood waters because of their low elevation and in the absence of appropriate measures, extensive flooding occurs.

Deltas are the outfalls of the hinterland and it is through the ports located on the estuaries of a main river branch that the river basin is in communication with other countries. Large cities such as Tokyo, Calcutta, Rangoon, Bangkok and Karachi are located either in or near deltas of major rivers. Many harbours in these locations tend to silt up and, because of the presence of thick layers with a small bearing capacity in the subsoil, considerable problems of foundations for structures are encountered.

In conclusion, it can be stated that deltaic areas possess a great potential for intensive economic development but certain problems have to be solved in order to realize the full benefits of such potential. This feature is more pronounced in the economic development of deltaic areas than in the development of the other parts of the river basin.

2. Relation between the economies of the deltas and the other parts of a river basin

Deltaic and upland portions of a river basin have different possibilities and limitations for development of agriculture and development of industries, according to the distribution of the natural resources.

The deltas in the humid tropical zone of the ESCAP region by virtue of soils and topography are most suitable for growing a crop of rice during the wet season; with the increasing need for more production, better water control is required, as well as irrigation facilities for growing a second crop during the dry season. In the upland portions of a river basin, with lighter soils and often better drainage possibilities, dry root crops can be raised next to rice. In a certain stage of development both parts require water during the dry season and a conflict of interests may arise.

The optimum location of industries in a river basin depends, besides the type of industry, on many factors, such as: the availability of skilled manpower; the availability of raw materials, energy and water; the availability of communication facilities; and the magnitude of the measures that may be required for population control. Thus, in general, industries are found distributed throughout the river basin. There is, however, at present a tendency for industries processing bulk goods with imported raw materials to establish themselves close to the harbours on the coast to avoid costs of transshipment and to dispose of waste products cheaply.

In many developed deltas, the distribution of the economies of the river basin has led to a concentration of the population in the delta. A striking example in this respect is the basin of the Rhine in north-western Europe, where one of the most important industrial areas in the world, the Ruhr area, is to be found. The location in the middle portion of the basin was dictated by the presence of a suitable labour force, energy (coal) and the river, which is quite suitable for navigation. The total river basin covers 180,000 km^2, of which one ninth (20,000 km^2) can be considered as the deltaic reach. However, a total of 40 million live in this area. The port of Rotterdam, the largest in the world, is also located in this delta. Its harbour, originally at some 30 km from the coastline, is now gradually expanding into the North Sea.

B. WATER CONSERVATION

1. Water uses in the deltaic and upstream portions of a river basin

Deltas and other parts of a river basin share the need for large amounts of water of good quality for a great number of purposes. Sections 1 and 2 will deal with certain particular uses, i.e., water required for navigation, water required for repulsion of sea-water intrusion into open estuaries and water required for quality control in general.

One of the natural advantages of deltaic areas lies in the fact that the water levels in the river channels are governed by the upland discharge as well as by the

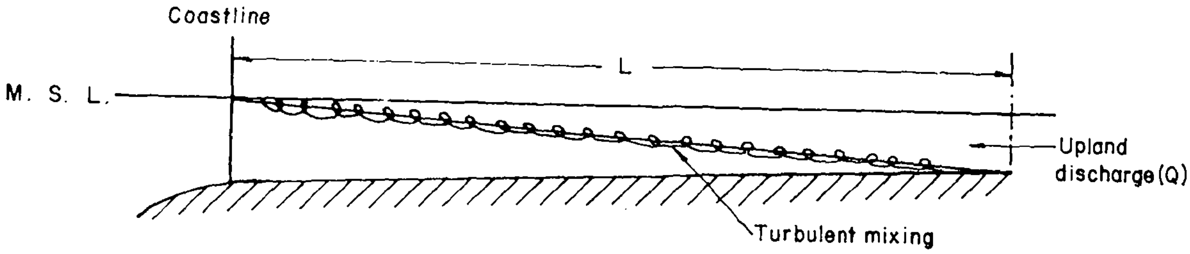

Figure 5. Sea-water intrusion into an open estuary

tidal levels at sea. In the coastal zone (fig. 3), the tidal effects are predominant and the water levels and the depths available for navigation are hardly affected by the upland discharge. Therefore there is no need to maintain a certain minimum flow in the downstream channels of a delta in the interest of navigation.

A very special need in a deltaic area to maintain a certain minimum outflow to the sea is related to the phenomenon of intrusion of sea water into open estuaries. This phenomenon is caused by the difference in density of the sea water and the fresh water of the river (around 2.5 per cent). The heavier sea water slides along the bed of the estuary in an upstream direction under the fresh river water (fig. 5). If there are no tides and if the estuary has regular cross-sections, the intrusion assumes the shape of a wedge with a more or less distinct interface between the fresh and the saline water. If the upland discharge remains constant, the saline water will be at rest, with the fresh water flowing in a seaward direction.

The length L (fig. 5) over which saline intrusion occurs in a given estuary depends on the magnitude of the upland discharge Q, L being inversely proportional to the square of Q. Thus, saline intrusion can be pushed back by increasing the upland discharge. The intrusion length L is also highly affected by the depth of the channel; other conditions being equal, the length increases proportionally to the fourth power of the depth and thus dredging operations in estuary channels increase the saline intrusion.

In the more general case of a sea with tides, irregular river profiles and tidal basins (such as harbours and creeks), the mixing at the interface becomes so intense that the stratification of the water disappears. Although the salinity near the bottom of the channel will always be higher than near the surface, a mean salinity C (figure 6) can be defined as the average salinity over the profile in each station along the river ("mixed estuary").

As yet there is no generally applicable method of analysing the sea-water intrusion into an open estuary. It is not possible to predict the horizontal salinity distribution in an estuary for a given estuary geometry, a given tidal variation and a given upland discharge. Various methods and approaches have been proposed (Rijkswaterstaat Communications 1976), but all the formulae contain parameters to be determined empirically from actual observations in the field under a wide range of upland discharges and tidal amplitudes. If a good simulation of the salinity distribution is obtained, the formulae can be used for interpolation and to the some extent for extrapolation, but the parameter values cannot be applied in other situations.

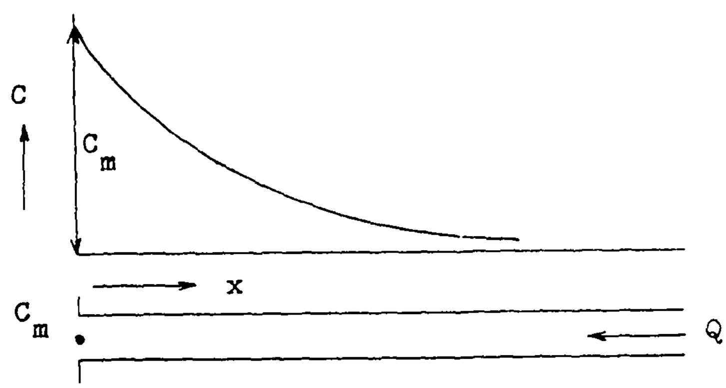

Figure 6. Salinity distribution in an open estuary

The damage caused by sea-water intrusion into open estuaries is of a different nature. The salinity at a given station along the river may be so high, especially during low-flow periods, that direct use of the river water at the banks is unacceptable and that intakes for irrigation, domestic and industrial water have to be shifted upstream beyond the saline reach (fig. 7). By seepage through to the subsoil to embanked areas, the ground water and hence the surface water may become brackish. The salinity of the water also affects the ecological systems in the estuaries and the land areas.

Sea-water intrusion occurs in all open estuaries of the deltas of the ESCAP region and has been studied in many cases, such as the Mekong River, the Chao Phya River, the Irrawaddy River, the Ganges and its distributaries and the estuary of the Euphrates and Tigris rivers. During low-flow periods, the saline effect is felt in all cases many tens of kilometres upstream of the coastline. There is no case so extreme as the one of the Gambia River in West Africa (Sanmuganathan and Abernethy), where during periods of minimum flow (5 m^3/sec) the saline effect (1.5 g/litre) was felt as far as 235 km upstream of the mouth.

would shift as follows (United Nations, Mekong Committee 1974):

Increase:	500 m^3/sec	Shift	0.85 km
	1,000 „		2.25 km
	2,500 „		5.00 km

The figures for the shifts refer to the average of the figures for the six branches through which the fresh water flows to the sea.

The most drastic measure to prevent saline intrusion in an open estuary consists of constructing a dam at the mouth of the estuary. This measure, which has been applied on a large scale in Japan and the Republic of Korea, will be discussed in section B.5 in connexion with estuarine storage.

Corrective measures of salinity control consist of flushing or rinsing of canals and other water courses in embanked areas that are exposed to salt-water intrusion. Fresh water is admitted at upstream points on the river beyond the saline reach and the brackish effluent is discharged in downstream points on the saline reach of the estuary.

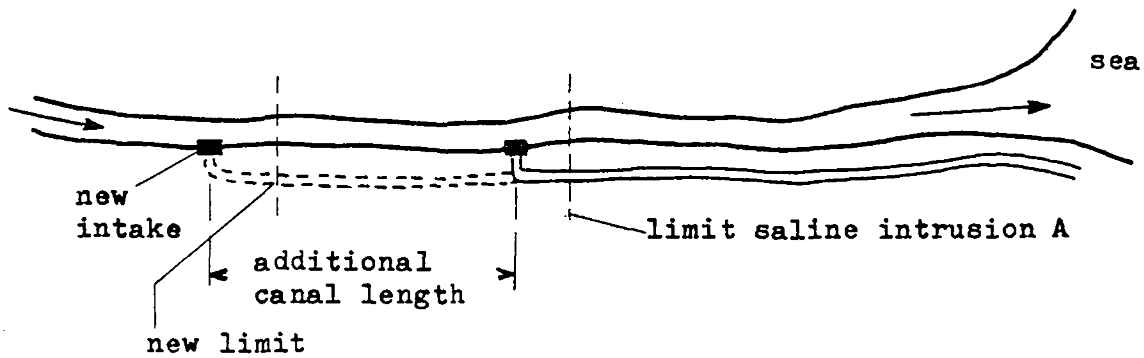

Figure 7. Shifting of intakes of fresh water in an upstream direction due to saline intrusion

2. Preventive and corrective measures for water quality control in deltaic areas

By increasing the upland discharge in an estuary, the saline-water intrusion is pushed back. This can be carried out by release of water from upstream reservoirs or by diversion of water from another branch in the delta during the low-flow season. Compared with many other water uses, a much larger amount of water is required to push the saline limit in a downstream direction. This is illustrated by figure 8, where for the Bassac River, one of the branches of the Mekong River, the relation is indicated between the salinity along the river and the up-land discharge. On the basis of an analysis of recorded salinity, it has been estimated that with an increase of the total flow to the delta (discharge at Phnom Penh) the salinity distribution curves

The surface waters in the canals of embanked areas in deltas are normally stagnant and all sorts of wastes accumulate there. Flushing and rinsing of these canals is also necessary for quality parameters other than salinity.

3. Coastal and upstream storage

In the context of this report, coastal storage will be defined as the storage of water in tidal embayments such as estuaries, sea gulfs and lagoons. Storage of water in coastal lakes, depressions and other low-lying coastal land areas will also be included under this heading.

In all these cases, the reservoir area is separated from the sea by a barrier or an enclosing dam equip-

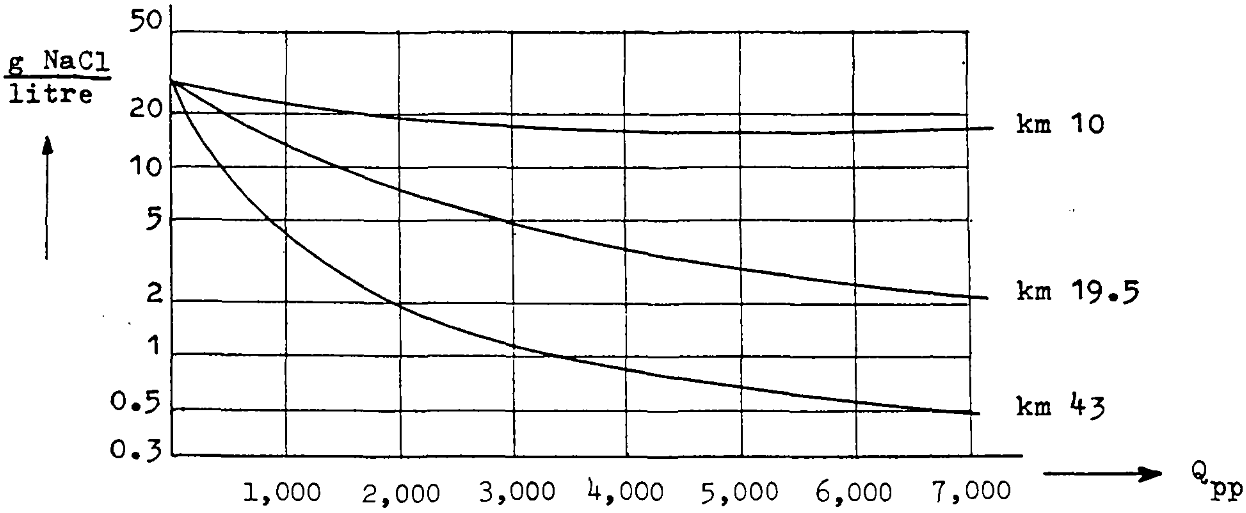

Figure 8. Relation between saline intrusion into the Bassac River and the upland discharge at Phnom Penh

ped with sluice gates. There is an inflow of fresh water of a river branch and excess water is discharged to the sea (fig. 9). By this means, the water in the reservoir which is still brackish at the moment of closure of the barrier gradually becomes fresh. The feasibility of coastal reservoirs was considered during the fourth session of the Committee on Natural Resources of ESCAP in 1977 (United Nations, ESCAP, 1978).

a relatively large surface area which is often available as an area of the tidal embayment. The large surface area of coastal and estuarine reservoirs, however, results in a relatively large volume of evaporation loss from the lake surface.

For the water supply to the delta, coastal and upstream storage can, in certain respects, be considered as alternative solutions. One of the factors governing

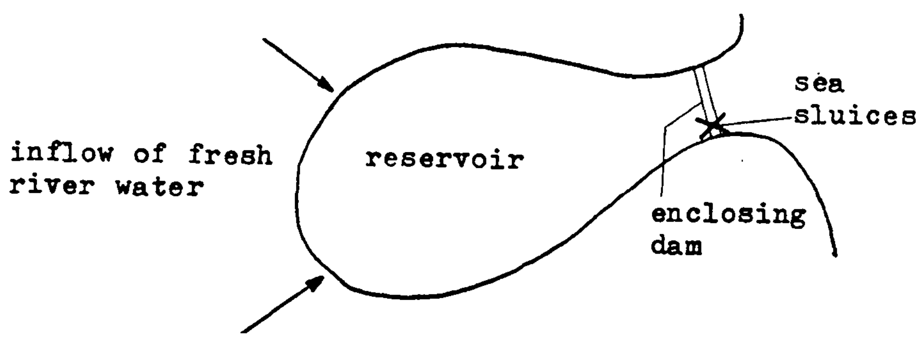

Figure 9. Principle of a coastal reservoir

Storage of water can also be arrived at by the construction of dams in the upstream portions of the river basin either on the main stem or on tributaries. This form of storage may also serve the deltaic portion of the river basin.

The two forms of storage have their specific characteristics. Coastal reservoirs are usually located in level areas. This implies that except in special cases,[1] the water level can fluctuate only within a narrow range, compared with the usually large variation of water levels in upstream reservoirs. To store a given volume of water, coastal reservoirs must therefore have

the choice between the two is the cost of storing one cubic metre of water. Of the very few studies that have been made on this question, mention can be made of the results of a study in the United Kingdom on the costs of various forms of storage in pennies per m^3 at 1977 price levels *(ibid.)*.

Method	*Location*	*Pennies per m^3*
Estuarine storage	Morecambe Bay	6.0
	Dee Estuary	4.8
	Wash Bay (phase 1)	16.7
Upstream storage	North-west England	3.8
	South-east England	9.2
Distillation	—	60.0
Reversed osmosis	—	20.0

[1] The Plover Cover scheme in Hong Kong.

Both coastal and upstream reservoirs can serve multiple purposes. As to the former, additional benefits consist of:

(a) Improvement of the protection against storm surges by creating a shorter length of coastline;

(b) Elimination of the intrusion of saline water into the areas adjacent to the reservoir;

(c) Possible improvement of the drainage conditions of the areas.

In addition to water storage, upstream reservoirs offer other well-known possibilities, such as generation of power, flood control and navigation.

Indirect additional benefits are more difficult to account for in the comparison between coastal and upstream storage. One of these is the benefit for the supply of water to the delta of having a reservoir on location. If the water has to come from upstream reservoirs, the time of travel of the water through the open channel must be taken into consideration and releases from the upstream reservoir must be based on forecasts of precipitation and demand. This may lead to an imbalance between supply and demand and hence to a less efficient use of water than in the case of coastal storage.

4. Water pollution aspects and requirements of minimum flow in the various river reaches

Upstream pollution of the river water affects the quality of the water reaching the delta. As long as traditional agriculture was the prevailing economic activity in the river basins of the ESCAP region, water pollution was no problem. The assimilative capacity of the river was sufficient to absorb the biologically degradable waste products. In the delta itself, with the great surface of water courses exposed to the air, a further purification took place (United Nations, ECAFE, 1973).

A different situation is found in river basins with other economic activities, such as chemical industries, paper and pulp factories and bio-industries. Pollutants are then produced, consisting of compounds of substances or of elements such as ammonia, iron, chromium, lead, copper and cadmium. Many of these pollutants are toxic and not or hardly oxidizable or degradable. The same applies to substances like pesticides and mineral oils and to trace pollutants like phenols and heavy metals (e.g., mercury).

Various international organizations have established standards for surface water in relation to the use of the water. Application of such standards to the water reaching the delta implies that in the delta itself no further disposal of non-degradable waste products can be allowed, the water from upstream being already loaded with pollutants to the maximum permissible degree. The delta on the other hand has the advantage of being close to the sea, if disposal of pollutants in the sea is acceptable at all.

Coastal reservoirs in deltas possess a great assimilative capacity for oxidizable pollutants because of the long residence time of the water. This capacity, however, is greatly reduced if the water supplied to the reservoir from upstream contains a high percentage of nitrogen and phosphorus. These substances may not be harmful for many water uses but promote an abundant growth of algae (eutrophication). The degradation of the remnants of the algae, which consist of organic matter, requires so much oxygen that the water cannot assimilate any more pollution and that biological life (fishes etc.) disappears.

For a given pollution load, the concentration of the pollutants decreases with increasing river discharge. To achieve this dilution effect, however, requires the maintenance of a minimum flow in a river channel so that the permissible concentrations are not exceeded. This applies to all river reaches. Maintenance of a minimum flow is also necessary in view of other interests, such as the environment, river morphology and water supply. Determination of this minimum flow is a delicate problem, the solution of which is highly dependent on the local situation. In any case, allowance has to be made for the special conditions and interests of the deltaic portion of the river basin, where besides the factors mentioned in this section a minimum outflow of river water to the sea is required in order to control the saline-water intrusion (section B.1).

With respect to water quality and minimum flow, the deltas and the other parts of a river basin have divergent interests and conflicts are likely to occur. If both parts are situated within the frontiers of the same country, an agreement can be arrived at through the river basin authority or the provincial or central government.

In the case of "international" river basins, it may be much more difficult to find a solution since pertinent "regulations" in international law do not exist (see section D.2).

A striking example is that of the basin of the Rhine River. The river is the navigable waterway of a number of important industrial areas and is perhaps the most polluted of the larger rivers of the world, especially with toxic substances. Five countries share the upstream portion of the basin with the deltaic area situated in a sixth one. It took some 20 years to arrive at an agreement on a limitation of the toxic substances but it was found much more difficult to agree on a limitation of the salt load. This load consists mainly of sodium chloride (NaCl) as a waste product of potassium mining upstream. This load as an external supply adds to the other "internal" sources of salt in the delta. The concentrations caused by the external load only are around the tolerance limits so that any further addition leads to concentrations that make the surface water in the delta less suitable for certain purposes, such as production water in certain industries, irrigation water in hothouses and domestic use. An agreement could only be concluded if the principle of "the polluter pays" were discarded. The present treaty foresees that the two countries which discharge salt in the river upstream each pay one third of the extra costs of production resulting from a retention of the salt upstream and that the interested deltaic country pays the remaining one third.

5. Integrated water conservation policy in the upstream and downstream portions of a river basin

It can be concluded from the previous section that an intimate relation exists between water conservation, including water quality control in the deltaic and upstream portions of a river basin. An integrated policy takes this relation into account and aims at making "the best use" of the water available in the river basin and the possibilities for water conservation in the various parts of the river basin. The question is then, what is the criterion for this "best use" or "optimum development"? This will be considered in section D.1; here only some technical and economic factors will be identified.

Storage of water destined for the entire river basin can be achieved by either storage in the head reaches of the river or by a combination of storage upstream and storage in the coastal zone. There are many examples of the former: Euphrates-Karun River, Indus River, Krishna River, Chao Phya River and the envisaged Mekong River basin development. In most cases these are multiple-purpose projects aiming at, besides water conservation, power generation and flood control. An important element as far as storage is concerned, is the allocation of water between the upstream and the deltaic areas. Such an allocation may be based on purely economic grounds, considering the returns of a unit volume of water in the two parts of the river basin. As mentioned earlier, a special requirement for water in deltaic areas is salinity control, which demands high flows of water; the economic justification for that use lies primarily in the elimination of the damage that would otherwise occur in agricultural, industrial and domestic uses of water. Next to the economic factors, considerations of regional development, nature conservation and political factors may also have a bearing on the water allocation.

The allocation problem is particularly delicate in the case of "international" river basins, where it is related to the pollution problem.

There are only a few cases in the ESCAP region where storage reservoirs exist in the head reaches of the river basin together with a significant storage in the coastal zone of the river basin (Japan and the Republic of Korea). In principle, conjunctive use of both types of reservoirs is then possible. The ideal meteorological conditions, where periods of abundance of water and periods with a deficit differ for the deltaic and upland portions of a river basin, will never be found. Since, in general, both reservoirs also have a flood control function, the regulation curves for reservoir operation should be carefully harmonized to the extent possible in order to avoid a clash of interests. In one case, in the ESCAP region, the initial filling of a reservoir after completion and the attendant reduction of the discharge to the delta caused an increase o fthe sea-water intrusion so that the water in the estuary which was used for irrigation became brackish. The result was considerable damage to orchards in that area.

C. FLOOD CONTROL

1. Floods in the deltaic and upstream reaches of a river and methods of flood control

As stated already in the introduction, deltaic areas are exposed to floods from two sides: the river and the sea. Obviously, the nature of the river floods is of significance for both the deltaic and the upstream reaches of the river while the nature of the sea floods is of importance only for the most downstream reaches. Measures upstream affect the flood conditions of the deltaic river reaches.

River floods may be flash or gentle. Flash floods are characterized by rapid rises of the river level (more than 0.3 to 0.5 m per day), sharp peaks and a quick recession (fig. 10). Gentle floods present a gradual increase of the river stage, a flat flood peak, sometimes with a duration of a few weeks, and a very gradual depletion during the whole dry season. Flash floods are typical for small river basins with steep slopes and many impervious watersheds. Gentle floods occur in large river basins with gentle slopes and contribute considerably to the river discharge by outflow from ground water. The large river basins like the Ganges-Brahmaputra-Meghna, Irrawaddy, Chao Phya and Mekong all present gentle floods. However, the floods of the Red River in the northern part of Viet Nam are of a flashy nature.

From the point of view of land utilization and flood conditions, flash floods present more problems

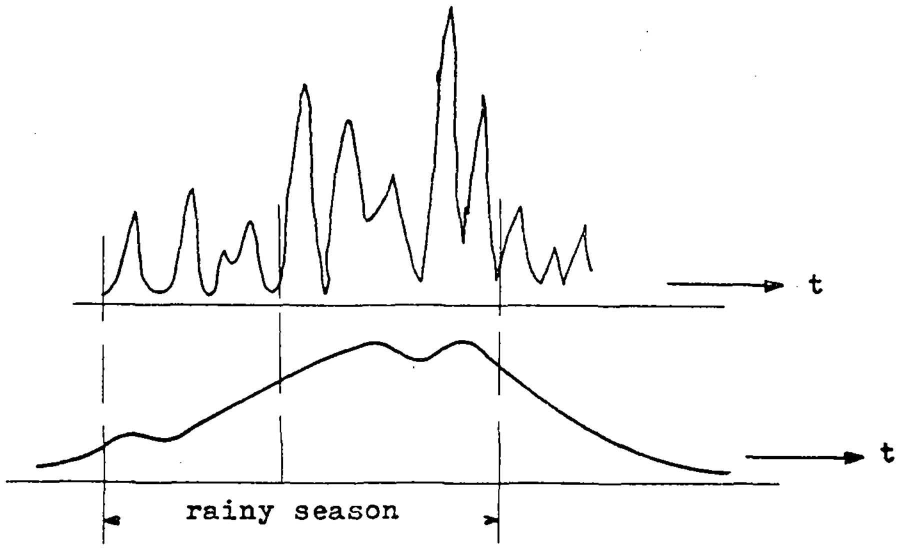

Figure 10. Flash and gentle floods

than gentle floods. In the ESCAP region, local varieties of rice have been developed that can grow in areas which are inundated by the water from the rivers provided that the water does not rise too quickly. In the zones of deep flooding (2 to 4 m) in the upper portion of a delta and in the river valley, a special variety of rice is used, the so-called floating rice. This species can grow in depths of water up of 4 m, provided that the water rises not faster than 5-10 cm per day. If there are flash floods, cultivation is only possible if flood protection has been provided.

A river with flash floods is more difficult to control than a river with gentle floods. This applies to bank protection, channel morphology and also to the effects of embanking such a river (section C.3).

In deltaic areas which are still expanding further into the sea, the bottom of the river channels shows a tendency to rise, causing a progressive rise of the flood levels. This is due to the lengthening of the river course and the subsequent decrease of the hydraulic gradient and the sediment transporting capacity. An example is found in the flood records at Bangkok in the period 1915-1953, which show a significant rise of 1.1 cm/year on the average (Kanchanalak, 1969).

The rise of the river bed starts in the lowest river reaches and extends in an upstream direction.

Flood control measures in the upper portions of a river basin may consist of erosion control (terracing, silt arresting, afforestation), flood detention with reservoirs, embanking and channel improvement (cutoffs, diversions, widening). They all may affect the flood conditions in the areas downstream of the flood control works, including, of course, the deltaic area.

Flood control in the deltaic area can also be achieved by structural measures on location, such as embanking, channel improvement and estuary control, as well as by non-structural measures such as flood plain management.

2. Effect of upstream flood control works on the hydrologic régime in the delta

Flood control works in the upstream portions of a river basin may have both adverse and beneficial side effects on the hydrologic conditions in the delta. The effect of a certain measure may be positive for one condition and negative for another.

Flood detention reservoirs may effectively reduce the flood flows reaching the deltaic area by temporary retention of the flood water. However, they also retain most of the silt so that downstream channel erosion may occur. The reduction of the amount of silt reaching the deltaic area may upset the delicate balance between the constructional forces of the river in the building-up of the delta and the destructional forces of the sea. The result may be a smaller growth of the delta or even the onset of erosion. The positive aspect is then a halting of the rise of flood levels resulting from delta growth. Upstream storage reservoirs which can augment the low flows to the downstream areas have, of course, a similar effect.

Erosion control measures in the upstream reaches of a river basin may affect the hydrologic conditions of the deltaic areas in a similar way as flood detention reservoirs.

Large-scale changes in land use of a river basin may have various repercussions on the runoff from

There still remains the effect of flow constriction. The occurrence of flash floods in the Red River in the northern part of Viet Nam is one of the reasons why the delta was embanked at a very early stage of history, perhaps 2000 years ago. On the other hand, the occurrence of gentle floods in the deltaic and flood plain areas of the Chao Phya River (Thailand) and the Mekong River allowed wet rice to be grown in the absence of flood protection.

The total effect of embanking may be considerable. In the case of complete embanking of the Pampanga flood plains, the maximum level of the highest recorded flood would rise in the upstream reaches by 2.5 to 3.5 m, making this type of flood protection unacceptable. A complete diking of the flood areas in the Mekong delta would increase the level of the 100-years' flood by 2.6 m at Phnom Penh and 0.6 m at Sadec some 100 km from the sea. The fear of a substantial hydraulic side effect of embanking has led to the system of open or horse-shoe shaped embankments in the deltaic area of the Irrawaddy River in Burma (fig. 13).

4. Integrated flood control policy of upstream and downstream portions of a river basin

As stated earlier, in occupying the deltaic areas of the rivers, man did not wait until flood control measures upstream had been taken which would be beneficial for the conditions in the area. In the larger deltas of south-east Asia, land was used without flood protection. Embankments were built only in the coastal strip and in some areas with flash floods.

There were good reasons to postpone further embanking in deltaic areas until some form of upstream flood control had been achieved. Apart from the side effects mentioned in the previous section, embanking may completely upset the water management in the areas that were previously exposed to flooding. In many deltas the floods supply the necessary supplemental irrigation water during the wet season and there have been cases where the farmers have cut the embankments which were destined to protect the land areas in order to admit the water. Embankments obstruct the drainage of excess water from rainfall after the recession of the floods and it is necessary to make a drainage system. This in turn leads to a quicker disposal of the excess water so that less water is available in the area during the ensuing dry period. Since embankments also halt the beneficial flushing of the land areas after the dry season, provisions have to be made for the removal of accumulated dirt and polluted or brackish water and supply of water from outside becomes necessary. The adaptation of the traditional farming and water management to new methods made possible by the embanking is a time- and fund-absorbing process.

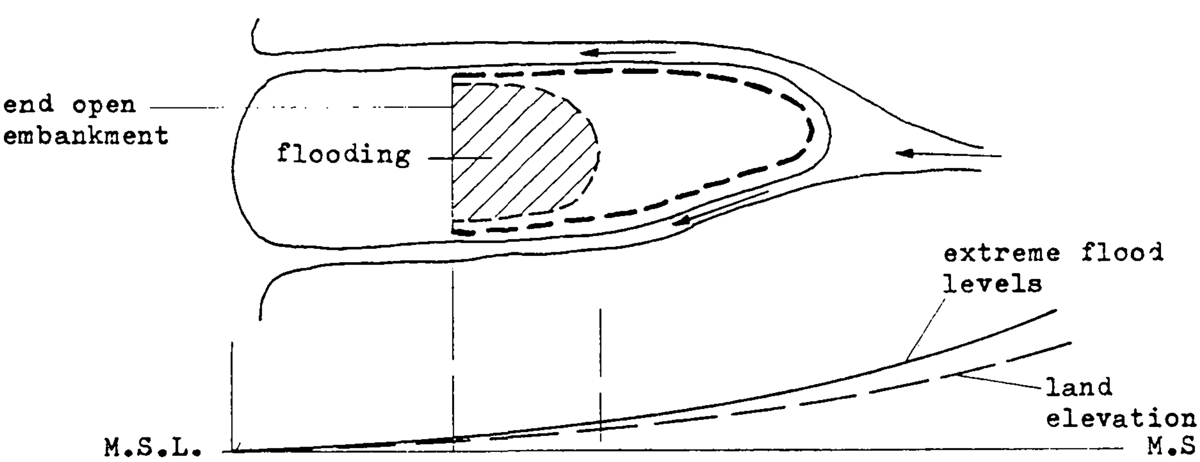

Figure 13. Principle of open embankments

Embanking may also have an effect on the channel morphology. Before embanking, a part of the sediments carried by the river was entrained to the flood plains, thus contributing to the natural build-up of the land areas. After embanking, the river has to carry all the sediments. The capacity of the river to do so has also increased because of the increase in velocity and slope. Depending on which factor prevails, scouring or silting-up may take place. In most cases, however, a rise of the river bed has been observed (ICID, 1960c). Even when deepening takes place or when by river training silting-up of the river bed temporarily is prevented, in the long term the bed will still rise owing to the natural delta expansion.

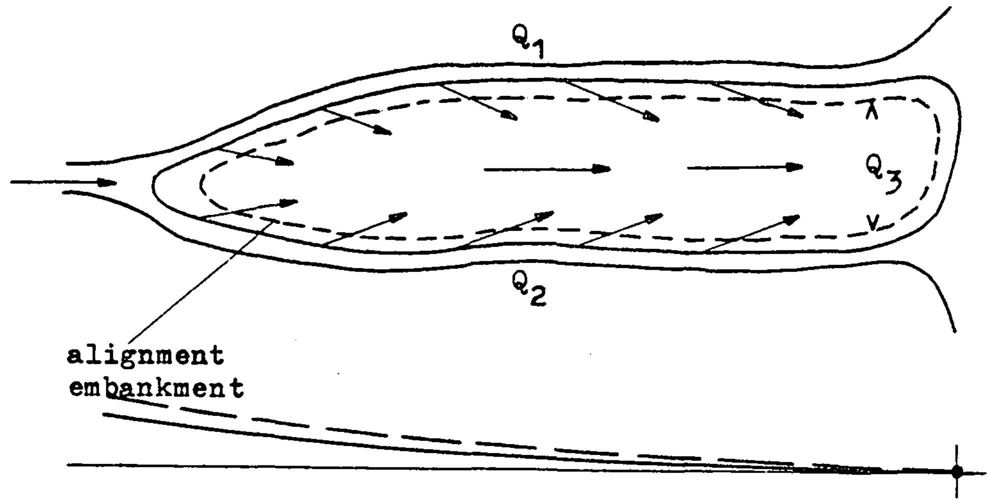

Figure 11. Effect of the elimination of the overland flow

that basin. Urbanization is the change that has the most drastic impact on the hydrologic régime. The effect on the hydrologic conditions of the deltaic area, however, is small because of the small percentage of the river basin that is occupied by urbanized areas.

Flood control works upstream, such as channel improvement, cut-offs, diversions and embanking, also influence the floods reaching the deltaic area. The effect of large-scale embanking upstream is, in many cases, the most complex and most important one.

3. Effects of embanking

Embanking is considered an economic and simple means of flood protection. In most cases, embankments can be erected with material available on location, using manual labour or simple equipment. Embanking may have several effects on the hydraulic and morphologic conditions of the river channels and the land areas. Only those effects will be considered here which are significant for the relation between the works upstream of a deltaic area and the magnitude of the floods in that area.

The hydraulic effects of embanking may consist of a rise of the flood level and an increase of the peak discharge. This is due to the elimination of the overland flow that occurred before embanking (fig. 11) and the elimination of the storage on the areas that were formerly flooded (fig. 12). The increase of the peak discharge occurs on location and downstream, while the higher flood levels produce a backwater effect in the upstream direction.

The effect of the elimination of overbank storage is most pronounced in the case of flash floods where at the time of occurrence of the peak discharge there is still a considerable lateral inflow. In the case of gentle floods with peak flows varying little over several weeks, the lateral inflow finally becomes very small and the effect of embanking will accordingly be small.

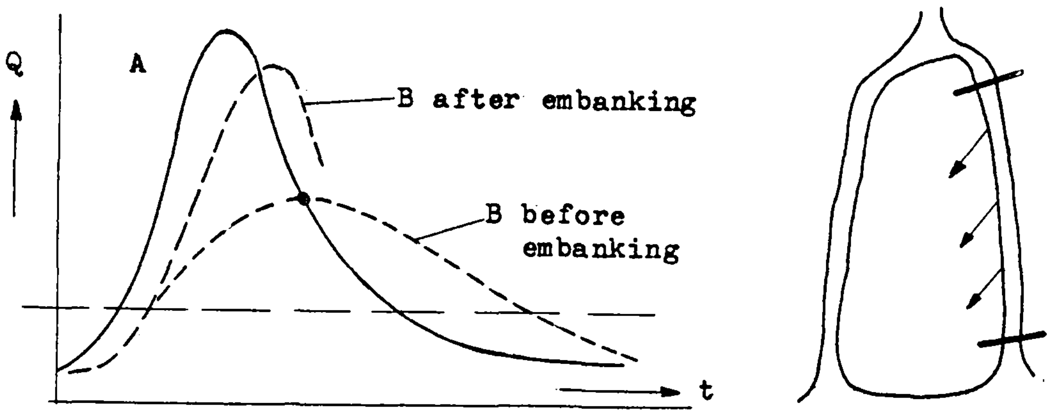

Figure 12. Effect of the elimination of the overbank storage

If embanking can be combined with upstream flood control, a gradual development of the areas to be protected become possible. In a first stage, only extreme floods which are damaging can be reduced by flood detention reservoirs and the normal floods can continue their course. With improved facilities for drainage and irrigation, embankments can be raised wherever desirable and feasible. These embankments can be lower than at places without upstream retention and have fewer side effects. With further gradual development of the areas, the original system of irrigation by flooding can be replaced by controlled irrigation and further flooding will be prevented either by providing more upstream storage or by extending the system of low embankments.

In Thailand the deltaic area of the Chao Phya River (the "central plain") offers an example of a gradual change from an uncontrolled system to a system where large parts have already been provided with control of the water management. A first step was the construction of a "headwork" at Chainat near the apex of the delta, whereby control of the distribution of the flood waters over the various basins in the delta became possible (1957). This was followed by the construction of the first multiple-purpose reservoir, the Bhumiphol dam, in 1964, and still later by a second one, the Sirikit dam, in 1973. The development of the delta has been keeping pace with the gradual improvement of upstream flood control and water conservation.

In the studies on the agricultural development with improved water control in the Mekong river delta (United Nations, Mekong Committee, 1974), the possibilities of reducing the floods arriving in the delta have played an important role. Thus, the reservoir of Pa Mong can compensate the effects of diking the Trans-Bassac. Pa Mong and Stung Treng together can achieve the same effect in the case of complete diking.

D. POSSIBILITIES FOR INTEGRATED OPTIMUM DEVELOPMENT OF THE DELTAIC AND UPLAND PORTIONS OF A RIVER BASIN

1. Criteria and general methodology

As mentioned in sections B.5 and C.4, the downstream and upstream portions of a river basin should be considered jointly in the development of water conservation and flood control. The interests of both portions are compatible in some respects and conflicting in others. The problem is that many alternative schemes can be drawn up which include combinations of the following elements:

Coastal or upstream reservoirs or a combination thereof;

Allocation of water in upstream reservoirs between the deltaic and upstream portions of a river basin;

Allocation of empty storage space in upstream reservoirs for flood control in the delta according to specific requirements;

Flood protection in the delta by embanking and other means;

Operation of the coastal and upstream reservoirs;

Water quality standards upstream and in the delta;

Allocation of water for salinity control;

Diversions of water, especially in the delta;

Choice of areas to be irrigated in the entire river basin.

The options are numerous and the various alternative schemes have different impacts on the private and national economies and on the environmental and social conditions. Decision makers have to consider these impacts and, in addition, to account for political factors, regardless of whether a "national" or an "international" river basin is concerned. The latter factors may entirely govern the ultimate decision. Yet an objective assessment of the economic impacts of various schemes and a quality ranking of their environmental merits is an indispensable tool in the decision-making process.

During the past two decades or so, methods have been developed based on systems analysis and computer application to select an "optimum" solution based on economic criterioa such as cost-benefit ratio, financial feasibility (possibility of repayment) and economic feasibility (impact on the gross national product). Generalized equations have been derived for optimizing rather simple systems, such as optimum water allocation for a multiple-purpose reservoir, optimum area to be irrigated and single reservoir or combinations of reservoirs.

For large-scale, complex, multiple-purpose water resources systems like the ones under consideration here, such a direct approach is not feasible. A division of the total system into subsystems is necessary, either according to geographical subregions or to economic sectors. Next to these submodels, over-all models integrating the results of the submodels (management strategy models) or referring to a single or a few variables (such as water distribution models) are considered. How this is done depends on the particular situation and the views of the model makers.

In the Netherlands, the first results have become available of a model, Policy Analysis of the Water Management of the Netherlands (PAWN), dealing with the policy analysis of the water management of that country (fig. 14). The model covers the deltaic area of the Rhine River and those parts of the Netherlands where water management is related to that of the deltaic area. It does not include the river basin proper and the amount and quality of the water supplied by the river are introduced as given quantities varying with time ("scenario-assumption"). The chief objective of the model was to design a number of over-all policies, assess their impacts on the various sectors of the economy and the environment and present these impacts in such a way that they become visible and comparable, helping decision makers in their choice between policies.

2. The main problems

In the foregoing sections, the technical problems encountered in the integrated development of the deltaic and upstream portions of a river basin have been set forth, as well as the general methodology for identifying optimum development possibilities according to objective criteria. The problems which, when it comes to decisions, principally involve considerations beyond the technical and economic sphere, are those of water allocation from upstream reservoirs in the basin in the interest of salinity control in the delta, the reservation of upstream storage space in the interest of flood protection in the delta, the phased development of the two portions and the organizational and legal aspects of integrated development. In addition to this, in industrialized river basins there is the problem of the effect of upstream pollution on conditions in the delta.

The problem of phased development has already been touched upon in relation to flood protection in the delta (section C.4). The problem presents itself in all sectors of integrated development. The economic impacts of different timings of the implementation of technical works can be evaluated and introduced into the optimization models. Phased development may be desirable from the technical and economic point of view; it may also be imposed in a quite different direction by requirements of regional development and related priorities.

For integrated development to be achieved, there must be an organizational framework and almost always a legal framework. The organizational framework may take different forms; a national water authority, a river basin authority or a joint commission with representatives from the deltaic and the upstreams portion of the river basin. A legal framework is required to endorse the competence of the organization and to ensure the implementation of an agreed or imposed integrated scheme.

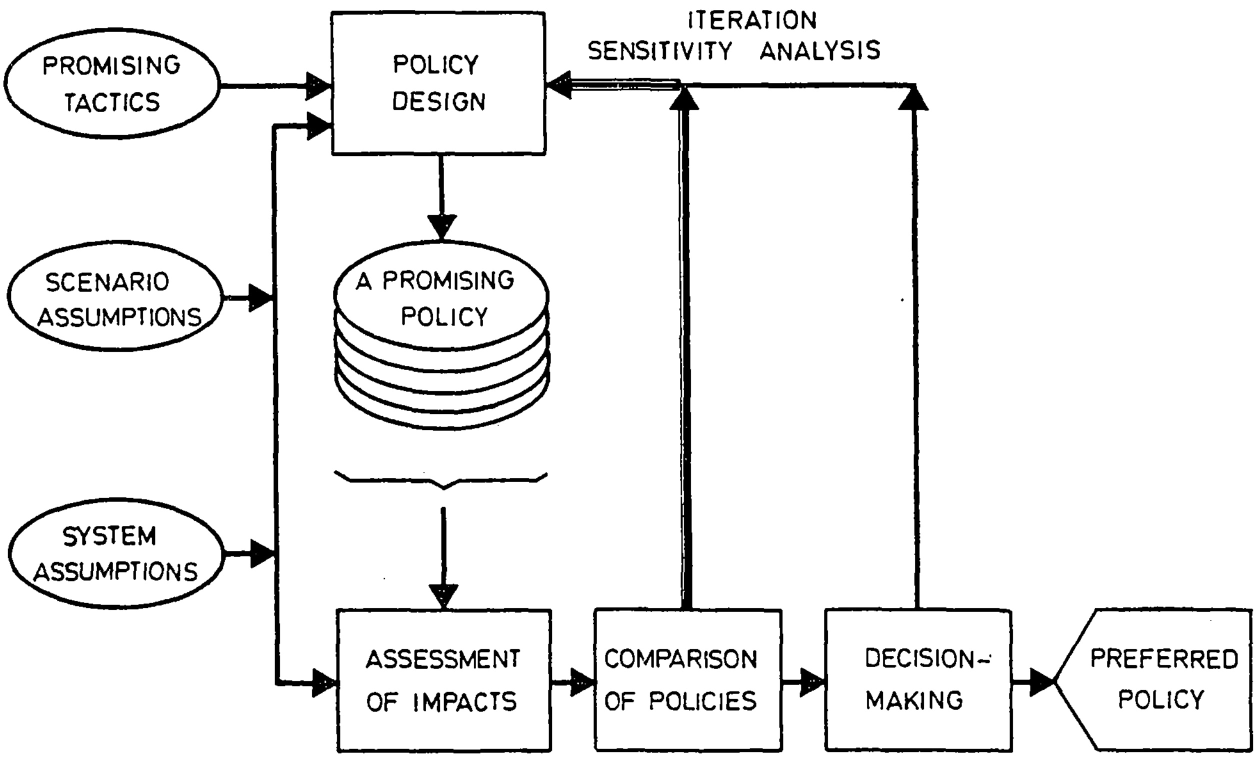

Figure 14. Stages of policy analysis (PAWN)

In many countries inside and outside the ESCAP region, solutions are being sought for the problems of setting up such organizations and one is confronted with great difficulties in integrating new organizations with the existing organizational and legal structures. For this reason, one cannot expect that for the management of "international" river basins generally accepted directives are available.

It is now generally accepted that in the management of "international" river basins, the interests of all riparian countries should be taken into due account. However, it has become more and more apparent that in view of the conflicting interests, agreements can only be concluded for each case separately, whereby full consideration must be given to the sovereign rights of each country concerned to develop its own resources. A review of existing agreements, conventions and treaties (Colorado, Rhine, Ganges, Niger, Indus etc.) shows indeed that they differ so much with respect to water allocation, sharing of costs, quality stanndards etc. that one is still far from discerning directives or common rules that could be applied to all cases.

E. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The optimum development of a river basin requires a comprehensive and integrated approach in which due consideration should be given to the interrelated interests of both the deltaic and the upland portions of the basin.

Many deltas in the ESCAP region are still at an early stage of hydraulic and agricultural development; the further exploitation of their great natural potentialities depends a great deal on the proper management of the water resources of the upland portions of the basin. Important considerations include the regulation of the river flow for flood control, provision of minimum flow for salinity control in the delta and the protection of the quality of the river water in general.

Development of the water resources in the upland portions of a river basin can have both beneficial and adverse effects on the hydrologic conditions of the delta. Thus, reservoirs upstream may reduce the floods reaching the delta and increase the liw flow during dry periods. However, they also retain the silt which may cause channel erosion downstream and reduce the rate of growth of the delta. Use of river water upstream may also decrease the amount of water available for the delta and result in deterioration of the water quality.

Critical problems in the joint development of the two portions of the river basin are those of allocation of space in upstream reservoirs for salinity control and also for flood protection in the delta, the proper phasing in the development of the two portions, and the organizational and legal aspects of integrated development. In industrialized river basins, there is also the problem of the effect of upstream pollution on the conditions in the delta.

Since a great number of alternative schemes and development options are possible in the joint development of the deltaic and the upland portions of a river basin, the beneficial impacts of which have to be optimized, the application of methods based on systems analysis can be of great help.

However useful, optimization models are no substitute for vision and statesmanship; however, they do show clearly the hierarchy of tactics, strategy and policy in the decision-making process and the objective indicators that can be applied in that process.

Recommendations

The development of river basins should be based on comprehensive master plans which include the development of the deltaic portions of the basin.

In the formulation of master plans for integrated river basin development, various alternatives should be considered for the allocation of water between the deltaic area and the upland portion of the river basin with respect to their economic, environmental and social merits.

When deciding on a high degree of flood protection in deltas which formerly were exposed to floods, it is necessary to examine the possibilities of a gradual transition from uncontrolled to controlled conditions by using a combination of upstream flood retention and the construction of low embankments in the delta.

Considering the serious problem of sea-water intrusion in the estuaries of a delta and the overriding importance of minimizing outflow of river water to the sea to control such intrusion, it is recommended that ESCAP, in co-operation with other appropriate agencies, should organize a symposium on the effects of salt-water intrusion on surface- and ground-water supplies and measures to control such intrusion.

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IV. INDUSTRIAL WATER USE IN RELATION TO OVER-ALL MANAGEMENT OF WATER RESOURCES

(E/ESCAP/NR. 7/4)

INTRODUCTION

The over-all management of water resources requires an integrated approach to the planning and management of this resource. Integrated policies and legislative and administrative guidelines are needed so as to ensure a good adaptation of resources to need and reduce, if necessary, the risk of serious supply shortages and ecological damage, to ensure public acceptance of planned water schemes and to ensure their financing. Proper management of water resources should ensure optimum social benefits of water resources use, as well as the protection of human health and the environment as a whole.

As there is increasing competition for water for various purposes, the development and management of water resources need to be planned and carried out in the context of a national water plan, which itself is a component in national planning generally. The major uses of water are for agriculture, community water supply, municipal water supply, hydroelectric power generation, industry, fisheries, control of salt-water intrusion and inland navigation.

In general, the amount of water required for fisheries, control of salt-water intrusion and inland navigation is more or less fixed, while that for hydroelectric power generation is non-consumptive in nature. With these considerations in mind, the management of the rest of the available water resources will depend on the competing demands of agriculture, community water supply, municipal water supply and industry.

In this context, a brief review of the characteristics of these various competing demands may be useful. With a given land area and specific crops, the amount of water for agriculture will be a more or less fixed quantity. Some of the needs for agricultural water supplies may be beneficially supplied from nitrate and phosphate-rich sewage effluents. In any case, the irrigation supplies should be provided from controlled storage in such a way that only the required quantities of water are delivered at the time of need.

The requirements for community water supply, however, will continue to increase because of (a) the increasing population, (b) the rising standard of living and (c) the increasing complexity of urbanizing regions. The requirements for the municipal water supply will not increase very much after a given level of services has been reached. It is, however, in the industrial sector that the greatest scope for adjustment in the use of water exists. Many possibilities are available because of improvements in technology, recycling, salvage of materials and increase in efficiency.

As the competition for water becomes keener with the economic and social development of the developing countries in the region, industrial water use will gain increasing importance in the over-all management of the water resources of these countries. The Governments of the countries of the region will have to be ready to change their policies regarding the use of water as well as to provide more effective storage and control of their water supply systems, especially in times of drought and seasonal shortages.

A. WATER FOR INDUSTRY

It was pointed out in a United Nations report[1] that in the past the cost of water was not a major cost item in most industrial processes. This being the case, industrial planners and managers have not been accustomed to paying close attention to matters concerning water. Likewise, Biswas[2] has pointed out that water is rarely a major issue in industrial plants since it represents 0.005-2.58 per cent of the total manufacturing costs in a group of industries. However, the availability of good quality water has been an important factor in industrial plant relocation. The availability of good water supplies has been an important factor in the planning of new industrial estates in Iran, the Republic of Korea, the Philippines and Malaysia. The growing need for water to support the increasing requirements for food, jobs and industrial output has given rise to a very real concern for the prudent use and reuse of water. The moral commitment to the wise use of water resources has dictated a reassessment of water resources management, while in the past the economic cost of a clean and plentiful supply of water was not a major factor in industrial management. Adjusting the cost of water for industries can be an important factor in promoting conservation measures.

Recently some areas of the world (California in 1975-1976 and London in 1976) have suffered from severe drought during which the water supplies of industrial communities had to be severely restricted. The fact that these areas were able to cope under these trying circumstances demonstrated that the water consumption habits of a community are far in excess of its real water needs. Blackburn[3] cited the recently completed interconnexions in parts of the London water supply system as an important factor in the delivery of emergency supplies to the most highly distressed parts of the water supply network during a drought.

Bower and Sewell[4] have shown a general outline of a procedure for analysing an industrial water supply when recirculation and treatment are employed. This schematic diagram and the definition of the various symbols and terms are shown as figure 15.

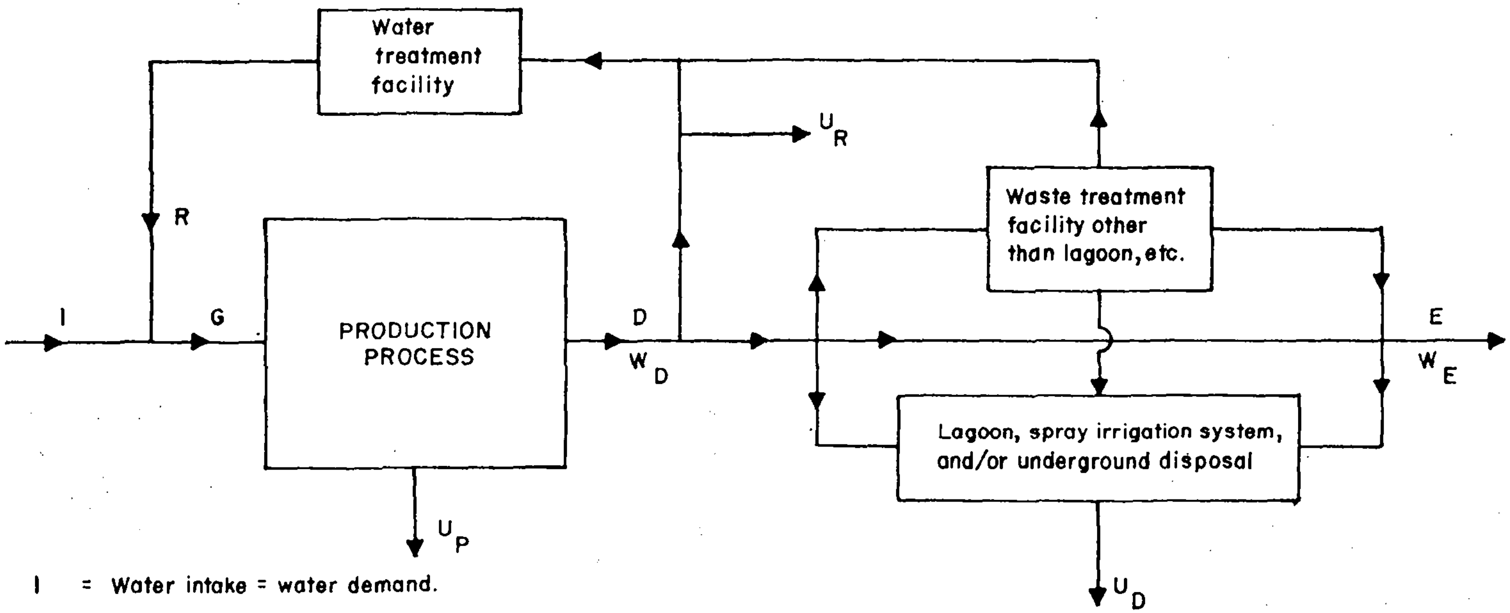
Bower and Sewell have defined a degree of recirculation which is the percentage of the gross demand which is recycled (fig. 15). As the industrial water-use efficiency improves, the degree of recirculation increases. As the degree of sophistication of the management of industrial water supplies increases, this degree of recirculation will increase. The type of use, eva-

[1] *The Demand for Water* (United Nations publication, Sale No. E.76. II.A.1).

[2] A. K. Biswas, "Water: a perspective on global issues and politics", *Journal of the Water Resources Planning Division,* American Society of Civil Engineers, vol. 105, No. WR 2, pp. 205-222.

[3] Anne M. Blackburn, "Management strategies: dealing with drought", *Journal of the American Water Works Association,* vol. 70, No. 2, pp. 51-59.

[4] B. T. Bower and W. R. D. Sewell, eds., *Forecasting the Demand for Water* (Government of Canada, Department of Energy, Mines and Resources, 1967).



I = Water intake = water demand.

R = Water recirculated.

G = Gross water applied for all in-plant uses.

U = Consumptive use or net depletion of water, = $U_P + U_D + U_R$, where U_P = consumptive use in the production process, U_D = consumptive use in the waste water disposal system, and U_R = consumptive use in the recirculation system.

D = Waste water discharge from the production process.

E = Final effluent from the production unit (available for reuse). Where a lagoon or spray irrigation system is involved, the final effluent --- if any --- consists of lagoon overflow, seepage, and/or surface runoff.

W_D = Waste load in the waste water discharge, for example, pounds of biochemical oxygen demand (BOD).

W_E = Waste load in the final effluent, i.e., pounds of BOD.

Degree of recirculation = R/G x 100 %.

Source : Bower and Sewell (1967)

Figure 15. Definitions of terms relating to industrial water utilization

poration and other losses and the nature of the pollutant added to the water provide an upper limit to the degree of recirculation. New industries must be encouraged to develop a high degree of recirculation.

1. Industrial consumptive use

A certain quantity of water used by an industry is removed at least temporarily from the total water supply. This includes such things as the water used in the preparation of beverages and canned food and the water used in the manufacture of Portland cement etc. The consumptive use (U) would also include water which is evaporated, such as water used to quench hot steel, or water used in the operation of wet cooling towers. The consumptive use would also include water which is lost by leakage, seepage or is unaccounted for in the water balance.

The consumptive use is an upper limit to the amount of recirculation which could take place within that industry; i.e., water which is consumed cannot be recirculated or reused. In the case of the data for the mining industry in Hungary, it is seen that the consumptive use is 44 per cent of the annual water intake, while the degree of recirculation is 56 per cent.

There is some opportunity to reduce the consumptive use in industries through the elimination of losses and through the reduction of evaporation losses. Sometimes the industrial wastes are held in evaporation ponds while the water evaporates. More careful management of the washing process which produced the waste in the first place might result in a smaller volume of water being evaporated. The case of the mining industry in Hungary, which was cited previously, is a good example. If the slurries and ores could be processed in a more concentrated form, a smaller volume of water would be consumed and the consumptive use would be smaller than the 44 per cent shown for this industry.

The water consumption of various industries in the United States of America is shown in table 13. Where available, the consumptive use for similar industries is Hungary is also shown for comparison.

Table 13. Consumptive water use for major types of industry

Industry	*Consumptive use (percentage of intake)*	
	United States	*Hungary*
Automobile	6.2	—
Beet sugar	10.5	8.3
Cane sugar	15.9	—
Chemicals	5.9	12.7
Coal preparation	18.2	—
Wheat and corn milling	20.6	—
Distillery	10.4	—
Food processing	33.6	10.6
Meat	3.2	7.4
Poultry processing	5.3	—
Salt	27.6	—
Soap and detergents	8.5	—
Machinery	21.4	8.1
Petroleum	7.2	3.4
Steel	7.3	—
Pulp and paper	4.3	4.3
Textiles	6.7	15.1
State-owned industries	—	11.9

2. Electric power generation

The industry with the largest gross water loss due to evaporation is steam-driven electric plants. Because it is a very large industry in all industrial societies, this represents a significant water loss on a world-wide basis. There has been a concerted effort in many countries to use water of poor quality for electric power station cooling. Brackish or salt water is used where possible. In South Africa, sewage plant effluent is used for this purpose.[5] There are three basic ways to dissipate heat from an electric power station: (a) once-through cooling systems, (b) either wet or air cooling towers and (c) cooling ponds. In the past, the waste heat was discharged into a nearby stream by diverting cool water from the stream, passing the water through the steam condenser and discharging the heated water back into the stream. The power plant may also have discharged some waste products from the boilers into the stream. As a result, there was both chemical and thermal pollution of the stream. These acts are no longer always permissible, and cooling towers, cooling ponds and a larger degree of recirculation have resulted. The changing trend in past and future use of water in steam-powered electric generating plants in the United States is shown in table 14.

Comparison of the growth of water demands in the United States shows that the rapid rate of increase in water requirements for industrial purposes in the United States was exceeded by the rate of increase in the water requirements for the generation of electricity by steam-power plants. The current crisis in world-wide energy production might have an effect on the future growth in water requirements for both the industrial sector and the thermal electric power sector. The depletion of the world's reserves of oil is within sight. While conservation of the remaining supplies of oil is commendable, it is not the solution to the problem. The solution to the problem lies in the

[5] E. F. Schulz, *Vaal River Studies: Development of Planning Procedures for Optimum Utilization of Water Resources* (Johannesburg, University of the Witwatersrund, Hydrological Research Unit).

Table 14. Past and future use of water for electric power station cooling (United States)

	Past use			Estimated use		
	1954	*1959*	*1965*	*1970*	*1975*	*1980*
Steam-generated electricity (billions of kWh)	368	569	880	1 250	1 730	2 300
Thermal efficiency (percentage)	28	31	33.5	36	38.5	40
Gross cooling water use (litres/kWh)	272	235	208	185	163	155
Gross cooling water use (litres $\times 10^{12}$/year)	103	133	148	232	285	370
Total intake (I)	94	124	—	182	—	258
Fresh water intake	70	80	—	130	—	180
Brackish water intake	23	34	—	54	—	80
Recirculation (R)	11	19	—	50	—	103
Degree of recirculation $\frac{R+I}{R}$ (100)	10	13	—	22	—	29
Evaporation loss (litres/kWh)[a]	2.5	2.1	1.9	1.6	1.5	1.4

Source: Adapted from G. O. G. Löf, "The water demand for power plant cooling", *Industrial Water Engineering,* December 1966.

Note: [a] Computed from generation and thermal efficiency by assuming 90 per cent boiler efficiency and that all heat entering cooling water results in evaporation at the rate of 0.35 litres per 1,050 BTU heat discharged (this is equivalent to assuming that 75 per cent of the heat is ultimately discarded by evaporation of cooling water and the balance by conduction and radiation to the atmosphere).

development and utilization of alternative sources of energy. These include: (a) coal; (b) uranium (U); (c) oil shale and tar sands; (d) natural gas; (e) hydro-electric power; (f) solar energy; (g) geo-thermal energy; and (h) wind.

The development of some of these alternative energy sources has been progressing rapidly and it is obvious that many countries are seriously trying to escape their dependence on oil for their energy requirements.

The development of some of the alternative energy sources also has a considerable effect on requirements for water. A study of the cooling water requirements of different electricity generating technologies was made by Thompson and others.[6] Table 15 is a comparison of the heat producing characteristics and the cooling requirements of various methods of producing electricity.

The use of alternate sources of energy to operate industries and generate electricity in the coming decade is likely to cause an increase in the rate of growth of water required for cooling. This may, in part, be offset by the application of new technology in power station cooling.

Table 15. Thermal heat rate and cooling requirements of potential electricity generating technologies

Method	*Heat rate (BTU/kWh)*	*Cooling water requirements (litres/kWh)*
Fuel cell	5 000	Nil
Breeder reactor	8 500	140
Magnetohydrodynamics		
Driving gas turbine	6 200	Nil
Magnetohydrodynamics		
Driving a steam turbine	5 690	61
Electrogas dynamics	7 100	Nil
Solar collector	18 000	Nil
Fusion	5 700	61
Fusion with direct conversion	4 900	38
Oil- or coal-fired steam		
1970	10 800	164
1980	9 500	140
1990	9 000	130
Conventional nuclear		
1970	10 700	206
1980	10 500	198
1990	10 000	186
Internal combustion	12 500	144
Gas turbine	14 000	Nil

Source: R. G. Thompson and others, *Forecasting Water Demands* (United States National Water Commission, Report No. PB 206 491, Springfield, Virginia).

[6] R. G. Thompson and others, *Forecasting Water Demands* (United States National Water Commission, Report PB 206 491, Springfield, Virginia).

3. Types of industrial water use

Large quantities of water are required by industry. In the United States, 48 per cent of the total water used is taken by industries, while in Czechoslovakia, Poland, the two Germanies and the United Kingdom between 70 and 90 per cent of the total water used is for industrial water use. Water is used in the industrial sector in a number of ways. Some of these needs are consumptive in nature and others are not consumptive. The industrial water uses can be classified into five main industrial groups: (a) food and meat products, (b) pulp and paper, (c) chemicals, (d) petroleum and (e) coal and primary metals. These uses account for slightly more than 85 per cent of the withdrawals for industrial needs. A large proportion of the industrial water supplies is required for cooling and this need not be water of high quality. Sea water can be used for this purpose and where water is in very short supply, this operation might be carried a step further: the heat might be used as the start of a saline water demineralization process; the waste heat would thus be absorbed and the supply of good-quality water extended.

Of all the common substances, water has a relatively high specific heat. This means that it has a relatively large capacity to transfer heat in relation to its mass. This property of water makes it ideally suited to control temperatures or for cooling in various manufacturing processes. In many of these applications water is not really consumed in the cooling process, but the water is of such high temperature that it cannot be directly discharged as waste water. The water is held in a pond for further cooling before discharge into a stream. The cooling in the pond is by convection to the atmosphere, conduction to the surrounding soil mass and evaporation from the pond.

In some industrial processes, water is used for quenching of hot metal parts, a process which nearly always results in the formation of some steam. The evaporation in the cooling process is a consumptive use of water.

4. Growth in demand

One of the key elements of good planning and management is always to have all of the necessary components of the production process available at the time they are required, not too soon and not too late. Skilled management of water resources therefore means that some prediction of future needs is necessary in order to be able to have the required quantity and quality of water available at the right time.

The growth of the water demand in the United States in the 75 years between 1900 and 1975 is shown in figure 16. This figure also shows the growth in demand for purposes of irrigation, industry, generation of electricity by steam plants and municipal and domestic uses. The comparison of these curves shows that while there was an increase in the demand for all of these purposes, it was not always a steady or a consistent growth in demand. As an example, the effect of the great depression (1929-1933) on the growth rate can be seen in the curves for industrial use, municipal use and domestic use. The rapid industrial expansion during the Second World War (1939-1945) caused sharp increases in water demand for generation of thermal electricity, industrial needs and municipal needs. This sharp rise was followed by a decrease in the demand for electricity and industrial purposes in the period 1944-1946, when the war ended and there was a period of economic retrenchment. The effect of the technological advances made in the design of automatic clothes washing machines, dish washing machines and household garbage grinders can be seen in the sharp increase in demand for domestic purposes in the period 1945-1950.

The effect of the population increase and the growth in industrial productivity (measured by GNP) on the daily water demand is shown in figure 17. The total water demand from figure 16 is compared with the population and gross national product produced in the United States in figure 17. A multiple regression equation can be derived from the data shown in figure 17. The equation is:

$$\text{Daily water demand (litres/capita/day)} = -3{,}139.14 + (54.51 \times 10^{-6} \times \text{population}) - (0.07 \times \text{GNP}) \quad (R^2 = 0.97).$$

This shows that the gross water demand can be predicted when the population and industrial productivity can be predicted. The problem of predicting future water needs is always going to be complicated at times of economic recession or depression, as shown during the periods 1929-1933 and 1944-1946, when the regression equation would overestimate the demand. A second problem occurs when there are great technological changes. The regression equation would underestimate the growth in the domestic demand owing to the introduction of the automatic clothes washers, dish washers and garbage grinders during the late 1940s.

It should be pointed out that this regression equation was derived for data in the United States between 1900 and 1975. This equation would not fit the growth in water demand in any other country nor would it fit the data for the United States during the next 75 years because the next century will be marked by a greater awareness of environmental and social factors. The regression equation demonstrates, however, that growth in water demand is a function of population increase and national productivity. Each

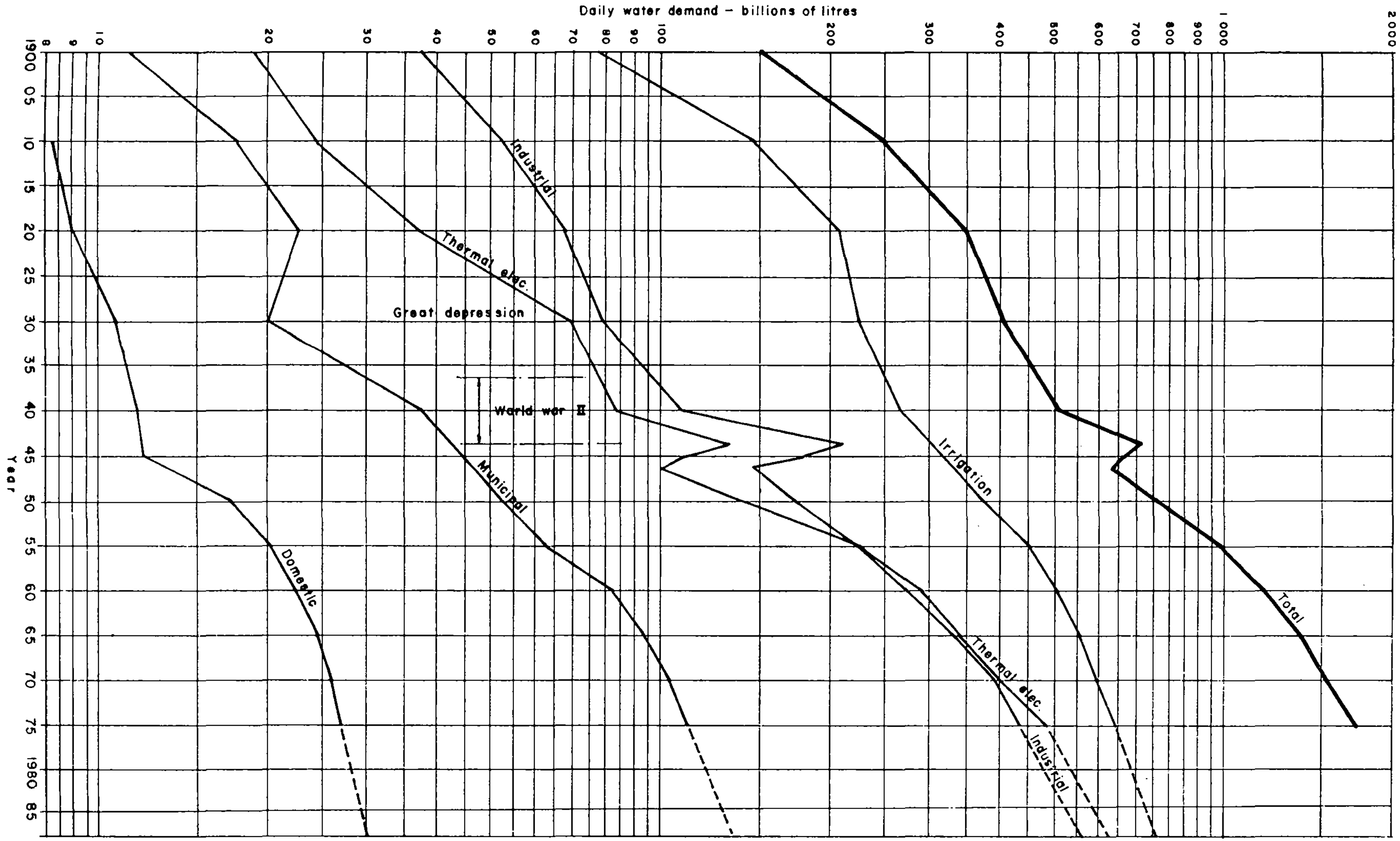


Figure 16. Growth in water demand, United States of America (1900-1975)

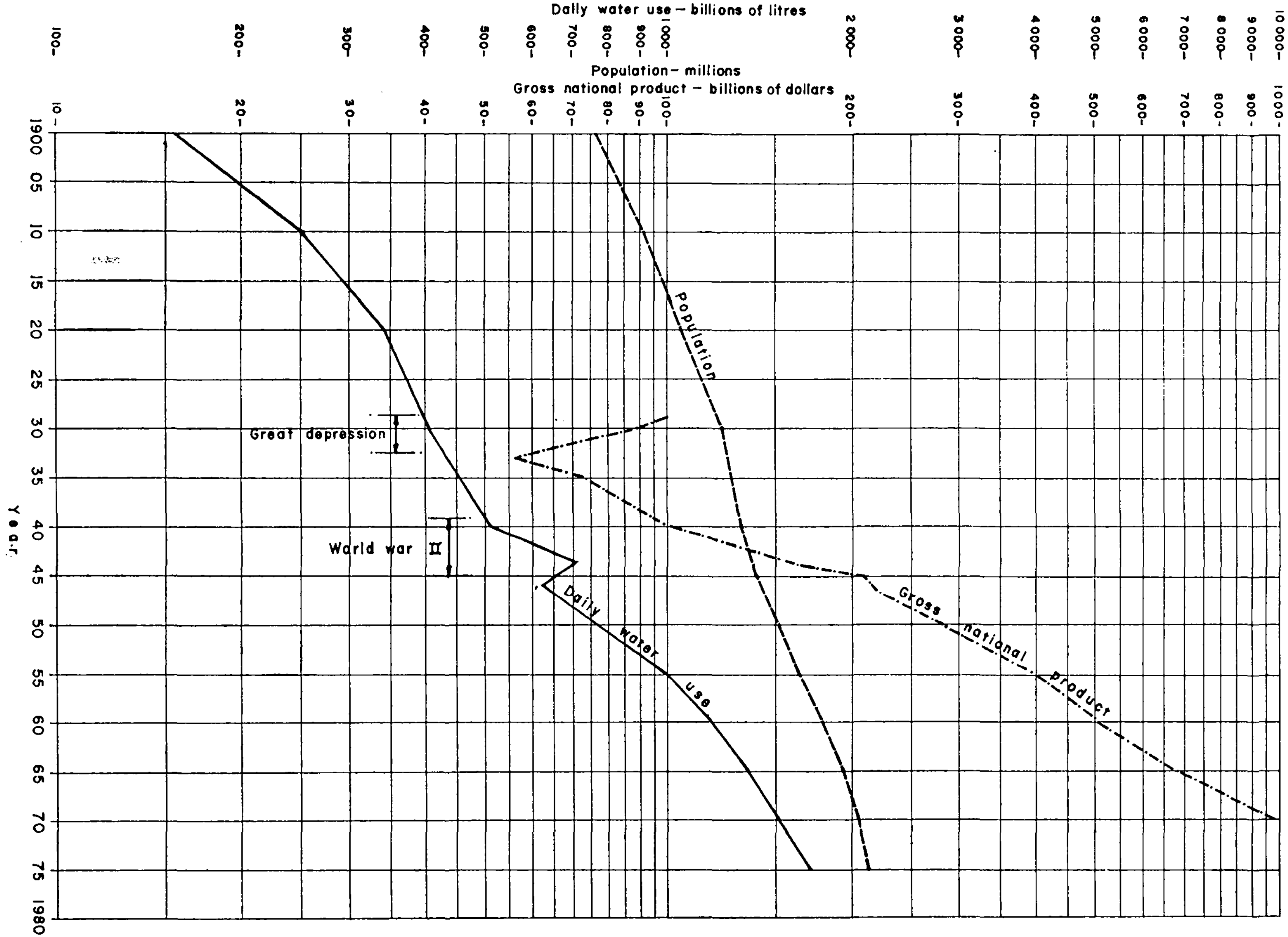


Figure 17. Comparison of water demand, population growth and national productivity for the United States of America (1900-1975)

country will have its own relationship. Furthermore, water demand increases more rapidly than the rate of population growth and this more rapid increase in water demand is correlated with rapidly rising national industrial activity. Realistic planning for industrial water supplies needs to be aware of these two facts.

B. WATER-USE PATTERNS IN SELECTED COUNTRIES

The relationship of water used for municipal and domestic water supply, agriculture and industry is shown in table 16. These data are given for a variety of developed and underdeveloped countries of the world.

Table 16. Water-use data in selected countries

Country	Year	Annual per capita withdrawal (cu m)	Distribution among different uses (percentage)		
			Domestic and municipal	Irrigation and agriculture	Industry
(1)	(2)	(3)	(4)	(5)	(6)
Bulgaria	1965	615	8	72	20
Czechoslovakia	1965	285	13	6	81
France	1965	540	13	38	49
German Democratic Republic	1965	380	8	12	80
Germany, Federal Republic of	1965	245	20	10	70
Hungary	1965	390	9	45	46
India	1968	600	3	96	1
Israel	1960	630	16	80	4
Japan	1965	710	10	72	18
Mexico	1970	920	4	91	5
Mongolia	1965	135	12	80	8
Poland	1965	250	13	17	70
United Kingdom	1965	200	31	3	66
United Republic of Tanzania	1970	36	63	35	2(est.)
United States of America	1965	2 300	10	42	48
USSR	1965	1 000	8	53	39

The countries with the highest **per capita** withdrawals of water are also those countries which use approximately 50 per cent of their withdrawals for irrigation. However, in countries where more than 40 per cent of the water is used for industrial purposes, recirculation becomes an important consideration. In these industrialized countries, it has been profitable to implement water salvage or water reuse. Water salvage is more practicable in certain industries. Table 17 shows a comparison of the intake water for industrial uses (I), the recirculated water (R) and the water actually consumed (U) for Hungary (1965) for various types of industries.

Comparison of the data for Hungary given in table 17 shows that the paper, chemical, food processing and mining industries have the highest degree of recirculation. This is in part due to the fact that these industrial effluents tend to be highly degraded and that these industries have been compelled to reuse and treat their effluents for environmental reasons. These industries have already achieved a high degree of reuse, as evidenced in the relatively large figures in the column showing the degree of recirculation in table 17.

In order to be able to predict the future needs for industrial water, it is necessary to know the type of industry planned and the size of the industry. The United Nations[7] has assembled data from various countries around the world on the water required per unit of output for a large number of different industries. For some of the industries, data are given from several different countries. In addition, ranges of values of water use are given for some of the industries. These ranges of values give an indication of the range in water needs for these industries, based on different levels of technological development and different climatic conditions. These data were provided by the respondents to a request from the Secretary-General for this information in 1957 and 1978 and represent the technology prevalent at the time.

[7] *The Demand for Water* (United Nations publication, Sales No. E.76. II.A.1).

Table 17. Comparison of water recirculation and consumptive use for various industries, Hungary, 1965

Industry	*Annual industrial water intake (I)*	*Recirculated water (R)*	*Degree of recirculation (R) (percentage)*	*Consumptive use (U) (percentage)*
	cu m × 10⁶	*cu m × 10⁶*	$\frac{R}{R+I}(100)$	$\frac{U}{I}(100)$
(1)	*(2)*	*(3)*	*(4)*	*(5)*
Paper	32.4	50.3	61	6.3
Chemical and rubber	144.3	229.1	61	12.7
Petroleum refining	32.8	2.8	8	3.4
Food	93.6	56.4	38	10.6
Sugar	30.2	27.7	48	8.3
Canning and preserving	14.5	6.1	30	11.0
Meat	9.4	2.4	20	7.4
Dairy	9.6	1.1	10	6.2
Textiles	39.7	4.1	9	15.1
Leather and fur	5.5	0.21	4	7.3
Mining	33.9	44.7	56	44.0
Building materials	19.7	4.3	18	37.1
Wood processing	3.8	1.4	27	10.5
Machines and appliances	12.3	2.2	15	8.1
State-owned industry	1 684.0	2 035.0	55	11.9

1. Impact of environmental conservation

Under the impact of environmental conservation, many industries are now developing new technologies for the reduction of their dependence on water and for the reduction of environmental pollution. In 1969, the National Environmental Protection Act was enacted in the United States. This and other laws made the discharge of pollutants into the nation's atmosphere, streams and land unlawful. The Environmental Protection Agency, which was established to administer the new law, acquired almost dictatorial powers in some cases. Some industries faced virtual shut-down because there was no economically feasible way in which they could meet the requirements of the law. New professions were created which had a complete knowledge of the details of the new law and could help industrial management in designing acceptable remedies to pollution problems.

Similar environmental concerns have resulted in drastic changes in water use strategy in Japan, central European countries and the United Kingdom.

It has been pointed out that in the United States the chemical industry ranked second (after electric power generation) in the consumption of water and that by the year 2000 the chemical industry would be the leading user of industrial water.[8] By 1975, about 45 per cent of the water intake by the chemical industry was used in the production of organic chemicals, while about 60 per cent was used for cooling. Some of the cooling water was recycled into the process water. Good quality water is often wastefully used in cooling.

2. New water-saving technology

Azad[8] presented a scheme whereby the cooling water intake of a chemical process could be reduced from 250,000 lb/hour to zero by the introduction of an air fin cooler; however, in the conversion there was an increase in the energy input because of the electric power required to drive the fans, and moreover, the concentration of the pollutant in the effluent was increased 26-fold. Schematic diagram of these three possible cooling systems are shown in figure 18. Part of the water saving may be offset by an increase in the water requirements of the electrical energy component.

Millington[9] cites an example of an industry in the United Kingdom where the cost of installing an air cooling tower paid for its capital cost in one year through the savings in the cost of fresh water, which was previously used on a once-through-the-plant basis. Most internal combustion engines successfully use a water-cooling engine with an air-cooled radiator. In a similar way, many cooling problems in the industrial sector could be solved using a water jacket and air cooling tower at a considerable saving in expense, pollution and water.

[8] H. S. Azad, ed., *Industrial Wastewater Management Handbook* (New York, McGraw Hill Book Company, 1976).

[9] P. E. Millington, "Give priority to the wise use of water", *Water Services*, vol. 83, No. 1003 (October 1978), pp. 781-783.

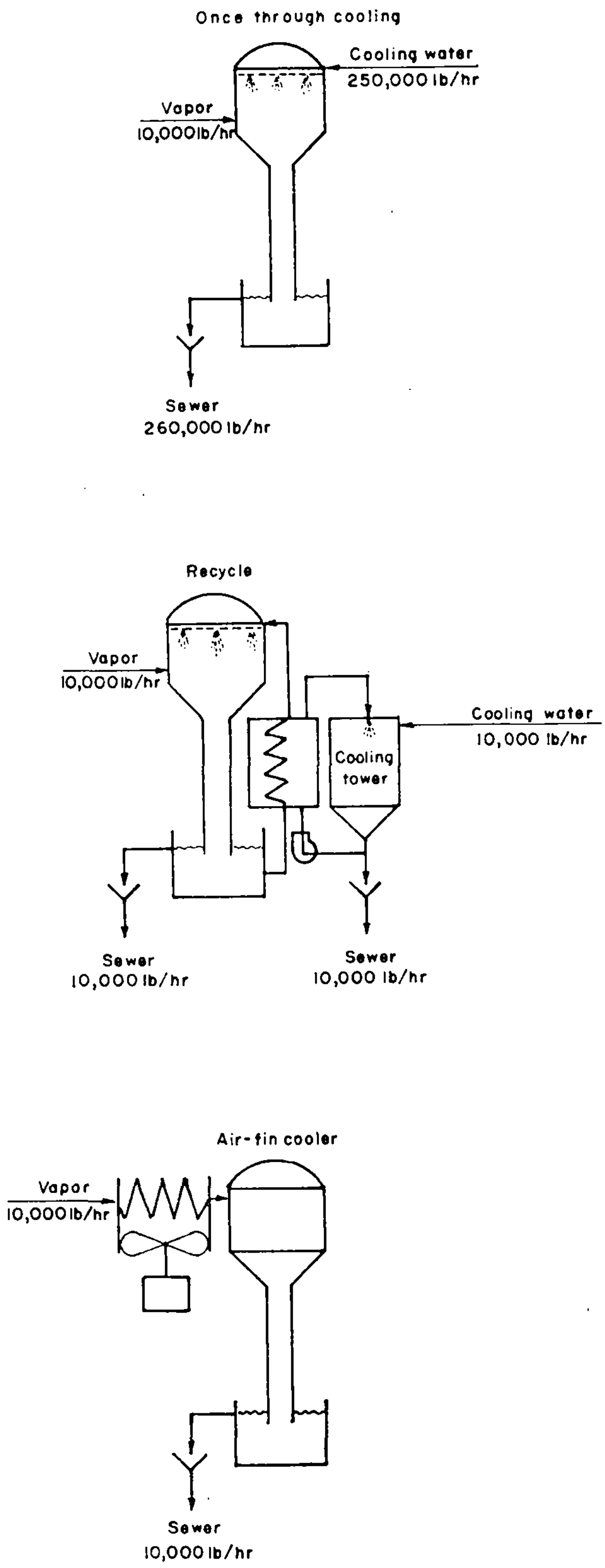


Figure 18.

Comparison of three systems for water cooling

Another example of the application of new technology to reduce the need for cooling water in electric power generation is under investigation in the United States. A test facility is being built to transfer the waste heat from the steam turbine generator to a cooling tower by boiling ammonia. The heat is dissipated to the atmosphere at the cooling tower.

New technological advances may allow water use and water pollution to be greatly reduced. An example is given in the food processing industry. The peels must be removed from fruits such as tomatoes, peaches, pears and apples before canning. These may be removed by a peeler followed by washing. Water is required and the peels pose a disposal problem. As an alternative, the peels may be removed by a chemical "burning" process which saves water and reduces the pollution and disposal load.

The fruit is passed over a sorting table where leaves, stems, foreign material and badly damaged fruit are removed. The fruit is then coated with a powder of sodium hydroxide (common lye). The fruit then passes on a conveyor belt which rolls the fruit over and over through a "heat" tunnel heated by electric heaters. The sodium hydroxide "burns" the peel, which falls off the fruit as a dried skin as the fruit rolls along the conveyor. After the heat tunnel, the fruit passes a high-frequency shaker which gently vibrates any loose skin and sodium hydroxide free. The fruit then rolls through a light water spray which removes the sodium hydroxide. This is the only water used and amounts to a relatively small volume. The major part of the waste is in the form of dried peels and sodium hydroxide powder. By screening, some of the sodium hydroxide powder is salvaged for reuse and the dried peels are relatively small in volume and can be disposed of as dry waste in a suitably double-sealed container by burying. The process uses much less water than the conventional fruit peeler, but the electrical energy input is higher and the water used is highly charged with sodium hydroxide, which may be neutralized with hydrochloric acid and the resulting salt salvaged by evaporating the water. This example shifts some of the industrial water demand to the electric power industry.

The adoption of new technology has been resisted by industrial management because, among other reasons, the application of these techniques makes the plant work less efficient, results in a poorer quality final product, causes rapid obsolescence of the existing plant and equipment and requires more expenditure for plant and equipment. There may be some validity to these arguments; however, water which is unnecessarily used or polluted is a cost to society. Society has a right to expect the most efficient over-all use of its resources.

Nearly everywhere, industries are being called upon to treat their effluents and wastes so as to protect the environment. Established industries are faced with the alternative of either ameliorating the adverse effects of their effluents or shutting down. New industries must take into account the probable effects of their proposed operations on the environment. Azad has given a table showing the known significant pollutants which result from the operation of 27 different classes of industries. These pollutants are given in table 18. Skilled management requires that these pollutants be given due consideration in planning and designing the industrial plant.

Reduction in the amount of water used by industries can be achieved through:

(a) Technological improvements;

(b) Recirculation, treatment and filtration of water used for washing or cleaning;

(c) Reduction of losses;

(d) National policy and legislation encouraging industry to devise and utilize water-saving measures;

Table 18. Known significant pollutants for selected industries

Categories of sources	*Known significant pollutants*
1. Pulp and paper mills	BOD, COD, SS, bac, WSL, NH_3, DS, biocides
2. Paperbased, builder's paper and board mills	BOD, COD, SS
3. Meat product and rendering process	BOD, DS, SS, N, NO_3, NH_3, O&G, P, bac.
4. Dairy product processing	pH, BOD, COD, DS, SS, set. s.
5. Grain mills	BOD, SS, pH, DS, N, P, heat
6. Canned and preserved fruits and vegetables processing	BOD, SS, pH
7. Canned and preserved seafood processing	BOD, COD, SS, DS, O, fecal coliform, Cl
8. Sugar processing	BOD, COD, SS, DS, coli, NH_3, pH, heat
9. Textile mills	BOD, COD, DS, color, SS, O&G, heavy metals (Cu, Cr, Zn)
10. Cement manufacturing	DS, SS, pH, heat
11. Feedlots	BOD, DS, SS, NO_3, P, coli
12. Electroplating	Heavy metals (Cr, Zn, Ni, Cd, others), CN, acidity, pH, DS, SS
13. Organic chemicals manufacturing	O, unreacted raw materials, BOD, COD, SS, acidity or alkalinity, heavy metals and heat
14. Inorganic chemicals manufacturing	Divided into 22 discrete subcategories* BOD, DS, COD, pH, heat
15. Plastic and synthetic materials manufacturing	BOD, COD, SS, heavy metals, pH (subcategories vary extensively)
16. Soap and detergent manufacturing	BOD, COD, SS, O&G, surf, pH
17. Fertilizer manufacturing	
Subpart A — Phosphate type	pH, P, F, Cd, As, V, U
Subpart B — Ammonia	pH, N, O
Subpart C — Urea	pH, N
Subpart D — Ammonium nitrate	ph, N, NO_3
Subpart D — Nitric acid	ph, N, NO_3
18. Petroleum refining	O, S, Phen, NH_3, BOD, COD, heavy metals, alkalinity
19. Iron and steel manufacturing	Phen, CN, NH_3, O, SS, heavy metals (Cr, Ni, Zn, Sn), DS, acidity, heat
20. Nonferrous metals manufacturing	BOD, SS, DS, COD, CN, pH, color, turb, heavy metals, P, N, O&G, heat
21. Phosphate manufacturing	F, As, P, H_3PO_4, H_2SO_3, H_2SO_4, HCl, SS, Cr, DS, NH_3
22. Steam electric power plants	BOD, SS, DS, COD, CN, pH, surf, color, O&G, phen, turb, heavy metals, VS, P, N, heat
23. Ferroalloy manufacturing	
Subpart A — Open electric furnaces with wet air pollution control	SS, Cr, Cr^{6+}, CN, Mn, O, phen, PO_4
Subpart B — Covered electric furnaces with wet air pollution control	SS, Cr, Cr^{6+}, Mn, O, phen, PO_4
Subpart C — Slag processing	SS, Cr, Mn, O
Subpart D — Noncontact cooling	Heat, SS, Cr, Cr^{6+}, O, PO_4
24. Leather tanning and finishing	BOD, COD, DS, alkalinity, hard, color, NaCl, SO_3, S, amines, Cr, Na_2CO_3, O&G
25. Glass and asbestos manufacturing	
Glass	NH_3, pH, color, turb, heat, phen, BOD, COD, DS, SS, O&G
Asbestos	SS, BOD, pH
26. Rubber processing	BOD, COD, N, surf, color, Cl, S, O&G, phen, Cr
27. Timber products	BOD, COD, SS, DS, color, TOC

Table 18 (contd.)

Definitions of parameters

phen	Phenols	NH_3	Ammonia	Cr	Chromium (total)
BOD	Biochemical oxygen demand	pH	pH	WSL	Waste sulfite liquor
COD	Chemical oxygen demand	color	Color (APHA) and/or dyes	NaCl	Sodium chloride
DS	Dissolved solids	turb	Turbidity	hard	Hardness
SS	Suspended solids	heat	Thermal	Mn	Manganese
O	Oil	N	Nitrogen (organic or Kjeldahl)	V	Vanadium
G	Grease	NO_3	Nitrate	U	Uranium
set. s.	Settleable solids	P	Phosphate	S	Sulfide
Cl	Chloride	bac	Bacteria	Sn	Tin
Cu	Copper	coli	Total coliform	VS	Volatile solids
Zn	Zinc	F	Fluoride	Cr^{6+}	Chromium hexavalent
Ni	Nickel	As	Arsenic	SO_3	Sulfite
Cd	Cadmium	H_3PO_4	Phosphoric acid	Na_2CO_3	Sodium carbonate
CN	Cyanide	H_2SO_3	Sulfurous acid	TOC	Total organic carbon
alk	Alkalinity	H_2SO_4	Sulfuric acid		
surf	Surfactants	HCl	Hydrochloric acid		

• Inorganic chemicals manufacturing sub + categories

1. Aluminum chloride
2. Aluminum sulfate
3. Calcium carbide
4. Calcium chloride
5. Calcium oxide
6. Chlorine, sodium, hydroxide, potassium hydroxide
7. Hydrochloric acid
8. Hydrofluoric acid
9. Hydrogen peroxide
10. Nitric acid

Source: M. S. Azad, ed., *Industrial Wastewater Management Handbook* (New York, McGraw Hill), pp. 1-12 and 1-13.

(e) Economic instruments, including appropriate water pricing policies, which encourage or discourage industries to convert to less wasteful use of water;

(f) Vigorous publicity and public information programmes to publicize the adoption of water-saving measures by industries.

Summary and conclusions

Industries must grow and expand in order to provide not only for the needs of a growing population but also for the employment of a growing labour force. Increasing industrial output need not necessarily increase the total requirements for water. New technology, more recirculation and more attention given to water reuse can help to keep down the rising needs for industrial water supply as well as cope with the growing awareness regarding stream pollution by industries. Governments need to develop a vigorous public education programme on water saving and the activities of industries to reduce their water requirements and their pollution loads. Economic incentives need to be provided to help industries to convert to water-saving technology.

Part Three

INFORMATION PAPERS SUBMITTED BY GOVERNMENTS

I. AUSTRALIA

(NR.7/CRP.12)

Introduction

This report reviews progress in Australia in a number of important areas of water resources development and management since the fourth session of the ESCAP Committee on Natural Resources in 1977. It has been prepared by the staff of the Department of National Development and Energy of the Commonwealth Government, which has primary responsibility for the Commonwealth's interest in water resources matters and also provides a secretariat for the Australian Water Resources Council (AWRC), formed in 1963 with a membership of ministerial representatives of the Commonwealth and State Governments.

A. WATER RESOURCES MANAGEMENT

Responsibility for water resources management lies with each of the seven State Governments and with agencies of the Commonwealth Government in respect of the Australian Capital Territory (ACT). The Commonwealth Government has a direct involvement in the operations of the River Murray Commission and the Snowy Mountains Hydro-Electric Authority. Moreover it was responsible for the establishment of AWRC, which provides a forum for co-ordination at the national level and for the exchange of information of mutual interest to the Commonwealth and the States, and it also provides special assistance to the States for water resource projects.

The main water management agencies have been established by the States and, in the case of urban supplies, by local government with State Government support. There are generally one or two large boards or departments in each State providing metropolitan water supply, sewerage and drainage services together with State-wide commissions providing or co-ordinating the provision of irrigation and rural water supply and performing broad water management functions throughout the State. Two exceptions referred to above are the River Murray Commission and the Snowy Mountains Hydro-Electric Authority, each of which was formed to deal with matters related to the use of water by more than one State.

While there are some private schemes, major irrigated areas in Australia have generally developed on a large scale through government investment. Most urban areas are serviced by comprehensive water supply systems with considerable attention being given to high reliability of supply. Waterborne waste disposal systems, although not as comprehensive as water supply systems, also serve large areas of most urban centres.

B. WATER RESOURCES ACTIVITIES SINCE 1977

1. National water policy and planning

In 1978, a Senate Committee of the Commonwealth Parliament reported to Parliament on its inquiry into the Commonwealth's role in the assessment, planning, development and management of Australia's water resources (1). The inquiry was undertaken with regard to the diverse responsibilities of the Commonwealth and the States in these matters and the AWRC statement on a national approach to water resources management which had been endorsed by the Commonwealth and State Governments (2). The Senate Committee's first and most important recommendation was that the Commonwealth Government make a clear statement of its water policy objectives. Such a statement was made by the Government on 28 March 1979 (3). In the broadest terms, the Commonwealth's objective is the long-term beneficial use of Australia's water resources. The statement identified a number of policy thrusts and various means available to Government to achieve this end.

Concurrent with the Senate inquiry, the Commonwealth Government announced a new National Water Resources Programme to assist the States on water resource projects. Later it also decided to operate separate sub-programmes for flood-plain management and salinity control, both identified by the Senate Committee as areas of high priority and national concern.

Since 1977, and based on considerations discussed in the Senate Committee's report, there have been some further changes in the institutional structures in Australia for co-ordinating water resources activities. At the national level, the Commonwealth Department of National Development and Energy now has prime responsibility for the Commonwealth Government's interests in all aspects of water resources. There has also been a recent restructuring of the AWRC committees to reflect a greater concern for specific aspects of water resources management. Several of the States have also moved either to strengthen their legislation, so that main responsibility for water is vested in one government department, or to establish State co-ordinating agencies.

2. Water resources assessment

Detailed information on Australia's water resources is available in a review document published for AWRC in 1976 (4). A further updated review is planned for 1985.

Under the National Water Resources Assessment Programme, the Commonwealth Government has provided assistance to the States for the assessment of Australia's water resources since 1964 and measurement networks are well developed. In 1978 a decision was taken to review the programme, particularly as to the most efficient and rational future directions to be taken in the collection and analysis of Australian water resources data. This has entailed the examination of long-term objectives and requirements, appropriate mechanisms for regular review, means of ensuring adequate availability of information and a review of costs. The working group undertaking this task is currently finalizing its report.

Related to this and under the auspices of AWRC, a review of the design of water resources data networks in Australia was undertaken by the Snowy Mountains Engineering Corporation, supported by a grant from the Water Research Fund administered by the Commonwealth Department of National Development and Energy (5).

Under the Australian Representative Basins Programme, initiated in 1968, a number of river basins selected to represent the major hydrologic regions of Australia are being progressively and comprehensively covered by a network of measuring instruments, and studied with the aid of a mathematical process model in order to gain a clearer understanding of hydrological relationships under the range of conditions experienced in Australia (6). It was expected that the results could be extrapolated to predict the hydrologic response of small ungauged catchments. In the past two years, the objectives and certain other aspects of the programme, including the concept of representativity, have come under question and the whole programme is currently being reviewed.

3. National survey of water use in Australia

The primary uses of water in Australia are irrigation of agricultural lands and urban and industrial water supply. Data on water use is essential as a basis for projecting future demands and planning. As in most other countries in the region, the collection of data on water use presents some problems, but it is an important area which has received increased attention in the past two years.

A first national water use survey developed within the framework of AWRC was carried out in 1978-1979 in respect of data for the year 1977 (7). Preliminary results were discussed in a paper prepared for an ESCAP expert working group meeting on water use data held at Bangkok from 31 July to 6 August 1979, at which Australia was represented. This work is continuing.

4. Flood mitigation in Australia

A number of large cities and smaller rural towns in Australia face potentially serious flooding problems. Under the provisions of the National Water Resources Programme, areas of serious risk are being identified and the Commonwealth Government is providing assistance to State Governments in the development of appropriate mitigation strategies.

There is increasing awareness of a need for more comprehensive strategies than in the past, incorporating a range of non-structural measures where appropriate. These include relocation from areas of severe danger, zoning and planning of land use and the improvement of flood warning systems.

In 1979/80 much of the effort was devoted to studies of flood mitigation options for various localities, mapping of flood prone areas and initial implementation of flood mitigation strategies. The severe flood problem in Brisbane which manifested itself in January 1974 has now been significantly reduced, although work is still proceeding in the Brisbane Valley.

5. Irrigation

Of the total land area in Australia, about 64 per cent, or 493 million hectares, is currently used (1978/79) for agricultural enterprises. Only about 44 million hectares, however, are actively cropped or under improved pasture. The bulk of Australia's agricultural production is derived from a little under 6 per cent of the total area, although the effects of agricultural activity are felt over a much wider area.

At present, nearly 1.5 million hectares of land are irrigated for agriculture and pastoral purposes. This figure has increased only slowly since the 1940s (table 19) and in the absence of any major change in the economic situation, there is unlikely to be any major over-all expansion in the future.

The economics of some existing irrigation systems are probably marginal and investigations based on available river systems indicate that others may be even less favourable in strict economic terms. Increased irrigation with water from whatever source could lead in places to further degradation of soils through increased salinization, already a serious problem in some areas. In other places, some States have taken measures to limit the growth of new irrigation

Table 19. Area of land under irrigation in Australia

Area irrigated (thousand ha)

Year	*Sown and native pastures*[a]	*Cereals for all purposes*	*Sugar cane*	*Vegetables for human consumption*	*Fruit and grapevines*	*All others*	*Total*
1949/50	277.9	66.3	19.8	24.7	60.1	145.9	594.8
1954/55	441.4	[b]	25.2	26.6	67.1	143.7	704.0
1959/60	559.5	[b]	25.2	29.1	72.0	161.4	847.3
1964/65	664.2	[b]	48.8	38.1	88.9	329.9	1 169.9
1969/70	868.8	[b]	61.2	68.9	104.0	305.1	1 476.9
1974/75	955.1	184.4	74.0	67.1	101.0	85.6	1 467.3
1975/76	920.4	252.7	73.3	63.4	98.5	66.6	1 474.9

Source: ABS, *Year Books 1977/78, 1979.*

[a] Including lucerne.

[b] Included in "all others".

development on heavily committed regulated streams. In addition, New South Wales has embarked on a very comprehensive investigation of water needs for all purposes for the next 25 years and how they might be met, with the objective of developing State water plans.

6. Salinity problems

In recent years salinity has emerged as a major problem in some parts of Australia. In conjunction with inadequate drainage and water logging, it has arisen in a number of irrigation areas; it has been estimated that some 700,000 hectares of land are or will be affected in the Murray River basin alone. Dry land salinity is also causing problems, particularly in western Australia, mainly as a result of the clearing of deep-rooted vegetation for agriculture and the consequent raising of saline water tables. Over-all, the areas affected are increasing and if preventative action were not being taken, the problems would almost certainly become even more serious in the future.

In 1978, a Senate Committee recommended to the Commonwealth Government that salinity be recognized as a national problem and that it receive high priority attention (1). A report by consultants to the Commonwealth, New South Wales, Victoria and South Australia Governments has identified a series of works and measures to be undertaken in an action plan to deal with the immediate problems (8). Under the National Water Resources Programme, the Commonwealth Government is now providing financial assistance to the three States for approved salinity control and drainage projects. Other measures of longer-term significance are also being investigated.

River water quality, particularly with regard to salinity, has now become a key factor in the long-term utilization of the River Murray, Australia's most important water resource. Over the past few years the four Governments which are party to the River Murray Waters Agreement have been negotiating a new agreement which, among other things, will empower the River Murray Commission to take account of water quality in carrying out its operations.

7. Water quality and pollution control

Water quality regulation in Australia is the responsibility of State and Commonwealth (in respect of the Australian Capital Territory) water supply and health authorities. Where they arise, the main water quality problems result from inadequate disposal of effluents from urban and industrial centres and from agricultural drainage in rural areas. In general, there are no serious or persistent problems of water quality for domestic supplies. However, the microbiological soundness of small settlement water supplies in outback Australia is not always satisfactory.

Recently, AWRC joined with the National Health and Medical Research Council in the preparation of guidelines for desirable quality of drinking water in Australia (9). In their development, consideration was given to current practice and experience in Australia, published criteria and standards recommended by overseas and international agencies and, in particular, the drinking water standards issued in 1971 by the World Health Organization (WHO).

8. Water weeds

Australia has experienced problems with a number of introduced aquatic weeds which sometimes cause severe localized problems of water quality, filter clogging or impedence to river flow and the threat of infestations spreading to other regions (10). The long-term solution to aquatic weed problems is one of over-all water resources management, but several short-term control measures have proved successful, including chemical spraying and physical treatment such as harvesting. Research into biological control measures is also being carried out by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

In June 1979, AWRC in liaison with the Australian Agricultural Council established a National Committee on Management of Aquatic Weeds. AWRC has now endorsed that Committee's report and the establishment of a National Co-ordinating Committee on Aquatic Weeds to develop a national approach to aquatic weeds management, based primarily on appropriate land/water use management and control strategies.

9. Remote sensing

Traditional aerial photography is still providing by far the largest amount of remote sensing information in Australia. However, the use of satellite-based remote sensing is increasing. Potential applications were assessed a few years ago (11) and with the recent construction of a Landsat receiving station in Australia and the holding of a national conference, LANDSAT 79, at Sydney in May 1979, interest has been greatly stimulated.

AWRC established a Liaison Committee on Remote Sensing in 1977 to foster adoption of the technology, to provide a forum for exchange of experience and to communicate needs of water authorities to the Australian Liaison Committee on Remote Sensing by Satellite (ALCRSS). Rapid technological advances are now taking place with other forms of remote sensing, such as radar, microwave, thermal infrared, solid state sensors and data telemetry via satellite. The potential of such techniques, along with Landsat, for water resources management, has been recognized but their adoption by individual water authorities, except for special studies, is expected to be slow because of the cost.

10. Water resources mapping in Australia

Australian experience in the preparation of small-scale maps summarizing various water resources characteristics for the entire continent or for large regions within it was outlined in a paper presented during a regional meeting of national committees for the International Hydrological Programme held at Bandung in September 1978 (12).

Since 1977 notable new water resources mapping carried out by the Commonwealth's Division of National Mapping includes four maps on variability of run-off in Australia (13) and present mapping of the pluviograph network in Australia (at 1:1,000,000). The map, "Australia: Dams and Storages (1975)", is also now being issued in Natmap's new 1:5,000,000 map series.

11. Water resources research in Australia

Australia is well served by research institutions such as CSIRO, universities and units of State and Commonwealth agencies. Since its inception, AWRC has engaged in regular reviews of the collective national research effort and the development of national priorities. Based on these reviews the Commonwealth Government has administered a water research fund to augment current research effort where there are gaps in identified priority areas. The programme is operated on a triennial basis and a new triennium commenced in June 1980.

12. Water information services

Adequate information is basic to any management activity. The first comprehensive review of Australia's water resources in 1963 highlighted inadequacies in the measurement and collection of data over large parts of the continent. The position has improved markedly as a result of the national water resources assessment programme. However, the need for more comprehensive planning has highlighted information deficiencies in other areas and the additional problems of exchange and dissemination.

The establishment of an Australian water resources information system, linking existing water libraries and other water information sources, was first proposed in 1973 (14). Recent technological developments in the information field have given impetus to a renewed investigation into means of improving the services currently available to the water industry. In June 1979 an AWRC working group on water resources information services was established for this purpose, supported by resources made available by the Commonwealth Department of National Development and Energy.

From a detailed study of overseas information systems, other industry data bases in Australia and an assessment of the current information requirements of the water industry, the working group has already indicated to AWRC that there is a need to create an Australian water data base. Its full findings are expected to be available in 1981.

13. Education and training

Education and training for professional development are reasonably well catered for in Australia through universities, colleges of advanced education and technical colleges. These have tended to be discipline oriented but there is now an increasing number of courses being offered which combine several disciplines relevant to resource planning and management.

People with appropriate skills and adequate education and training are an essential component of any water management system. In recent years, measures have been instituted within the AWRC framework to evaluate manpower needs in the water industry. Supported by the Commonwealth's Water Research Fund, a research project has been undertaken to review water resources education in Australia. In particular, programmes are now available or are being developed through the National Training Council for Driller Training (ground-water technology) and means for training water treatment plant operators are also being developed.

C. AUSTRALIAN EXPERIENCE RELATIVE TO THE MAR DEL PLATA ACTION PLAN

Activities undertaken in Australia since 1977 are consistent with the Mar del Plata Action Plan and other recommendations of the United Nations Water Conference. Areas of highest priority have been:

(i) continuation of water resources assessment with some emphasis on water quality aspects;

(ii) water use efficiency, including research into water pricing and other economic instruments;

(iii) flood mitigation and flood-plain management;

(iv) salinity mitigation.

These problem areas have been discussed in the preceding section of this paper.

D. MUTUAL SUPPORT AND TECHNICAL CO-OPERATION AMONG DEVELOPING COUNTRIES (TCDC)

In the past three years, Australia has participated in several ESCAP expert working groups pertinent to the Mar del Plata Action Plan.

In general, Australia responds to requests for assistance by developing countries and does not initiate projects: therefore no promotional activities have been taken to encourage TCDC in the water supply sector. However, Australia has responded favourably to a binational request in which water resources development is part of a much larger study. Support is also provided to the lower Mekong basin project. Australia has been prepared to consider any request for assistance. However its response is governed by budgetary constraints, other commitments in the region, the ability to provide the requested type of assistance, and government policy at the time.

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II. BANGLADESH

(NR.7/CRP.5)

A. ACTIVITIES IN THE APPRAISAL, DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

Bangladesh recently started implementation of its ambitious second five-year plan. The country desires to achieve self-sufficiency in food production by 1984/85, as well as control over the population growth rate.

Bangladesh is located between latitudes 20°30′ N and 26°45′ N and longitudes of 88°0′ E and 92°45′ E, and has an area of about 144,000 km². It is one of the most densely populated countries in the world; at certain places density is around 5,200 per km². One of the prominent characteristics of the topography of the country is extreme flatness. The climate is of the tropical monsoon type with erratic distribution of rainfall throughout the year. In winter, temperature and humidity are high.

The national policy for water resources development and management is currently aimed at the optimum development of available water resources in the country and their proper use in order to accelerate agricultural production, especially of cereals. A specific aim is to increase food production to at least 20 million tons from the present level of 13 million tons by the end of the second five-year plan (1980-1985). Depending on the performance and achievement during the first two years of this plan period, a supplementary programme for production of an additional quantity of 2 million tons will also be launched from the third year, thus bringing the target of food production to 22 million tons by 1984/85.

Water resources development, particularly irrigation, will be the main instrument to bring about a radical change in agricultural practices and productivity. In order to help achieve the food production target, the specific objectives of water resources development during the second five-year plan period are as follows:

(1) To provide irrigation facilities sufficient to increase foodgrain production from the present level of 13 million tons to at least 20 million tons;

(2) To develop and control surface water resources in order to provide dependable and timely irrigation for winter crops;

(3) To complete the ongoing surveys and studies of ground-water resources in the country, so that the total availability of water for irrigation from this source may be known with more accuracy;

(4) To use water resources development programmes and projects as an instrument for developing the less developed regions in order to achieve as far as possible a balanced development in all regions;

(5) To protect coastal areas from saline water inundation and to control and regulate floods in the affected areas;

(6) To reduce dependence on cash resources for implementing water development programmes by intensifying the utilization of voluntary labour for the excavation or re-excavation of canals and construction of embankments;

(7) To devise appropriate institutions and organizations with people's representatives at village and regional levels and to reorganize and strengthen existing institutions, so that land and water will be effectively and efficiently utilized;

(8) To arrange training for personnel at all levels involved in planning, design, construction, management, operation and maintenance of water development programmes, so that a cadre of trained manpower will be developed.

Achievement of the national goal of increasing food production during this plan depends largely on the extension of irrigation to a total area of about 2.91 million ha by June 1985, from the 1977/78 level of 1.16 million ha. Table 20 shows the irrigation targets for the second plan.

Most of the flood control, drainage and irrigation projects executed so far or in progress have adopted labour-intensive methods of work, such as manual construction of flood embankments, excavation of irrigation canals and drainage channels. Some schemes were initiated by local agencies, such as the union and *thana parishads* and had been recommended by people's representatives. Out of 322 schemes initiated during 1979/80, over one third were initiated locally.

During 1979/80, special importance was attached throughout the country to small irrigation projects to be executed through mass participation, so that irrigation facilities could be provided at reduced capital cost. About 250 schemes were taken up for execution during 1979/80 under the special canal digging programme through voluntary participation of the masses. Out of 250 schemes, work on 242 schemes was started. Between 1 December 1979 and 30 June 1980 work on 183 schemes was completed. With a total of 19.36 million m^3 of earth work, 1,048 km of canals were excavated. The total area which will benefit from the completed schemes is 234,700 ha.

Table 20. Summary of flood protection, drainage and irrigation programmes in Bangladesh during the second five-year plan, 1980-1985

Agency/programme	Achievement as of June 1978	Expected achievement as of June 1980	Second plan target (1980-1985) Additional	Cumulative
		(thousand ha)		
A. Bangladesh Water Development Board				
1. Flood protection and drainage . . .	1 821	1 935	607	2 542
2. Irrigation	65	97	308	405
Sub-total—irrigation (A)	65	97	308	405
B. Bangladesh Agricultural Development Corporation				
1. Low lift pumps	548	600	230	830
2. Shallow tubewells	24	60	395	455
3. Deep tubewells	136	245	362	607
4. Hand tubewells	—	8	28	36
Sub-total (B)	708	913	1 015	1 928
C. Private irrigation				
1. Bangladesh Krishi Bank—shallow tube-wells	17	49	103	152
2. Integrated Rural Development Programme hand tubewells . . .	10	19	5	24
3. Traditional	364	405	—	405
Sub-total (C)	391	473	108	581
Total irrigation	1 164	1 483	1 431	2 914

The Bangladesh Water Development Board has already completed 493 schemes under its "Food for Work" programme, involving construction of 4,813 km of embankments, and repair and excavation of dead channels. An area of 1.24 million ha had benefited from the programme by June 1979. A total of 293,361 tons of wheat had been utilized for compensation by June 1979.

During 1979/80, a total of 104,000 tons of wheat was allocated for the programme. The programme envisaged construction and remodelling of 692 km of embankments and excavation and re-excavation of 1,696 km of canals and channels to benefit nearly 535,000 ha. Works on 120 schemes were completed by the end of May 1980, benefiting about 144,280 ha.

B. INTEGRATED OPTIMUM DEVELOPMENT OF THE DELTAIC AND UPLAND PORTIONS OF A RIVER BASIN

Bangladesh is a predominantly agricultural riverine country. The life of the people of Bangladesh is therefore closely linked with the waters of the rivers. The predominant need of Bangladesh is to grow enough food for its population, which is growing rapidly. Water is the key to the agriculture programme objective of attaining self-sufficiency in food grains. Water resources development is also essential for the river transportation system. Rivers can be harnessed for controlling and regulating floods, hydropower generation, prevention of salt-water intrusion, facility of drainage and reclamation of land.

The river network, underground waters and monsoon rainfall provide Bangladesh with an abundance of water resources. However, too much river flow and rainfall during the monsoon season and a shortage of water during the rest of the year make an unbalanced distribution of water and pose problems of flood during part of the year and drought during other seasons. Furthermore, all the major rivers are international and construction of works on these rivers outside the borders of Bangladesh affect conditions downstream in Bangladesh. No rational plan for the use of river flows in Bangladesh is therefore possible without establishing an understanding with the upper riparian countries, and no effective measures of flood control are possible without soil conservancy measures and control works in the head reaches of these rivers lying in other countries.

Until 1947, no major development work had been carried out in the region now comprising Bangladesh, nor had hydrological, meteorological and topographical data been collected. These have been gradually built up and a master plan for water resources development was prepared in 1964, using the information made available by that time. The main contribution of this master plan was that it brought together all available data, and on the basis of preliminary investigations and studies, indicated a portfolio of projects. Most of these projects were developed on the principle of the polder concept, i.e., suitable areas were selected and protected from flood by means of embankments, internal drainage was provided by control structures on the embankments and drainage channels within the polder, and pumping stations were set up to pump out accumulated rain water into the river. The same pumps which were used for drainage also were used to supply irrigation water by pumping river water into the poldered area. An example of this kind of project is the Chandpur irrigation project. Major irrigation projects were also carried out, of which the most important is the Ganges-Kobadak irrigation project. The only hydroelectric project that had been carried out is the Kaptai hydroelectric project. Flood control assumed great importance after the devastating floods of 1955-1956. The most notable flood protection project is the Brahmaputra right embankment project, which measures 217 km from Fulchari to Serajganj. A major coastal reclamation project is the 3,535 km long coastal embankment project which has reclaimed about 1.2 million ha of land in the southern region of Bangladesh. Water development in Bangladesh has suffered because of the reluctance of aid-giving agencies to finance any project which involves the use of waters of international rivers. The local constraints include: lack of co-ordination among different agencies dealing with water development of related matters; the problem of acquisition of land required for development works; maintenance and operation of completed projects; and factors associated with development of irrigation arising from fragmentation of land and smallness of the holdings. The experience gathered while the Ganges-Kobadak project and others were being carried out has been used to modify the outline and planning of projects such as the Chandpur irrigation project and the Barisal irrigation project.

The Mar del Plata Action Plan provides recommendations for the use, management and development of shared water resources, in which national policies should take into consideration the right of each State sharing the resources to equitably utilize such resources as the means of promoting bonds of solidarity and co-operation. It was further recommended that in the absence of bilateral or multilateral agreements, the member States continue to apply generally accepted principles of international law in the use, development and management of shared water resources.

In November 1977, Bangladesh and India concluded a short-term agreement to share the dry season flows of the Ganges River from 1 January to 31 May of each year, with effect from 1978 for five years. The agreement also includes provision for augmentation of the dry season flow of the Ganges for a long-term solution of the problem. The long-term solution as proposed by Bangladesh envisages storage of the monsoon flood by constructing storage dams at appropriate sites in the upper reaches for its utilization in the dry season. It calls for active co-operation among all the riparian states for their common agricultural and economic development. Bangladesh is currently endeavouring to ensure just and equitable sharing of the water resources of not only the Ganges but also other common rivers with other concerned states. It may be recalled in this connexion that the Mar del Plata Action Plan recommended that for mutual co-operation on water resources and management, increased attention to integrated planning and water management was required. It further declared that river basin planning of water resources schemes with multi-purpose objectives will give an optimum benefit to all the countries participating in such a plan. It is hoped that all the States sharing a basin will respond favourably so that the objectives of agricultural and economic development will be fulfilled through mutual co-operation.

To achieve these recommendations, a legal framework is necessary. The codification of an international water law should not be further delayed.

III. BURMA

(NR.7/CRP.8)

GROUND-WATER DEVELOPMENT*

Introduction

To keep pace with the increases in population, agricultural and industry, proper development of water resources is of vital importance. Burma has a monsoon climate; however, the mean annual rainfall gradually increases from about 635 mm in the central dry zone of the country to more than 2,500 mm as one goes north, south, east and west, and the minimum relative humidity increases from 80 to 90 per cent respectively. The highest mean daily temperature is more than 37°C in the central part of Burma and evaporation is high throughout the country. Under such circumstances, except for the portion of rainfall which seeps into the ground and the water that seeps from canals and perennial streams, not much rain water is likely to become part of the ground-water reserves. The utilization of ground water becomes important where surface water is not available or has not been harnessed for technical and/or financial reasons. In the central dry zone of Burma, ground water should be developed for domestic, drinking, agricultural and industrial purposes.

Burma has been very poorly studied from a hydrogeological point of view. Hydrogeological investigations were carried out only for solving the problems of supplying water to population centres. Ground water, where required and found of suitable quality, is detained by means of shallow hand-dug wells; it is used mostly for domestic purposes, and to a small extent, for agricultural ones. About 6,475 ha of land are cultivated by hand-dug well water. However, utilization of ground water from deep tube-wells for domestic purposes is comparatively limited, and that for agricultural and industrial purposes is negligible. The utilization of ground water from tube-wells for domestic purposes has increased manyfold since 1952. Before 1952, ground water was tapped for domestic purposes only for Rangoon and about 20 large towns. Since 1952, several thousand villages and towns have begun to use ground water for domestic water supply, in conformity with the rapid increase of population. This increase in the consumption of tube-well water is the outcome of a country-wide programme of supplying tube-well water to towns and villages for domestic use in order to reduce the incidence of water-borne diseases and to improve the hygienic condition of the people. The Rural Sanitation and Water Supply Board was founded in 1952 to operate the rural community water supply. In addition to the Rural Sanitation and Water Supply Board and to the private contractors who cater for various private persons and industrial concerns, the Defence Department, the National Housing Board and Burma Railways have also been drilling for their cantonments, housing estates and railway stations respectively, although on a very minor scale compared to the Rural Sanitation and Water Supply Board.

Status of ground-water development

Development of ground-water supply began in about 1890 in Burma, but its progress has been slow, except in the Rangoon area. The total number of domestically and industrially usable tube-wells in Burma is not known. It is roughly estimated that there were more than 4,000 tube-wells as of 30 June 1962. These included 700 wells in the Rangoon area and 2,700 wells drilled by the Rural Sanitation and Water Supply Board; the rest was made up of wells drilled by private drilling contractors, the Defence Department, the National Housing Board and Burma Railways.

There are over 2,250,000 people in Rangoon. Ground-water consumption in the Rangoon area was about 19 million litres per day in 1930. This had increased to about 38 million litres per day in 1978. The increase in ground-water consumption has resulted from population and industrial growth.

The Agricultural Mechanization Department has been drilling tube-wells for rural community water supply as follows:

	1974/75	*1975/76*	*1976/77*	*1977/78*
Number of tube-wells .	7 783	7 832	7 910	8 139
Number of villages . .	5 276	5 510	5 347	5 442
Population (thousands) .	3 081	3 110	3 135	3 203

To increase agricultural production and cropping intensity, an exploration project to study ground-water resources for irrigation purposes is currently being conducted by the Irrigation Department, with assistance from UNDP under the multisector programme of project preparation. The areas to be studied and area coverage are:

Area	*Hectares*
Yinmabin-Pale	101 200
Monywa-Chaungoo	85 000
Wundwin-Tatkon	168 000
Nattalin-Paunde	117 300
Total	471 500

* By Thein Lwin, Geologist, Hydrogeology and Engineering Geology Section, Department of Geological Survey and Mineral Exploration, Rangoon, Burma.

The investigation started in December 1978 and the first phase studies are expected to be completed in December 1980. The Irrigation Department intends to extend the hydrogeological studies beyond the above four areas for future development of ground-water resources.

The Burma Geological Department (now the Department of Geological Survey and Mineral Exploration) began to establish a hydrogeological survey in 1955. Experts from the United Nations were invited and a systematic hydrogeological survey was carried out in the dry zone in 1959. One of the experts made studies on the utilization of ground water in areas such as the dry zone, the Shan States and the Irrawaddy delta. His prominent contribution was the report "Ground waters of Burma and perspectives of their uses", and the first hydrogeological map of Burma on a scale of 1:2,000,000. Hydrogeological and ground-water surveys were continued by the hydrogeologists and engineering geologists of the Burma Geological Department until 1965. At present, the Department performs water resources investigations for mines and industrial plants.

Conclusion

In view of the importance of the exploration, development and management of water resources, the Water Supply and Utilization Committee was formed under the Research Policy Direction Board in 1978. Under the guidance of this Committee, a systematic and intensive study on water resources is in progress.

IV. China

A. THE DEVELOPMENT AND UTILIZATION OF GROUND-WATER RESOURCES IN CHINA

(NR.7/CRP.13)

Since the establishment of the People's Republic of China, great attention has been given by the Government to the investigation and development of ground-water resources. In the 1950s, the Bureau of Hydrogeology and Engineering Geology was set up in the Ministry of Geology. This Bureau is responsible for the investigation of ground-water resources throughout the whole country. It co-operates with the agencies of water conservancy, urban reconstruction and industrial sectors in exploiting ground water for domestic water supply, agriculture and industry.

All the provincial geological bureaus and those of autonomous regions now have their own hydrogeological teams that undertake relevant tasks under unified state leadership. To co-ordinate the prospecting work, three research units have been set up under the Ministry of Geology. They are the Institute of Hydrogeology and Engineering Geology in Zhengdin, the Institute of Karst Geology in Guilin, and the Research Brigade of Technology and Methodology in Hydrogeology and Engineering Geology in Paodin. These units are principally engaged in scientific research. With regard to education, there are five major geological colleges, all with departments of hydrogeology and engineering geology, established to train specialists.

China has a total land area of around 9.6 million km^2, most of which has been covered by hydrogeological surveys on scales of 1:200,000 and 1:500,000. Much specialized prospecting work has been carried out for the development of well irrigation, the improvement of saline soil and the control and harnessing of swamps, especially in the agricultural areas of northern China. Investigations have been undertaken to facilitate water supply to many large- and medium-sized cities and industrial bases as well as to pastoral areas and water-deficient mountainous districts. The recently published "Hydrogeologic Atlas of China" gives all the details of the hydrogeological work being carried out in China.

The extensive work mentioned above has provided a preliminary knowledge of regional hydrogeological conditions and the ground-water resources of the country, and also a scientific basis for the development and utilization of ground-water resources. Ground-water resources in China have become an important supply source of water for domestic as well as industrial and agricultural use and play a significant role in urban construction and industrial and agricultural development.

1. Outline of regional hydrogeology

Over the vast territory of China, physiographic and hydrogeological conditions vary greatly in different regions, those in the north differing strikingly from those in the south.

The east-west Qinling Shan mountain range is the natural dividing line between north and south China. In areas north of these mountains, the annual precipitation is less than 800 mm, and the amount is gradually reduced from east to west. In the semi-arid region east of the Holan Shan mountain range the annual precipitation is commonly about 300 to 600 mm, while in the region to the west of this range, which is known as the extremely dry Gobi area, the annual precipitation gradually decreases to below 200 mm.

As flat plains cover a large expanse of northern China, the amount of cultivated land in that area makes up more than 50 per cent of the total of the whole country. The water resources are not sufficient, however, for the run-off of the surface water is only 6 per cent of the total of 2,600 billion cubic metres. In contrast, ground water is comparatively plentiful and plays a more important role in northern China.

Geologically, the major plains, such as the Sungliao, the Huang-Huai-hai, the Hetao, the Guanzhong and the Yinchuan plains are mainly Mesozoic or Cenozoic down-faulted basins with enormously thick unconsolidated sediments which provide favourable conditions for the preservation of plentiful ground water. These plains are the principal cereal-growing areas in China. The construction of wells and installation of pumps has already become one of the important ways to bring all the farm land under irrigation. With such wells already built, remarkable results have been achieved in combating drought and in promoting the increase of food-grain production.

In north-western China (chiefly west of the Holan Shan range), although rainfall is scarce, ground water in the vast piedmont plains, such as those in the Hexi corridor and along the southern border of the Junggar basin, is mainly recharged by the streams originating from the melting snow on the high mountains chains known as the Qilien Shan and Tian Shan. Almost 60-80 per cent of the run-off penetrates into the ground of the piedmont Gobi region, where the gravel beds formed of alluvial and deluvial deposits several hundred metres thick serve as a great natural subsurface reservoir for the storage of a large volume of ground water, which then discharges onto the surface in the form of spring clusters in the frontal part of the alluvial fan and flows into so-called "oases" to become the main water source for irrigation.

In areas to the south of the Qinling Shan (excluding the Tibetan plateau), the annual precipitation is much higher than that in northern China, averaging 1,000-3,000 mm. Lakes and rivers are densely distributed, hence the surface run-off accounts for about 75 per cent of the total of the whole country. The widely distributed mountains and hills are the chief physiographic features in the south. The mountains formed of bedrock yield mainly fissure water, and the development of ground water is therefore restricted. The plains in southern China are relatively small in area. Although Quaternary aquifers of great thickness and abundant ground water are found in such areas as the delta plain of the Changjiang River (the Yangtze River), the Jianghan plain and the Chengdu plain, there is no acute demand for ground water in agriculture. On the contrary, the ground-water level there generally is too high to favour cereal production. The problem of how to lower the level of ground water has therefore become the chief hydrogeological concern in those regions.

Although southern China is quite rich in surface water, some areas are still seriously short of water because of its unbalanced distribution. These water-deficient areas can be divided into three types:

Coastal plains: rainfall in the coastal areas is comparatively scarce, and generally concentrated in the rainy seasons. Widespread salinity in shallow aquifers is the main cause for difficulties in water supply. As a result of extensive investigations, fresh water has been found in confined aquifers below the saline water beds and is now being highly exploited for agricultural, industrial and domestic use. Especially in the Guanghai district of Guangdong province, abundant ground-water resources have been found in the artesian basin of Tertiary strata covered by Quaternary lava, and this water now has become the principal source of agricultural and industrial water supply.

Red-bed basins: Mesozoic and Cenozoic red-bed basins of rolling hills are widespread in southern China. These basins, along with others, are the chief cereal production areas in the south. The Sichuan basin is the biggest red-bed basin in China. Although rivers and streams are well developed in the central and eastern parts of Sichuan, there is often drought in spring or summer, causing many small reservoirs to become dry. This not only seriously affects cereal production, but also causes a shortage in drinking water. Several projects have been considered by the Government, including the building of channels to bring in water from the rivers in the mountain areas of west Sichuan.

Hydrogeological investigations have revealed that there is plenty of ground water in the weathered zone of the red beds. Although the water yield per well rarely exceeds 100 m^3/day, there are advantages in using the water for domestic purposes, as it occurs at a shallow depth and therefore can be easily exploited. Consequently, the serious shortage of water in the dry seasons has now been relieved to some extent through universal exploitation of such shallow aquifers. The red beds are usually intercalated with calcareous sandstone or calcareous conglomerate to form confined aquifers commonly yielding as much as 100-1,000 m^3/day from a single well. Such aquifers are often used as the water supply source for small industrial enterprises. In southern China, many other red-bed basins are found to have similar hydrogeological conditions, promising good prospects for ground-water development in these regions.

Karst mountain regions: carbonate rocks are widespread in south China, especially in the south-western part, where they make up one third of the total area. The karst strata are mainly of Palaeozoic and partly of Triassic limestones of great thickness, which form hills and mountains. Karst features are extensively developed. Because of the occurrence of fissures and cavities in karst rocks, rainfall penetrates rapidly into the ground to become ground water. Thus, most valleys on the land surface become dry, causing a serious deficiency of water, while underground the run-off is mostly concentrated in the karst tunnels to form an underground stream system, chiefly controlled by tectonic conditions.

Many field investigations have been carried out in recent years. In central Guangxi, for example, within an area of about 150,000 km^2, 353 underground streams have been found with a total flow of 158 m^3/sec in low water seasons, indicating that the underground streams have fairly good development prospects. Now many engineering measures have been taken to exploit the underground streams in different ways, such as constructing channels, building underground reservoirs and setting up pumping installations and small electric power stations.

2. The utilization of ground water in agriculture

In the arid and semi-arid regions of northern China, ground-water resources in the vast plains are fairly plentiful. According to statistics, 11.3 million ha of arable land are now irrigated with water from wells, and the annual exploitation of underground water has reached 40 billion cubic metres. The cultivated land which might potentially be irrigated by water from wells amounts to 33.4 million ha. From this one can see that there are great prospects for exploitation of ground water.

Before 1949, the Hebei plain was often menaced by drought; the grain yield was very low and the region had to rely on support from southern China to meet its cereal demand. In the last 20 years, more than 400,000 irrigation wells have been built, with an annual yield of about 10 billion cubic metres. The area under well-water irrigation is more than 2 million ha, occupying 60 per cent of the total irrigated area and over one third of the cultivated land. The situation in Shandong, Henan and other provinces is similar. Taking the Xinxiang region in Henan province as an example, since the 1960s the number of pumped wells has increased from 4,000 to 50,000 and the land irrigated by well-water has reached 244,000 ha, 63 per cent of the total irrigated area. Because the cultivated land in northern China has basically been brought under irrigation by universal construction of wells or wells and channels in combination, this part of China has witnessed bumper harvests for many years, and consequently has become self-sufficient in cereal products. Thus it is no longer necessary to send grain from the south to the north.

Such achievements in developing well irrigation in the north can be attributed mainly to the close cooperation between the local departments of water conservancy and geological organizations. Furthermore, while laying emphasis on water prospecting, geological units are also engaged in the construction of wells for exploitation in the course of prospecting. They provide hydrogeological maps to county departments and communes, give rural peasants guidance in allocating wells, help them to keep records of pumping wells and offer them technical services. Thus they have trained many peasant technicians. Now most of the countries and communes in the region have their own well-digging teams, drilling machinery and gravel-cement pipe plants. The government provides funds for developing pumping wells every year and has set up many local factories that manufacture pumps and necessary machinery.

However, there are still many problems which have arisen in the course of developing well irrigation. For example, it is common found that wells are so closely spaced that they interfere with each other, and as a result the water yield is generally quite low. It should also be noted that an excessive number of wells has entailed unnecessary capital investment. In the Rongcheng area of Hebei province it was originally planned to set up 2,700 wells, but after investigation only 1,300 were found to be necessary. This example shows how important it is to know how many wells are actually needed. Accordingly, adjustment of the well networks is now being carried out, with due attention to well spacing. Another common problem in construction of wells is that the quality of wells is often neglected, so that the water yield and the life of the wells are seriously affected.

In some areas, such as the central part of the Hebei plain, the water level keeps declining, because of excessive exploitation, and consequently new water pumps have to be installed from time to time to replace the original ones. In some cases the pumps of a single well has had to be replaced four times, and a great deal of money has thus been wasted. This is more common where deep confined water is exploited. Rational ground-water exploitation and the control and alteration of conditions that cause the water level to drop are therefore of particular importance in water supply to agriculture.

In order to expand ground-water resources, intensified experimental tests and research on artificial recharge have been undertaken in China and preliminary results have been obtained. For instance, an experiment on artificial recharge in sand-gravel pits in the western suburbs of Beijing has shown that the volume of the percolating water reached 2 million m^3/day within an area of one km^2. This suggests that with a flood period of 60 days, 200 million m^3 of ground water can be stored every year. Nangong County in Hebei Province took advantage of an old river course to store ground water, and the volume of water stored amounts to 100 million m^3, which is enough to irrigate 13,340 ha of cultivated land.

As northern China is characterized by strong evaporation of ground water, proper control of the ground-water table will naturally be another important way to enrich the ground-water resources. All in all, it can be concluded that artificial recharge is doubtlessly an important measure for increasing the ground water in the future.

In northern China, saline ground water is widespread due to continental salinization. The improvement and utilization of the saline water is one way of finding additional exploitable sources of ground water. For example, a pilot irrigation scheme with saline water containing 3-5 g/l of dissolved solids in Yucheng County, Henan Province, resulted in a 26.5 per cent increase in cereal production and now the area of irrigated land has increased to 6,670 ha. Practice has proved that pumping up the saline water to replenish the fresh water can accelerate the circulation of the ground water and hence promote the desalinization of the saline water.

In part of the northern China plain in the 1950s secondary salinization of soil occurred as a result of inappropriate extensive irrigation with water from the Huanghe River (the Yellow River), which led to an increase in the salinized land from 1.9 to 4 million ha. The salinized land did not gradually become cultivable again until measures had been taken to drain the land and develop well irrigation to reduce the area covered by canal irrigation. In the areas of the Hetao and Yinchuan plains, where the farmland is irrigated by Huanghe River water, the extensive secondary salinization of soil caused by flood irrigation still remains severe at present. It seems that in those areas irrigation with well water in co-ordination with restrained use of surface water will conserve surface water, help to prevent soil from salinization and improve salinized soil. Therefore, the rational and multi-purpose conjunctive use of surface and ground water should be given due attention.

3. Some problems related to urban water supply

Many of the important cities in China are dependent mainly on ground water for their water supply. The level of exploitation of ground water in Beijing, Shenyang, Xian and other cities has increased to one million m^3/day.

With the growth of the urban population and rapid development in industry and agriculture, water demand has also increased significantly. For example, the output of the waterworks in Beijing has increased 40-fold since the early 1950s. To meet the increasing demand, a new ground-water plant was recently set up to exploit ground water in the alluvial fan of the Chaobai River and was scheduled to begin production in 1980. Total water resources available amount to 5 billion m^3 per year, of which the ground-water resources are calculated at 3 billion m^3 per year and the surface water resources (chiefly in reservoirs) at about 2 billion m^3 per year. The amount of annual water consumption, however, has already grown to 4 billion m^3, of which 63 per cent is consumed by agriculture and 30 per cent by industry. The total output of ground water, which is 2.6 billion m^3 per year, makes up 60 per cent of the total water consumption. In the central part of the city, the water level has dropped by 20 m and more at a rate of 1-1.5 m per year owing to excessive exploitation of the ground water. Therefore, the water yield per well has been remarkably reduced and the original pumps of some production wells have had to be replaced. At present, effective ways are being sought to control water consumption. It is estimated that total water demand in 2000 will reach 6 billion m^3 per year, which is beyond the capability of the water supply in this area.

Because of the rapid increase in industrial water consumption, the needs of industry and of agriculture for water supply are coming into greater conflict. The extensive exploitation of water by industrial wells has caused most of the nearby irrigation wells (mainly shallow wells) to dry up or be abandoned. For example, exploitation of ground water by industrial enterprises in Cangzhou, Hebei, caused the water level to drop by 60 metres, and 38 per cent of the irrigation wells within range of a 100 km^2 depression cone were abandoned. Such a conflict becomes even sharper when the amount of water in reservoirs is greatly reduced in years of drought. In order to ensure sufficient water supply for industry, the water supply to agriculture has to be reduced and cereal production is seriously affected.

A special problem that has appeared in urban water supply is land subsidence. Such a phenomenon occurs mainly in large coastal cities which consume much water. A distinct example is Shanghai, where the cumulative maximum of land subsidence has reached 1.6-2.4 m, and this has brought about a great loss to the national economy. Statistical analyses have indicated that the magnitude of subsidence increases with the rise in output of the ground water, and the area of the subsidence commonly coincides with the coverage of the cone of depression. This suggests that the subsidence of land is chiefly caused by the compaction of the soft soil layers as a result of over-exploitation of ground water.

The city of Shanghai has adopted since 1965 multiple measures to control land subsidence. These include: reduction in water consumption; adjustment in the order of exploitation of aquifers and artificial recharge; and studies of the interrelations among groundwater output, recharge and water-table fluctuation. In line with the requirements for low-temperature water in summer and medium-temperature water in winter by industrial enterprises, the city of Shanghai has developed a method of regulating ground-water storage by winter recharge for summer use and summer recharge for winter use, which has not only helped control surface subsidence but has also made use of the peculiar thermopreserving property of the ground water. Now such a method has found wide application in many cities.

Also important to note is the fact that water pollution has brought about a serious menace to the urban water supply. Discharge of industrial waste water and the use of polluted water for irrigation in city suburbs are among the main causes of ground-water pollution. An investigation has indicated that in more than 40 cities the ground water is polluted to different degrees, containing such harmful substances as phenol, cyanide, mercury, chromium and arsenic. It is polluted in both shallow and deep aquifers. This has caused some production wells to stop operating. The use of chemical fertilizers and farm insecticides on suburban farms are among the main causes of the ground-water pollution.

Besides the pollution resulting directly from domestic and industrial sewage, the hardness of the ground water has kept rising, making the water quality even worse. Preliminary studies have shown that the increase in hardness is related to the large-scale exploitation of the ground water. The increased hardness not only harms public health, but also affects the normal production of pharmaceutical factories, wineries and other enterprises.

In some coastal cities, such as Luda, excessive exploitation of ground water has caused the intrusion of sea water, which has resulted in an increase of chlorine ions and a decline in water quality. In some other cities, such as Tianjin, there occur two separate aquifers, the upper one containing saline water and the lower being a fresh-water aquifer. However, in the construction of industrial wells, usually no proper measures are taken to separate the two aquifers, resulting in deterioration of water quality in the surrounding areas.

The pollution of ground water has menaced the people's health, and sharpened the already acute urban water supply situation. In this connexion, the Government has stipulated that the Ministry of Geology is in charge of monitoring ground water. Now many observation stations have been set up, especially in important cities. On the basis of the monitoring work, research has been conducted on the origin and the course of pollution, the intensity of pollution and the scope of dissemination of polluted substances, so that appropriate effective measures may be proposed to prevent ground-water pollution.

Conclusion

A comprehensive appraisal of water resources in China has become an important aspect of the realization of national development. Appropriate measures are now being taken to conduct more detailed investigations and to make a separate regional estimation of surface and subsurface water resources, so as to provide scientific bases for the solution of the water supply problem for farmland irrigation.

In the last few years, the scheme of diverting water from south to north in the eastern part of China to meet the demand of water-deficient northern China has aroused heated discussion among the organizations concerned. There exist two different opinions. Some people hold that to solve the water-deficiency problem in the north there is no other choice but to divert water from the south. Others believe that a basic supply-demand balance can be achieved if water resources in the region are fully developed and utilized. The two opinions differ mainly in the assessment of the water resources, particularly the ground-water resources, of the region. Therefore, a further in-depth study is required in this respect in the future.

To discuss the principles of ground-water resources appraisal and the system of rational utilization and management of ground water for development, the Geological Society of China organized the First Symposium on the Appraisal of Ground-water Resources in 1978. While discussing the methodology applicable to ground-water resource appraisal, the participants to the symposium pointed out the current arbitrary exploitation of ground-water resources in some of the regions. As a result of the lack of a unified planning and strict management system, arbitrary exploitation of ground-water resources in some regions has led to a consistent decline in the ground-water level and a gradual reduction in ground-water yield. Therefore the daily conflict between industry and agriculture in the use of water has been sharpened and the area of water pollution enlarged. The wasteful use of water to a serious extent is also common. This situation will surely have a harmful effect on the lives of the people and industrial and agricultural production if no effective measures are taken.

To settle the above-mentioned problems, the government is now considering the following measures: (a) to work out a unified programme of rational utilization of both surface and subsurface waters; (b) to formulate, as soon as possible, a Water Resource Act to ensure legally the rational development and utilization of water resources; (c) to establish appropriate controlling agencies to undertake management in a scientific way, comprehensive planning, rational adjustment and regulation, supply-demand balancing, and water resource conservation; (d) to apply the method of artificial recharge to regulate the storage of surface water and increase ground-water resources; and (e) to make intensified investigations of water resources.

While conducting an over-all appraisal of ground-water resources in the entire country in support of regional planning of agriculture, the Ministry of Geology of China has strengthened ground-water monitoring services in key cities and major areas of water-well irrigation. As a result of the close co-operation between geological and urban construction departments, some key cities such as Shanghai have already achieved fairly good results in the management of ground-water resources. Similarly, as a result of joint co-operative efforts, excellent achievements have also been made in the rational development of well irrigation in some of the irrigated agricultural areas.

B. A BRIEF REVIEW OF WATER CONSERVANCY AND FLOOD CONTROL WORKS

(NR.7/CRP.15)

1. Natural and geographical conditions

The topography of China is such that the land in the west is of high altitude and that in the east of low altitude. It slopes away from the Qinghai-Xizang (Tibet) plateau 4,000 metres above sea level northerly and easterly to the highlands and basins 2,000-1,000 metres above sea level, and then descends further eastward to hilly regions and plains below 1,000 metres above sea level. The whole country has an area of 9.6 million square kilometres.

Plateaux and mountainous areas cover 59 per cent, basins 19 per cent, plains 12 per cent and hilly areas 10 per cent of the total territory. One hundred million hectares of cultivated lands are concentrated in the three main plains of the country (the north-eastern plain, the north China plain and the middle and lower Changjiang plain) and the Zhujiang River delta as well as some inland plains.

China has more than 1,500 rivers, each of which has a drainage area of over 1,000 square kilometres and among which the Changjiang, Huanghe, Huai, Hai, Zhujiang, Liao, Heilong, Songhua, Yarlung Zangbo, Lancang and Nu Rivers are the longer ones.

The normal yearly run-off of all rivers reaches 2,600 billion m^3 and the average yearly depth of the run-off is 273 mm. The hydropower potential is 680,000 MW. The run-off of rivers north of the Qinling Shan mountains and Huai River is unevenly distributed, varies greatly between flood seasons and non-flood seasons and also changes from year to year, while the run-off of the rivers south of the Qinling Shan mountains and Huai River is plentiful and changes relatively little between seasons. The inland rivers, such as the Tarim, Qaidam and Shule, are located in the arid areas of north-western China. These inland rivers originate in the snow-covered mountainous areas, so that the run-off often disappears and they become seasonal rivers. Moreover, there are some rivers flowing from the south-west, north-east and north-west boundaries of the country.

The lengths, catchment areas and annual runoffs of the main rivers in China are as follows (not including international rivers):

River	*Length (km)*	*Catchment area (thousand km^2)*	*Annual run-off (billion m^3)*
Changjiang	6 300	1 807	921
Huanghe	5 460	752	47
Zhujiang	2 200	453	307
Hai	1 090	319	23
Huai	1 080	262	39
Liao	1 390	232	22
Songhua	1 660	546	76

China's climate is strongly influenced by the monsoons. It is wet with abundant rain in summer, and dry and short of rain with a prevailing north-west wind in winter. The normal yearly precipitation of the whole country amounts to over 6,000 billion m^3, and the average yearly depth of precipitation to 630 mm. The precipitation in the four months of June, July, August and September is often up to 70-80 per cent or more of that for the whole year. The precipitation is unevenly distributed and decreases from the south-east coastal region, where the normal yearly precipitation is 1,500-2,000 mm, toward the north-west arid region, where the normal yearly precipitation is less than 200 mm. Run-off in the main rivers differs significantly from wet to dry years, easily causing drought or flood.

Note: All the figures hereafter are based on statistics taken at the end of 1978.

2. General features of water conservancy construction

China has a long history of combating flood and drought; there were many famous water conservancy works built in ancient China by labouring people. About 2,200 years B.C. the Chinese people who inhabited the Huanghe River and Huai River valleys began building dykes to control rivers. The Dujiangyan irrigation system was built in 256-251 B.C. It was located on the left bank of the Min River in Sichuan Province. This large-scale water conservancy project could be used for both irrigation and flood control. The irrigated area covered more than 200,000 hectares. From 486 B.C. onward, many generations of labouring people dug the Grand Canal, which is 1,794 km long, and reaches from Beijing to Hangzhou.

However, under past feudal dynasties and as a result of reactionary rule in the country's long history, socially productive forces developed very slowly and water conservancy works failed to be well maintained and repaired. Floods and droughts were frequent; historical records show that a total of 1,092 big floods and 1,056 severe droughts occurred over the period of 2,155 years from 206 B.C. to the founding of the People's Republic of China in 1949, with an average of almost one disaster every year.

Since 1949, water conservancy works have been regarded as an important part of socialist construction. By the end of 1979, 84,000 reservoirs of all sizes had been built, with a total storage capacity of 400 billion m^3; 319 of these were large-sized ones, each with a storage capacity of more than 100 million m^3, and 2,200 were medium ones, each with a storage capacity of 10 to 100 million m^3. At present, the total output of the mechanical and electrical pumping stations amounts to 70 million hp, altogether covering an irrigated area of 29.7 million hectares. In the last 10 years, the ground-water supply has been widely developed in the arid areas of northern China and there are now 2.1 million power-operated wells for agriculture all over the country. The total installed capacity of large and medium-sized hydropower stations is 17,000 MW, while 90,000 rural small-sized hydropower stations have a capacity of 6,300 MW. The irrigated area throughout the country has increased greatly and it is now 47 million hectares, covering 48 per cent of the total farmland. There are over 20 million hectares of farmland susceptible to waterlogging, of which two thirds have been preliminarily remoulded.

3. Harnessing big rivers

The Changjiang River is the longest river and the main waterway for transportation in China. The flood of 1931 covered an area of 3.33 million hectares of farmland in the middle and lower reaches of the river; 28 million people suffered and 145,000 people died as a result of the flood. Since 1949, flood and drought have been better controlled and at the same time the abundant water resources of the Changjiang River. are being explored and utilized. Dykes have been strengthened in the middle and lower reaches. The Xiang Jiang flood diversion works and the Hanjiang flood diversion works have been constructed, ponds and low-lying lands were dredged and 926 large and medium-sized reservoirs as well as 45,000 small ones have been built, with a total storage capacity of 110 billion m^3. Some big pumping stations have been built on both banks of the Changjiang River. The irrigated area has reached 14.9 million hectares. At the same time, the river has been regulated and great efforts have been made to improve its navigability, and now the navigable length of the main river has reached 2,900 kilometres.

The Sanxia (Three Gorges) project is the key project of the multi-purpose development of the Changjiang River. It is located upstream of Yichang City, Hubei Province. In order to satisfy the needs of flood control, power generation, navigation and irrigation, a series of problems or conflicts must be solved. According to the over-all plan, the Sanxia reservoir can provide more than 30 billion m^3 volume for flood control, and thus, in co-ordination with other projects, it can control the flood peak in the Changjiang River and prevent inundation in the middle reaches. With regard to power generation, the total installed capacity can reach 25,000 MW, with an annual output of 120 billion kWh. The power generated can be transmitted to Beijing, Shanghai and Guangzhou, forming a unified national network. As to navigation, there are many gorges and dangerous shoals in the natural waterway of the Changjiang River from Yichang to Chongqing, causing many difficulties. After the completion of the Sanxia dam, the natural navigation channel will be improved and at the same time the navigation conditions in the 1,800 km river channel downstream will also be improved because of the regulation of run-off during the flood season and the dry season. In the future, it might be possible to bring water from the Sanxia reservoir to northern China, thus providing an abundance of water to the arid areas.

The Gezhouba project is located near Yichang City, 40 km downstream of the Sanxia project. The dam is 2,561 m long and 70 m high. The installed capacity of the power station will be about 2,718 MW. The total earth and rock work involved is 72 million m^3, and total concrete work is nearly 10 million m^3. The principal structures are now under construction on a large scale and the first stage of work is expected to be completed before 1982. Navigation and power generation will then began.

Comprehensive exploitation of the tributaries of the Changjiang River is being carried out. The Tanjiangkou water control project, for example, is situated on the Han River. Its main structure is a concrete dam 110 m high, while the subdykes are earth dams. With a total storage capacity of 29 billion m^3, it is a large-scale multipurpose water control project for flood control, power generation, irrigation, navigation and fish breeding. It protects 5 million people and 730,000 hectares of farmland downstream from the threat of flood. The power station has an installed capacity of 900 MW, and 246,000 hectares of farmland can be irrigated. A 150-ton ship elevator has also been installed for the development of navigation.

The Huanghe River has a very high silt content. Every year 1.6 billion tons of silt are brought down to the lower reaches, but its annual volume of flow is only 47 billion m^3. This has brought about sedimentation of the river channel in its lower reaches. The river bed was raised continually and it became higher than the surrounding land. During the 2,000 years prior to 1949, there occurred in the Huanghe River over 1,500 breaches of dykes and 26 major shifts of water course. Flood covered an area of 250,000 km^2, north to Tianjin and south to the Changjiang and Huai Rivers. In the past 30 years, soil conservation works were undertaken by the labouring people in the upstream area, while reservoirs were built on the main river and its tributaries. There are now 150 large and medium-sized reservoirs and 3,700 small ones, with a total storage capacity of more than 55 billion m^3. As a safeguard against flood, 1,800 km of dykes along the lower reaches of the Huanghe River were strengthened and heightened. Since 1949 the Huanghe River has experienced peak discharges exceeding 10,000 m^3/sec on four occasions; in 1958 the peak discharge reached 22,300 m^3/sec, but in spite of that, the flood discharge flowed down safely. Together with the upper and middle reaches, the irrigated area of the whole river valley amounts to 4.3 million hectares.

Some large multipurpose projects have been built on Huanghe River. In the middle reaches, the concrete gravity dam of the Sanmenxia reservoir is 106 m high. By holding the flood and discharging the silt, it can control the flood over an area of 688,400 km^2 in the upper and middle reaches. In co-ordination with the dykes in the lower reaches, it can prevent the Huanghe River from overflowing its banks. In the upper reaches, there are also six multipurpose projects, one of which is the Liuchiaxia hydropower station. It has a concrete dam 148 m high and it is China's biggest hydroelectric station at present, with an installed capacity of 1,225 MW. Built mainly to generate power, it also provides flood control, irrigation, fish breeding and prevention of ice jamming.

Dykes in the lower reaches of the Huanghe River are being strengthened and heightened every year because of the sedimentation of the river channel. More large reservoirs will be built in the ravines and gorges along the main river in the future.

In its history, the Huai River basin was an area frequently visited by disasters. After 1949 the Huai River was the first river to be radically controlled. In the past 30 years, 184 large and medium-sized reservoirs with a total storage capacity of 35 billion m^3 and 5,000 small ones with a total storage capacity of 3 billion m^3 have been built in the mountainous areas. In the plains, lakes and ponds are controlled in order to store flood water and the storage capacity has now reached 28 billion m^3. In the lower reaches, new outlet channels have been dug and enlarged, connecting the Changjiang River and the sea, so that the flood-discharging capacity has increased from 8,000 to 22,000 m^3/sec. Moreover, all dykes on the main river and its tributaries have generally been strengthened and all the big and small rivers have been dredged and deepened. The above measures, have basically brought the floods under control. Irrigated lands have increased from 0.8 million hectares shortly after 1949 to 7.4 million hectares.

The Hai River is the largest river system in northern China. In the past it was known as a harmful river. With many tributaries upstream, it fans out over the north China plain. It often overflowed its banks because of the great difference between the water coming from upstream in the flood season and the discharging capacity downstream. Moreover, floods and droughts were very serious, for there used to be low-lying land between two rivers and the drainage capacity was low. In the mountainous areas, 22 large reservoirs have been completed up to now. Miyun reservoir is the largest among them, with an earth dam 66 m high and a storage capacity of 4.4 billion m^3. There are also 90 medium-sized reservoirs and 1,300 small ones in the Hai River system. The total storage capacity of all reservoirs amounts to over 20 billion m^3. Independent channels for the five main tributaries to discharge flood water directly into the sea have been excavated. Therefore, the capacity for carrying flood water has been increased from the original 4,600 m^3/sec to 24,680 m^3/sec. The capacity for draining waterlogged areas has increased from 400 to 2,100 m^3/sec. Thus the Hai River basin is basically free from the menace of floods and droughts. At the same time, small water conservancy works have been carried out on a broad scale and more than 700,000 power-operated wells have been drilled so that the irrigated lands have been increased from 670,000 hectares before 1949 to 6 million hectares. Large areas of alkaline lands have also been improved. The development of water conservancy works promotes agricultural production and makes it possible to realize self-sufficiency for those areas originally seriously short of grain.

The annual run-off of the Zhujiang River is next only to that of the Changjiang River, taking second place in China. The Zhujiang River consists of Xijiang (the west river), Beijiang (the north river) and Dongjiang (the east river), of which Xijiang has the largest catchment area, occupying 80 per cent of the total. In the alluvial plain of the Zhujiang River delta, the cultivated land protected by dykes amounts to 570,000 hectares and is an important base for grain and economic crops and aquatic products in Guangdong. The total installed electrical pumping capacity in the Zhujiang River delta is 750 MW. The total mechanical pumping capacity is 190,000 hp. In addition, 4,200 km of dykes along the river and the seacoast have been built.

In the Zhujiang River basin, the large-scale hydro projects already completed are the Xinfengjiang reservoir (with a total storage capacity of 13.8 billion m^3, a concrete buttress dam 105 m high, and an installed capacity of 292 MW) and the Fengshuba reservoir (with a concrete hollow gravity dam 100 m high, a total storage capacity of 1.9 billion m^3 and an installed capacity of 150 MW). In co-ordination with other reservoirs and downstream dykes, they basically control the flood water in the Dongjiang tributary of the Zhujiang River.

The other hydroelectrical projects being planned in the Zhujiang River basin are the Feilaixia, Datengxia and Longtan projects. The Feilaixia project is situated in Qingyuan County, Guangdong Province. It should eliminate the threats of the Beijiang flood, and can bring benefits of irrigation, power generation and navigation. The Datengxia project is situated in Guiping County, Guanxi Province. It should reduce the menace of floods to the downstream area of the Xijiang and the Zhujiang River delta and it can bring benefits of power generation and navigation. In addition to the benefit of power generation, the Longtan hydropower station, situated in Tian County, Guanxi Province, can basically control the flood peak of the Hongshui tributary of Xijiang.

4. Irrigation development

Since 1949, old irrigation areas have been rehabilitated and new ones built. Now there are 150 large irrigation areas covering 20,000 hectares each, and more than 5,000 medium ones (from 667 to 20,000 hectares each). Depending on local conditions, the water supply for irrigation mainly comes from: storage (ponds and reservoirs); digging (utilization of ground water); diversion (diverting river water); lifting (mechanical pumping); and stoppage (blocking seepage flow from the seasonal rivers). In the 1950s, design was based on a single source of water, but now a combination of different sources of water supply is considered in the design. Thus the irrigated areas have been enlarged and high and stable yields have been secured. The different types of irrigation in several big catchment areas with examples, are presented below.

The Dujiangyan irrigation project in the middle reaches of Minjiang in Sichuan Province has a history of more than 2,000 years. Its headwork is composed of three major structures: the dividing pier, the water intake and the Feisha overflow weir. It can divert a flow of 665 m^3/sec from the Minjiang. It plays an important part in agricultural production. After 1949, the Dujiangyan irrigation system was restored, transformed and enlarged, and now the irrigated areas have been extended from the Chuanxi plain to the hilly areas and have reached 530,000 hectares.

The Huanghe River irrigation area in the Ningxia Autonomous Region has a history of more than 2,000 years. Since 1949, over 1,000 km of main canals have been enlarged, remoulded and dredged on a large scale. In 1958, the Qingtongxia hydroelectric project was built on the main stream of the Huanghe River, thus ending the history of water diversion without dams and ensuring water supply for agriculture. At the same time, new irrigation areas have been built and extended, and now the whole irrigation area includes 11 counties and municipalities, covering an area of over 170,000 hectares.

The Huanghe River irrigation area in the Nei Monggol (Inner Mongolia) Autonomous Region is located in the western part of the region and has a history of several hundred years. Before 1949 the irrigated areas were limited because of water diversion without a dam and because there were no drainage works. Since 1949, enlarging and remoulding works have been carried out. In 1961, the Sanshenggong project with a diversion capacity of 500 m^3/sec was built. Over 40 diversion canals and more than 30 drainage canals have been dug, 877 canal structures of different sizes and for various purposes have been built, and 30 water drainage stations have been set up, with a total draining capacity of 55 m^3/sec. The irrigated lands have increased from 200,000 ha shortly after 1949 to 500,000 ha at present.

The Huanghe River water has been diverted to irrigate 40,000 ha of farmland at Huayuankou, Henan Province. In the irrigation area, great changes have taken place by linking the wells and canals, combining irrigation and drainage, and controlling alkalization and improving the soil. The per hectare yields of grain and cotton has been increased manyfold. Many small irrigation areas have also been built on both banks of the Huanghe River.

The Pishihang irrigation project in Anhui Province is a large-scale water conservancy project between the Changjiang and the Huai Rivers. It covers an irrigated area of over 530,000 hectares. Because of the uneven distribution off precipitation, damages from flood, waterlogging and drought had been very severe. The Pihe, Shihe and Hangbuhe often overflowed their banks, and waterlogging occurred in the low-lying areas, while in the vast hilly area and highlands there were droughts in nine out of ten years because of the scarcity of precipitation. In 1951 the people began to control the Huai River on a large scale, and after seven years' hard struggle, in the upper reaches of these three rivers they had built Foziling reservoir (concrete multiple arch dam, 74 m high), Meishan reservoir (concrete multiple arch dam, 88 m high), Xianghongdian reservoir (concrete arch dam, 86 m high) and Mozitan reservoir (concrete buttress dam, 80 m high). With the completion of these reservoirs, these three rivers were basically controlled, and also provided an excellent water supply for the development of irrigation. The Pishihang irrigation project was started in 1958. Its three diversion headworks were completed in succession, with the main canals totalling 1,500 km, branch canals totalling 40,000 km and over 10,000 canal structures. The total earth and rock works amounted to more than 500 million m^3. Aside from the five large reservoirs (the above four reservoirs and the Longhekou reservoir), the Pishihang irrigation project is composed of more than 800 small-sized reservoirs interconnected with canals, ponds and farmland. It also links two irrigation areas in the Changjiang River and Huai River basins, and the benefits of navigation, irrigation, power generation, aquatic production and urban water supply have all been secured.

The Subei irrigation area is situated on the north side of the Changjiang River, Jiangsu Province, and cultivation extends over 3 million hectares, most of which are plains and low-lying lands. Before 1949, this area suffered not only from floods, but also from droughts, water-logging, alkalization and sedimentation, causing serious losses in agriculture. In the past 30 years, over 100 river channels have been dredged and deepened, more than 3,000 km of dykes have been strengthened and heightened and over 1,000 sluices have been built. The pumping capacity has reached 2 million hp, forming a new water system. The total irrigated area has increased to more than 2 million hectares.

The Shaoshan irrigation project in Hunan Province comprises the storage headwork, the diversion headwork and the irrigation area. The trunk and branch canals have a total length of more than 1,800 km, the trunk canal being 240 km long. There are also 26 aqueducts, 10 tunnels and more than 2,300 other structures of various sizes. The diverting capacity is 46 m^3/sec, which can irrigate 70,000 hectares of farmland. The project was started in 1965, and in 10 months' time the diversion headwork, the principal trunk canal and the northern main canal were completed, resulting in the irrigation of 30,000 hectares of farmland. Over-all planning and comprehensive control were given serious attention throughout the construction period; design and construction were carried out in the same year, and benefits and production increase were also realized in the same year. After this, further miscellaneous ancillary engineering works were completed, land was levelled, water was put to rational use, the irrigated area reached the design requirements, and grain output was doubled. At the two headworks hydropower stations, ship lock and a ship lift were also built to facilitate navigation and power generation. The building of the irrigation area was combined with the planting of trees, and fish breeding has became an important activity area. In this way, the project developed multipurpose benefits.

The Jiangdu hydroproject, the first stage of the project to bring water from south China to the north, is situated on the northern bank of the Changjiang River at the confluence of the outlet channel of the Huai River with the Changjiang. It is a large-scale water conservancy project for irrigation, drainage and navigation, comprising four pumping stations, 10 regulating sluices and two shiplocks. In the four stations there are altogether 33 machinery units with a total discharge capacity of 465 m^3/sec and a total installed capacity of 498 MW. In the future, the amount of water to be delivered northward is expected to expand to 1,000 m^3/sec. The total length of the diversion channel is 1,155 km, against a total pumping head of 70 m, which will be divided into 15 steps south of the Huanghe River. After crossing the Huanghe River, it will flow by gravity north to Tianjin. The total irrigated areas can be extended to 4 million hectares. It also can provide 2,700 million m^3 of water for urban water supply, industrial use and navigation.

C. EXPERIENCE IN RURAL WATER SUPPLY TO WATER-DEFICIENT MOUNTAINOUS AREAS OF NORTH CHINA

(NR.7/CRP.14)

China is a mountainous country, where it is difficult to supply sufficient water to local inhabitants and livestock in mountainous rural districts, particularly in the north.

To solve water supply problems in vast water-deficient rural mountainous districts, numerous water-storage projects such as small-sized reservoirs, pumping stations and water-storage pools, riverside ponds and underground cisterns. have been built according to local conditions by various people's communes with support from the State. Because of the serious deficiency of surface water in northern China, however, these water-storage projects have often failed to perform their normal function in drought years. Consequently, vigorous development and utilization of ground water have become an important approach to the supply of drinking water in such areas.

For many years, geological organizations in the country have made great efforts to solve water supply problems in water-deficient areas in northern China. In the course of hydrogeological surveys, these organizations have both assisted rural people's communes and brigades in locating water sources, and transferred wells originally drilled as exploratory boreholes to rural communities for local use. In connexion with the well-digging campaign to combat drought, provincial geological bureaux have often sent teams to rural areas to look for and exploit water in bed-rock fissures, karst caves or fault zones in close co-operation with water conservancy sections of counties and communes as well as with the local peasants. Provincial geological bureaux have also helped local people in selecting well sites, digging and expanding springs, discovering concealed water-flows and constructing various works appropriate to local conditions, so as to provide sufficient drinking water for the water-deficient mountain villages. By so doing they have made a valuable contribution to the living conditions of the people, the freeing of productive forces and the increase in agricultural production.

1. Hydrogeological surveys

China started planned nation-wide hydrogeological surveys in the 1950s. These surveys have been much accelerated and more closely linked with water-finding activities in water-deficient mountain districts since 1976. For example, the loess plateau in north-western China is one of the most water-deficient regions in the country. However, recent hydrogeological surveys in the loess plateau of northern Shaanxi indicate that the loess beds are underlain by an artesian basin of more than 14,000 km^2 of Cretaceous rocks with widespread occurrence of ground water. The hydrogeological team working in the region bored and constructed for the local communes over 160 water wells with a total yield for more than 44,000 tons per day, providing enough water to irrigate about 1,250 ha of arable land in addition to supplying local domestic needs. One of the wells completed in Shuanhochan brigade of Xinnoncun commune in Qingbien county has a daily yield of over 2,000 tons of water, resulting in an increase of 40 ha of irrigated land. It should be noted that in constructing these wells, all the expenses except for the pipes were covered by the State. Although the rural communities in this region are still unable to afford the machinery for well sinking, the hydrogeological survey has provided an excellent prospect for change in the future outlook of the region.

Among the "Support-the-Agriculture" teams, the Qianang team sent by the Geological Bureau of Henan Province to the seriously water-deficient mountains of Mixian county has made excellent progress. The team ascertained the hydrogeological conditions of the area and located many water-filled fracture zones by applying geomechanical methods. In collaboration with the local water-conservancy units and commune peasants, the team has constructed 1,658 wells, thus finding enough water to meet the drinking water demand of 140,000 people and reducing an increase of 56,7000 ha in irrigated farmland.

Quyang county in the Taihang Mountains is an area of predominantly Cambrian and Ordovician limestones. Here a team has helped the local communes to select over 1,000 well sites and now about 700 wells have been completed. As a result, 318 villages with a total population of about 34,000 have enough water not only for drinking purposes, but also for irrigation of 3,300 ha of arable land. Also based on a hydrogeological investigation, an inclined well 120 m deep was designed on the slope of the mountain near the Pangjiawa brigade. The well tapped a water-filled karst cave and yielded over 70 tons of water per hour, hence putting an end to the need for carrying drinking water from outside the village and for weather-dependent farming.

In the mountainous areas around Beijing, "Support-the-Agriculture" teams toured the water-deficient villages in the mountains and made over 800 proposals to help these villages to find water. As a consequence, within less than two years the villages became basically self-sufficient in drinking water and thousands of ha of farmland were brought under irrigation.

Among the provinces of northern China, Shaanxi has the largest area of mountainous districts and is the most water-deficient province. The provincial government has placed great emphasis on mobilizing the people and has made special arrangements to provide funds, equipment and materials for the construction of a large number of small-sized water conservancy projects of various types in conformance with local conditions; consequently it has succeeded in solving the water supply problems for 75 per cent of the rural community in the province.

In the vast mountainous districts of northern China, apart from an insufficient water supply, there is also the problem of various endemic diseases that are related to the quality of the drinking water. For instance, such endemic diseases as chronic keshan disease, the "big joints" disease, the "high-fluorine" disease and goitre are quite widespread in hilly areas in the north, causing serious harm to public health. Such endemic diseases are found in 70 out of 80 counties in Heilongjiang province. Investigations and studies in recent years have indicated that endemic diseases, excluding keshan disease and goitre, are known to be directly related to drinking water quality. Various measures of prevention and cure are now being practised to reduce the incidence of disease, the most important of which is the improvement in water quality. Case histories have shown that the level of morbidity in infected areas decreases remarkably after the original shallow wells and ditches are replaced by deep wells as drinking water sources. Therefore, improvement in water quality and introduction of new water sources have become important measures in areas of endemic diseases.

2. Future planning policy

To satisfy the basic need for drinking water in the water-deficient mountainous rural areas of the country by 1985, the Ministry of Water Conservancy in China has demanded that all the provinces concerned should formulate and ensure the fulfilment of respective programmes of work. It has also demanded that all construction works and measures to be taken should be adapted to local conditions, with special attention to their practical effectiveness. With regard to funds, materials and equipment, the principle of self-reliance should be considered the leading factor, while State support may be accepted as a supplement. In allocating the provincial budgetary funds for water conservancy, priority should be given to water supply projects for water-deficient mountain villages. Moreover, care must be taken to prepare the designs properly before such works are constructed and to provide for maintenance and management after they are built.

To define water deficiency of the rural community in mountainous areas, the Government has laid down some norms. Accordingly, water-deficient villages are those which are situated at a distance of over 1-2 km or at a vertical distance of over 100 m from the nearest water point where the villagers get their drinking water. As to the volume of available drinking water, the norm is 10 litres **per capita** per day in dry seasons in the north and 40 litres in the south, and 20-50 litres per head of cattle or buffalo and 5-10 litres per head of pig or sheep. Therefore, villages where the available volume of drinking water exceeds the above norms are tentatively considered as not having difficulty in drinking water supply.

With a view to realizing the four modernizations and steadily raising the people's living standard, the provision of water supply to rural communities in vast water-deficient mountainous areas has become a priority task. In this connexion, water conservancy and geological agencies are required to make still greater joint efforts and work is even closer co-operation so as to contribute further to the fulfilment of this arduous task.

V. INDONESIA

(NR.7/CRP.15)

INTRODUCTION

As an archipelago located on the equator, Indonesia is blessed with an abundance of water. However, the water tends to be available in the wrong place and at the wrong time. The unequal distribution of population among the islands, the rapid population growth and the increasing need for water, especially in the dry season, is straining the water resources. Realizing the pressing problems of water resources, the Government of Indonesia established its policy and programme with regard to water resources during the first five-year development plan (REPELITA), 1969/70 to 1973/74.

The development of water resources, being a part of the development of public works, was concentrated on providing infrastructure support for agricultural development, especially food production. Consequently, irrigation development, reclamation of swampy areas for agricultural purposes and flood protection of rice production areas were on the priority list of the national development plan. Efforts were focused on an increase in rice production, especially near the major consumption centres and around the areas prepared for farmer resettlement and transmigration schemes in underpopulated regions.

The activities relating to water resources development in REPELITA II (1974/75 to 1978/79) included in general:

(a) Support to the development of agricultural areas by supplying irrigation water and safeguarding those areas and the population against inundation by flood and volcanic debris;

(b) Support to the industrial sector by the construction of multi-purpose projects and by the supply of water for industrial purposes.

For the implementation of the development of water resources in REPELITA II, the following five basic programmes were adopted:

(a) Continuation of the rehabilitation and improvement of the existing irrigation networks and if possible, completion of the programmes of REPELITA I;

(b) Continuation and acceleration of the development of new irrigation networks, emphasizing development of simple irrigation and reclamation projects. These activities were concentrated around the areas of food-consuming centres, the areas for trasmigration and the areas with dense population;

(c) Intensification of protection measures in agricultural areas against catastrophes, e.g., inundations and volcanic eruptions;

(d) Intensification of water resources planning based on comprehensive river basin development to establish co-ordinated and synchronized master plans, to promote the development of industries and the generation of hydroelectric power;

(e) Intensification of study and research in the technology of water resources development.

In the present five-year development plan, REPELITA III (1979/80 to 1983/84), the goals for water resources development are as follows:

(a) To support food production, especially of rice;

(b) To support the transmigration programme;

(c) To support industrial development;

(d) To provide water supply for cities and rural areas;

A. WATER RESOURCES FEATURES OF INDONESIA

The archipelago of Indonesia, lying along the equator, forms a highway between the Pacific and the Indian Oceans, and a bridge between the mainland of Asia and the continent of Australia. The whole territory lies between 95° and 141° east longitude and about 6° north and 11° south latitude. The longest distance from west to east is 5,120 km, and from north to south 1,800 km. Covering a land area of 1,920,000 km^2, Indonesia consists of 13,700 islands, among which about 6,000 are uninhabited.

The total population of Indonesia is about 142 million people, 80 per cent of whom live in rural areas. About 64 per cent of the total population lives on the island of Java, although the area of Java is only 6.6 per cent of the total area of the archipelago.

The climate is distinctly seasonal. The eastern monsoon occurs from June through September, controlled by the continental air masses, and the western monsoon from December through March, controlled by moisture-laden maritime air masses. The months of April to May and October to November are in the transitional periods between the two seasons. The rainfall in Indonesia varies widely between 700 mm per year to 7,000 mm per year, with an average of 2,810 mm per year; evaporation and transpiration are generally within the range of 1,000 mm to 1,500 mm per year.

The water resources potential in Indonesia related to its population can be classified into three categories:

(a) The good water potential region, with more than 100,000 m^3/**capita**/year, consists of Kalimantan and Irian Jaya;

(b) The fair water potential region, between 10,000 - 100,000 m^3/**capita**/year, consists of Sumatra, Sulawesi and the Maluku islands;

(c) The poor water potential region, with less than 10,000 m^3/**capita**/year, consists of Java, Madura, Bali, and the Nusa Tenggara islands.

Figure 19 is a map of water potential in Indonesia. Specific details can be found in table 21. The water potential as stated above consists of surface water and ground water, of which only 25 to 35 per cent is available as firm flow, while 65 to 75 per cent is flood flow, which until now flowed to the sea. There are more than one thousand rivers, both perennial and intermittent, which are registered. There are 433 which are more than 40 km long, while 855 rivers are less than 40 km long.

Ground-water resources can be classified into the following groups: sub-surface water; confined and semi-confined ground water; fissure and fracture water, under drainage; and saline ground water.

The alluvial type of land which has good properties for irrigated agriculture, and with a slope of less than 8 per cent, covers an area of 16.8 million hectares or nearly 4 per cent of the total land area of Indonesia. This type of land, as well as the volcanic soil, are quite suitable for rice cultivation. Moreover, a large area of swamp land can be found on several islands, including Sumatra, Kalimantan and Irianian Java. The productivity of this kind of soil is substantially improved with better drainage and water control.

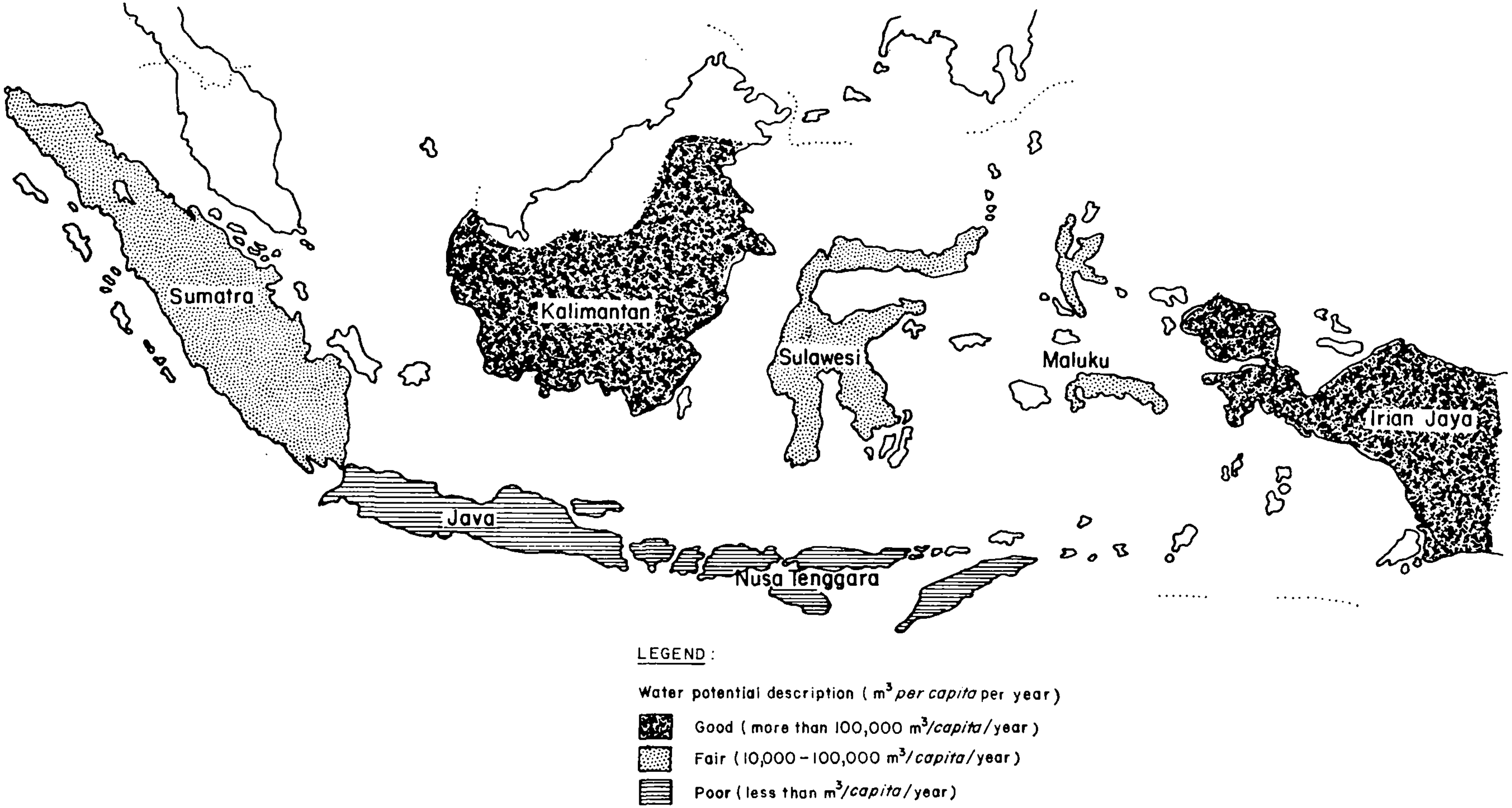

Figure 19. Map of the water potential of Indonesia

Table 21. Indonesia: land surface, agricultural land, irrigated land, rainfall and water availability by region

Region	Total area[a]	Agricultural land	Irrigated rice	Average annual rainfall	Average annual actual evapo-transpiration	Average annual run-off		Population 1980	Water availability
	(1 000 ha)	(1 000 ha)	(1 000 ha)	(mm)	(mm)	(mm)	(billion m^3)	(1 000)	(m^3/capita/year)
Java and Madura	13 219	5 647	3 100	2 580	1 250	1 330	175.8	89 657	1 961
Sumatra	47 361	3 909	1 150	2 820	1 350	1 470	696.2	26 635	26 138
Kalimantan	53 946	1 418	110	2 990	1 400	1 590	857.7	6 501	131 933
Sulawesi	18 922	966	354	2 340	1 200	1 140	215.7	10 279	20 984
Bali	556	382	109	2 120	1 100	1 020	5.7	2 460	2 317
Nusa Tenggara Barat	2 018	358	163	1 450	1 050	400	8.1	2 599	3 117
Nusa Tenggara Timur	4 788	469	51	1 200	1 000	200	9.6	2 641	3 635
Maluku	7 451	370	2	2 370	1 200	1 170	87.2	1 339	65 123
Irian Jaya	42 198	210	—	3 190	1 400	1 790	755.3	187	4 039 034
Total	190 457	13 729	5 039	2 810	—	—	2 811.3	142 298	—

Note: There are considerable spatial variations within each of the above regions.
[a] Not including land area of East Timor.

B. GROUND-WATER RESOURCES

1. Systematic hydrologeological mapping

There is a national hydrogeological mapping programme for the preparation of maps at a scale of 1:250,000. Each sheet covers an area of 1°30′ by 1°. By April 1980, five maps had been published, as shown in table 22. Hydrogeological maps are required for regional development planning, since they provide basic data on the mode of ground-water occurrence, availability of ground water and ground-water quality.

2. Ground-water resources evaluation

Areas of potential ground-water resources identified during the hydrogeological mapping programme should be further investigated for the assessment of such resources. In Indonesia, potential ground water can normally be found along the foot of Quaternary volcanoes and in the intermontane basin. Some coastal plains underlain by relatively thick Quaternary sediments and some limestone terrain also have good potential for ground-water occurrence.

Investigations have been carried out in 14 ground-water basins by the Directorate of Environmental Geology in co-operation with the Institute of Geological Sciences (London) and the Federal Republic of Germany through the Bundesanstalt für Geowissenschaften und Rohstoffe.

Table 22. Published hydrogeological maps of Indonesia, 1980

Name of map	Scale	Year of publication	Remarks
Tentative ground-water map of Java and Madura	1:1 000 000	1960	Geological Survey of Indonesia (with explanatory note).
Hydrogeological map of Madura island	1: 250 000	1962	Geological Survey of Indonesia and Bundesanstalt für Bodenforschung of the Federal Republic of Germany.
Hydrogeological map of Sumba island	1: 250 000	1965	Same as (2).
Reconnaissance hydrogeological map of Bali	1: 250 000	1970	Same as (2).
Reconnaissance hydrogeological map of Lombok	1: 400 000	1972	Same as (2).

Note: The map of Java and Madura consists of 9 sheets, which are now being prepared for publication. In addition fieldwork has been carried out in the northern and southern part of Sumatra (16 sheets), the southern part of Kalimantan (3 sheets), in the Sulawesi islands (5 sheets) and in most of the Nusa Tenggara islands. Thus some 25–30 per cent of the country has been covered by this programme.

3. Ground-water resources management and conservation

Proper management of ground-water resources can only be carried out in a basin or an area which has been intensively investigated. This requires reliable data on ground-water recharge and discharge, hydrogeologic properties of the aquifers, the extent of the aquifers and other important factors. The future effects of the ground-water abstraction can then be predicted. Optimum development of ground-water resources would be achieved if the recharge of the ground water were balanced by the total discharge. In most cases it is recommended to limit the rate of the ground-water abstraction to the practical sustained yield of the basin.

At present there are two areas which are being investigated in detail, both located in the highly developed northern coastal plain of Java. They are the Jakarta artesian basin and the Semarang area. Sea water intrusion has taken place along the northern part of Jakarta, as a result of large-scale ground-water abstraction for domestic and industrial water supplies.

4. Ground-water development projects: activities by the Directorate General of Water Resources Development, Ministry of Public Works

Some parts of Indonesia suffer severe shortages of water, especially in the dry season. The agricultural activities in these regions are therefore confined to the wet season, with one crop grown per year. Supplementary irrigation water is essential for growing a second or possibly even a third crop.

In some regions where construction of reservoirs for storage of surface water is not feasible, ground-water exploitation becomes the only option to remedy the situation. Therefore, ground-water development projects are now being carried out in Java, Madura, Bali, Lombok and Timor islands.

5. Ground-water data bank

The Directorate of Environmental Geology is in charge of the management of the ground-water resources of the country, and there is an urgent need for the establishment of a proper ground-water data system within this institution. The system should be suitable for the storage of ground-water data received from various other institutions and should be capable of speedy retrieval of data required for planning the development of the ground-water resources. At present, skilled personnel and facilities are still being sought through technical assistance from the Federal Republic of Germany and other sources.

C. WATER UTILIZATION

1. Domestic water supply

Throughout Indonesia, there are about 140 cities which already receive piped water supplies. Most of these cities receive their water from springs which originate on the mountain slopes, and only a minority obtain their water from artesian wells. A few cities, such as Jakarta, Bandung, Semarang and Surabaya, have their own water treatment installations. It is estimated that for all of Indonesia, water usage for this sector is about 9-15 million m^3 per day. Most of the smaller cities and villages depend on wells for their daily needs. Hence efforts for the improvement of sanitation in the future are necessary.

Water installations are divided into the following types: simple piping systems; rain water collection; protected springs; artesian wells; and wells with hand pumps. As seen in table 23, the larger part of the population served by water installations gets its drinking water from wells with manual pumps. However, the vast majority of the rural population obtains its drinking water from surface supplies, e.g., rivers or irrigation canals, or from shallow hand-dug wells.

Table 23. Distribution of rural water supply and sanitation facilities in Indonesia

(number)

Infrastructure	*1969-1974*	*1974-1979*	*1980-1981*	*Total*
Simple piping system .	108	692	300	1 100
Artesian well	3	188	100	291
Rain water collection .	24	2 108	1 000	3 132
Protected springs . .	16	1 000	400	1 416
Well with manual pump	2 882	84 682	48 000	135 564
Deep well pump . . .	—	1 061	4 500	5 561
Latrine	2 546	1 050 000	300 000	1 352 546

Source: Directorate of Hygiene and Sanitation, 1980.

2. Irrigation

The main food of the Indonesian people is rice. The water needed for irrigation of wet rice is estimated at between 10,000-14,000 m^3/ha per season, if all the canals and ditches are in good condition.

The majority of irrigation areas, especially those with technical irrigation facilities, are concentrated in Java. Irrigated areas in Indonesia are usually classified according to the type and quality of irrigation facilities provided, as listed below.

Technical irrigation systems are those which have a water supply system which is separate from the drainage system and where the volume of incoming water delivered can be measured at a number of points.

Semi-technical systems have fewer permanent structures and only one water measurement device (usually at the major intake), and the supply and drainage system are not always fully separate.

Simple systems have no measurement devices, conveyance systems for water supply and drainage are not separate, and there is the possibility of recirculation of water.

A further classification of irrigation systems is based on the controlling authority. Most of Indonesia's irrigation systems (about 80 per cent) are under the control of the Ministry of Public Works. The remainder are known as village irrigation systems. Village irrigation systems are managed, operated and usually constructed under the leadership of village chiefs. Data on Indonesia's irrigated areas are presented in table 24.

of March 1979, the total PLN installed capacity in Indonesia was about 2,413.38 MW, of which about 20 per cent was based on hydropower, 23 per cent on steam power, 21 per cent on diesel power and 36 per cent on gas turbine power plants. A higher proportion of demand comes from domestic consumers (66 per cent) than from industrial consumers (34 per cent), and all of the consumers are concentrated in the large towns.

Besides the PLN generation facilities mentioned above, there are also generating facilities owned by private industries and local government for their own use. These tend to be small units, separate from one another and also separate from the PLN network, which amounted to 2,059 MW in March 1980. In international terms, per capita electric consumption in Indonesia is still very low (about 69 kWh/capita), consisting of 38 kWh/capita from other generating sources.

Table 24. Irrigation areas in Indonesia
(hectares)

Island/province	Gravity						*Tidal and swamp lands*	*Total*	*Percentage*
	Technical	*Semi-technical*	*Simple*	*Total public works*	*Village*	*Total public works and village*			
Java	1 631 289	384 667	551,288	2 567 244	532 958	3 100 202	—	3 100 202	59
Bali	—	44 355	8 291	52 646	51 174	103 820	—	103 820	2
Sumatra	224 259	320 172	281 952	826 383	293 017	1 119 400	214 400	1 333 800	25
Kalimantan	3 490	15 184	41 226	59 900	15 920	75 820	107 600	183 418	3
Sulawesi	139 794	84 671	44 704	269 169	84 904	354 073	—	354 073	7
Nusa Tenggara	63 343	61 070	51 455	175 868	38 496	214 364	—	214 364	4
Maluku	—	1 419	—	1 419	—	1 419	—	1 419	0
Total	2 062 175	911 538	978 916	3 952 629	1 016 469	4 969 098	322 000	5 291 098	100

Sources: 1. Directorate of Irrigation, Directorate General of Water Resources, Ministry of Public Works, 1979.
2. Directorate of Swamp Land Development, Ministry of Public Works, 1979.

3. Industry

Indonesia has a range of light to heavy industries, most of which get their water from rivers. Therefore, many industries are located near such major rivers as the Brantas, the Bengawan Solo in east Java, the Ciliwung and Citarum in west Java and the Musi in south Sumatra. Over 77 per cent of the industries are located in Java, with 11 per cent in Sumatra.

4. Electrical power supply

The electricity supplied to the public is almost exclusively generated by the State Electricity Corporation (PLN). At present, electric power generation utilizes two kinds of energy resources, hydropower and fuel oil, while the types of power plants comprise hydroelectric, steam, diesel and gas turbine plants. As

5. Other uses

(a) Fisheries

The only fisheries which need fresh water are inland fisheries. The regions in which the population breeds fish are usually those around lowland plains, where ponds and dams are constructed for this purpose. The water used is generally from rivers. Another method of fish-breeding is to use rice fields (at certain times) as breeding places. Sometimes fish are bred in rivers by use of the karamba (a kind of box of plaited bamboo), or existing lakes, reservoirs and swamps are used. The area used for fish ponds is relatively small. About 68 per cent of the fish required by the Indonesian people come from sea fishing.

(b) **Inland navigation**

There are very few rivers in Indonesia which can accommodate the navigation of big ships. Rivers in Java are often shallow as a result of their high sedimentation content. The few rivers which can be navigated far inland are found in Sumatra and in Kalimantan. The Kapuas River in Kalimantan, which can be navigated up to Putusibau (a distance of 600 km) is, at present, the major one which can accommodate big ships.

(c) **Mining industry**

Data related to water resources needs and uses in the mining sector are relatively sparse. With respect to the monitoring of water utilization in extracting and/or refining the various mineral ores up to a required quality or grade of produce, the mining industry in general speaks of water withdrawal rather than water consumption or use. Very large volumes of water are used to produce one unit of the product; however, virtually all of the water is returned to the stream system, be it a nearby river or one which has been dammed up for the purpose. Until the mineral industry is required to reduce the possibly negative effects by restoring the quality of the water withdrawn and subsequently returned to the river for public use further downstream, water control by the mining companies will be limited to routine monitoring of water resources availability; anti-pollution measures are not included. Thousands of tons of water are used by the mining companies in Indonesia for mining and processing of tin, granite, iron sand, nickel ore and gold.

D. MEASUREMENT AND PROJECTIONS OF WATER DEMAND

1. Water demand for the population

Population statistics are basic in an estimation of domestic water demand. Therefore, population trends must be predicted. The total population of Indonesia in the year 2001 has been estimated at over 210 million people. If the urban/rural population pattern remains the same as at present (70 per cent of the population in rural areas), and the water demand for the urban population is estimated to be 200 1/day/**capita**, and 60 1/day/**capita** for the rural population, then the water demand for the population in 2001 will be as presented in table 25.

Table 25. Indonesia: estimation of domestic water demand for rural and urban population in the year 2001

Region	Population, year 2001 Urban (1 000)	Population, year 2001 Rural (1 000)	Water demand Urban (1 000 m³/yr)	Water demand Rural (1 000 m³/yr)	Total water demand (1 000 m³/yr)
Java and Madura	39 739	92 723	2 900 947	2 030 634	4 931 581
Sumatra	11 806	27 546	861 838	603 257	1 465 095
Kalimantan	2 881	6 724	210 313	147 256	357 569
Sulawesi	4 556	10 630	332 588	232 797	565 385
Bali	1 090	2 544	79 570	55 714	135 284
Nusa Tenggara Barat	1 152	2 688	84 096	58 867	142 963
Nusa Tenggara Timur	1 171	2 731	85 483	59 809	145 292
Maluku	593	1 385	43 289	30 332	73 621
Irian Jaya	83	192	6 059	4 205	10 264
Total	63 071	147 163	4 604 183	3 222 871	7 827 054

2. Water demand for irrigation

If Indonesia intends to become self-sufficient in rice, this means that in the year 2001 the country must be able to supply rice at the amount of $210.25 \times 10^6 \times 10^2$ kg, or 21.025 million tons of rice (assuming that the consumption of rice **per capita** per year = 100 kg). That amount of rice can be produced by 7.01 million ha of irrigated rice fields. At present the available irrigated area throughout Indonesia is 5.3 million ha. Therefore, an expansion of 2 million ha will be needed by the year 2000. Table 26 shows the extent of agricultural regions and irrigated regions in 1979.

Additional available land which has good properties for irrigation is chiefly of the alluvial type. This type of land represents plains (with a slope of 0-8°),

Table 26. Area of agricultural regions and irrigated regions in Indonesia, 1979

Region	Area[a] (ha)	Agricultural region (ha)	Irrigated region (ha)
Java and Madura	13 218 700	5 647 000	3 100 000
Sumatra	47 360 600	3 908 600	1 334 000
Kalimantan	53 946 000	1 418 000	183 000
Sulawesi	18 921 600	996 300	354 000
Bali	556 100	381 900	109 000
Nusa Tenggara Barat	2 017 700	357 700	163 000
Nusa Tenggara Timur	4 787 600	469 400	51 000
Maluku	7 450 500	370 000	1 500
Irian Jaya	42 198 100	210 000	—
Total	190 456 900	13 728 900	5 295 500

Sources: 1. *Statistical Pocketbook of Indonesia, 1977/1978*, Jakarta, Central Bureau of Statistics.
2. Directorate of Irrigation, Directorate General of Water Resources.

[a] Not including the land area of East Timor.

amounting to an area of 16.8 million ha or nearly 9 per cent of the total area of Indonesia. From the above it is clear that there is more than enough potential land available to support agriculture, especially rice, if other types of land are considered (for example latosol, with an area of 17 million ha). However, for the island of Java, the area for agricultural expansion is very limited. Therefore, it is advisable that priority be given to Sumatra and Kalimantan for agricultural expansion. For Java and Nusa Tenggara, rehabilitation and intensification of existing irrigated areas should be the first priority. Estimates of the area and water demand for irrigation for every island in the year 2000 are given in table 27.

Table 27. Estimation of water demand for irrigation in Indonesia (year 2000)

Region	*Estimation of irrigated area (thousand ha)*	*Estimation of water demand in the year 2000 (million m^3/yr)*	*Assumptions*
Java and Madura	2 600	52 000	Water demand for rice is around 1.1–1.5 l/sec/ha or equivalent to 10 000 m^3 for one crop, assuming a second crop, and homogeneous land conditions for every territory.
Sumatra	2 250	45 000	
Kalimantan	2 300	46 000	
Sulawesi	350	7 000	
Bali Nusa Tenggara Barat	250	5 000	
Nusa Tenggara Timur	250	5 000	
Maluku	5	100	
Irian Jaya	10	200	
Total	7 765	155 300	

Source: D. Muljadi and Ir. Sitanala Arsjad, *The Role of Land Factor in Land Use Planning*, Jakarta.

Apart from rice irrigation, land is also needed for a second crop and for vegetables. Land suitable for a second crop, in particular of andosol type soil, is plentiful, amounting to 4.7 million ha throughout the islands.

3. Hydro power

By March 1980, the electric power facilities owned by the PLN had a total installed capacity of 2,527.7 MW, of which 523.3 MW were generated by hydropower plants. In view of the meteorological and topographical conditions in Indonesia, the hydropower potential was estimated at around 31,000 MW, and it is planned to develop hydropower potential up to 11,000 MW by 1984, at the end of the third five-year development plan. Based on PLN long-term planning in Java, and parallel with increasing modernization and industrialization, the share of electricity in commercial energy consumption should be raised to 15-20 per cent by the year 2000.

Water utilized for hydropower plants is only "passed" through the turbine and does not represent real consumed water; the water can still be used for various other purposes.

The estimated water required to be drawn for steam power plants is 0.125 l/kWh and for hydropower plants 1.86 m^3/kWh, and the estimated percentage of water losses for boiler water (fresh water) is 3 per cent. Total water demand for energy production on Java is estimated at 14,113 million m^3 for the year 2000.

4. Water demand for industry

Water for industries is obtained from ground water and surface water. In Indonesia there is not yet an enterprise which supplies water particularly for industries. Therefore every industry or factory generally arranges for its own industrial water supply.

For a few types of important industries, located mainly in Java, data concerning the amount of water used have already been established, as seen in table 28.

Table 28. Estimation of water used in certain industries in Indonesia

(m^3/year)

Type of industry	*Capacity/year*	*Water used per year (thousand m^3)*
Beverages	156 000 m^3	300
Milk	86 000 m^3	850
Ice	250 000 tons	500
Leather	18 000 tons	1 300
Textiles	974 000 000 m	56 000
Cement	1 950 000 tons	5 000
Paper	50 000 tons	25 000
Urea/fertilizer	200 000 tons	4 000
Glass/mirrors	25 000 tons	80
Metal	450 000 tons	50 000
Total use of water for 10 types of industries for 1975		143 030

Since industrial growth in Java is more rapid than in other regions, and the island's water resources are relatively limited, the problem of water supply in Java needs more serious attention in the future. In regions outside Java, especially on the large islands of Sumatra, Kalimantan and Irian Jaya, the problem of obtaining water resources for industry is probably easier than in Java.

Total water demand for the year 2000 for the 10 types of industries listed in table 28 is estimated at 784 million m^3.

Table 29 shows the comparison between water demand and water availability in the year 2000. The major findings are the following:

(a) Java has already exceeded the critical point (over 100 per cent);

(b) Bali, Nusa Tenggara Barat and Nusa Tenggara Timur are in a critical situation (90 per cent);

(c) Sumatra, Kalimantan and Sulawesi are still far from the critical point (23-31 per cent);

(d) In Maluku and Irian Jaya the water usage is less than 1 per cent of the available firm flow.

Table 29. Comparison of water supply and demand in Indonesia for the year 2000

Region	*Estimated water availability (m^3/capita/year)* (Year 2000)	*Estimated water demand (m^3/capita/year)* (Year 2000)	*Comparison between water demand and water availability (percentage)*[a]
Java and Madura	332	540	163
Sumatra	4 423	1 366	31
Kalimantan	22 325	5 028	23
Sulawesi	3 551	963	27
Bali	390	480	94
Nusa Tenggara Barat	526		
Nusa Tenggara Timur	614		
Maluku	11 018	88	0.8
Irian Jaya	686 680	796	0.12
Location not yet determined:			
— industry		784.03	
— steam power plant (PLTU)		15.94	
— nuclear power plant (PLTN)		14.35	

[a] Estimated conditions of water supply scarcity in the various islands in 2000 can be determined as follows:

Approaching the critical point	50–75 per cent
At a critical stage	75–100 per cent
Exceeding the critical point	100 per cent

On the basis of these findings, the water in Java, Bali and Nusa Tenggara must be managed efficiently, while on the other islands, water usage may still undergo an increase.

E. WATER RESOURCES DEVELOPMENT IN INDONESIA

1. Policy, planning and management

Under REPELITA III, the third five-year plan (1979/80-1983/84), the goals for development of the water resources sector in Indonesia, as listed in the introduction, are the support of food production, the transmigration programme and industrial development, and the provision of water for cities and rural areas. Since agriculture is the largest single sector in the Indonesian economy, irrigation development has received considerable emphasis in the Government's development efforts.

Agriculture accounts for approximately 43 per cent of gross domestic product and for 60 per cent of employment. The Government is pledged to provide a considerable amount of water for rice cultivation and to give special attention to water resources development in the rural areas.

River basin development is considered to be the most suitable method for achieving planning aims. The river basin constitutes a development region. By this approach the ultimate water potential, including ground water, and the total water demand in the river basin development is aimed at the optimum utilization of water resources. It is understood that about 80 per cent of the population of a river basin live in rural areas; it is therefore the policy of the Government to develop the rural areas through the development of the basins as water resources regions. Accordingly, the whole country has been divided into 53 river basins or water resources regions.

2. Planning procedure

The planning of water resources development, with emphasis on river basin development, should be done through an over-all integrated approach, with multi- and interdisciplinary co-operation, should be well co-ordinated, and should take into account various needs in a balanced way. It should include a realistic time perspective and should recognize existing limitations.

The application of modern techniques, such as systems analysis, will enable people to make better decisions than had hitherto been made on the basis of intuition and experience. Such techniques will certainly be useful tools for the river basin approach. In the development of river basins, the planning body has to consider not only water resources, but also other related natural resources, especially land and forest resources, which form the most important elements in the hydrological cycle. Finally, human recources, to which the main efforts are devoted, must be prominently considered.

The planning process for water resources development consists of assessing activities which may require a year or several years to complete. Under favourable conditions, it is possible to carry out a sequential process for a project as follows:

(a) *Identification study*

The study may be initiated by the central Government or be requested by the provincial government. This first stage is carried out to formulate development planning objectives and implementation programmes based on the potential and problems of water resources development in the framework of regional development plan objectives.

(b) *Reconnaissance survey*

This stage is carried out to formulate preliminary ideas of possible development measures and the work programme for further stages.

(c) *Master plan study*

This stage is carried out to assess data and suggest measures to optimize water resources development and to identify priorities for implemenation.

(d) *Feasibility study*

From the priority list in the master plan there will be a selection of individual project(s) for which a feasibility study will be carried out.

(e) *Design*

Engineering design is the next step to make the project(s) ready for construction implementation.

3. Implementation

During the second five-year development plan (1974/75-1978/79), REPELITA II, there were four sections of work, as follows: rehabilitation and extension of existing irrigation networks; development of new irrigation networks; improvement and development of rivers and swamps; and institutional research for water resources development.

With regard to river basin planning, the ultimate water potentials, including ground water and total water demand in the river basins, were identified with the help of computer programming. Master plans for basin development were prepared, which aimed at the optimum utilization of water resources. In REPELITA II, 11 such basin studies were finalized. The problem of environment was considered in carrying out these studies. The ecological impact will be carefully examined to prevent destruction of the human environment by future development.

The targets of water resources development in REPELITA II were as follows:

Rehabilitation and improvement of existing irrigation networks	834 698 ha
Development of new irrigation networks	950 000 ha
River improvement and protection of agricultural and urban areas	407 190 ha
Tidal drainage and swamp areas development	272 000 ha
Total	2 463 888 ha

The third five year development plan (1979/80-1983/84), REPELITA III, includes the current activities listed below.

(a) Management of water resources development, handled by the Ministry of Public Works, covers irrigation and drainage; reclamation of swampy areas; river engineering, river training, river improvement and river basin development planning; protection and control of flood and volcanic debris hazards; and development of reservoirs for irrigation, flood control and multipurpose uses.

(b) Management, operation and maintenance of irrigation networks, under the provincial governments, are carried out by the provincial public works bodies.

(c) Improvement of irrigation works financed by the central Government carried out by the provincial public works department. The rehabilitated irrigation system is then handed over to the relevant provincial public works department for further management.

(d) For large developments such as river improvements and irrigation reservoir, which are financed by the central Government, a project is set up and a non-permanent executive body put in charge of the design and construction of the project.

(e) Village irrigation projects are managed by the village authorities or by the farmers' community under the guidance of the Ministry of Interior.

(f) Management of water use and management at the farm level (including consideration of the water requirements of various crops) is provided by the Ministry of Agriculture in co-operation with local government, while the general water management of the whole irrigation system remains the responsibility of the Ministry of Public Works.

(g) Management of soil and water conservation in the river catchment areas to prevent flood and erosion is implemented by the Ministry of Agriculture, and includes prevention of uncontrolled and improper planning of deforestation, and reforestation, terracing, contour farming and planting of ground cover.

The civil engineering aspect of soil conservation is controlled by the Ministry of Public Works and is co-ordinated with the river development programme.

4. Appropriate technology

Local technologies which are commonly used in Indonesia for water resources development include the following:

(a) **Water wheel in west Sumatra**

The water wheel lifts the water from the river to the rice field. It is commonly used in west Sumatra. The typical water wheel is made of bamboo and wood and is propelled either by human power or by water power.

(b) **Subak system in Bali**

A subak is a traditional Balinese water users' association. All decisions and regulations concerning the distribution of water to the members and construction of works are governed by the *subak*. A remarkable example of *subak* activity is the construction of water tunnels, using local technology.

(c) **The use of water pails (ebor) in central Java**

The *ebor* system is a method of lifting water from a river or canal to irrigate rice fields, using bamboo stakes. This method is practised by individual farmers or by a group of people organized by the head of the village.

(d) **The tidal irrigation system**

The tidal rice fields are found along the coast of east Sumatra, west Kalimantan and south-east Kalimantan, and were originally swamps. By using a canal system including main, secondary and tertiary canals, tidal fluctuations can be used to transform the swamps into rice fields. The system has been co-ordinated with the transmigration programme.

(e) **Polder system**

Polder is an irrigation system dependent on the control of the water table on low-lying land. Besides the construction of dykes around the polder, this system involves an arrangement for the distribution and disposal of water. The supply and disposal of excess water is carried out mechanically, using pumps. Polder Alabio, with an area of 6,000 ha, is located in south Kalimantan and Polder Mentaren, with 2,300 ha, is in central Kalimantan.

5. Environmental aspects

Watershed management methods proposed for overcoming negative environmental impacts have been directed to population activities, through:

(a) The reforestation programme, for which mass guidance has been provided by the provincial government;

(b) Contour farming, grass covering, strip cropping and terracing, which have received special attention in the hill farming areas, in order to prevent gulley erosion and topsoil erosion;

(c) Aquatic weed control, for which manual and mechanical measures have been attempted and tested;

(d) Check dam construction, as a measure against heavy granular sediment transport in the upper reaches of rivers; and

(e) River training and improvement, to prevent bank erosion along wild rivers.

Other means of finding effective methods for overcoming negative environmental effects were the exchange of knowledge and experience of the problems encountered, through seminars, workshops, symposia and conferences. The qualitative measures proposed to assess environmental disturbance caused by water resources development are set forth in environmental impact assessments, which should be submitted for every proposed water resources development.

At the national level, the environmental aspect of natural resources development is handled by the Ministry of Environmental and Development Control. In 1978, the Directorate General of Water Resources Development of the Ministry of Public Works set up a programme for monitoring the over-all environmental aspect of water resources development, with the following targets:

(a) To conduct an inventory of water quality of rivers, lakes, reservoirs, spring and ground water within the programme of water resources development for municipal and industrial water supply, irrigation, fisheries and other uses.

(b) To monitor through both intensive and extensive monitoring systems the quality of the water resources as mentioned above, affected by the development of urban areas, industry, mining and agriculture.

(c) To use the existing capacity of the available personnel for monitoring the aggregate water quality of 15 rivers, one reservoir and four locations of groundwater exploitation.

(d) To apply the extensive programme mainly to the rivers, reservoirs, ground water and industrial waste water throughout Indonesia.

The other activity concerned with the environmental aspect of development is the setting up of a task force for special monitoring of urgent cases to overcome the water pollution caused by industries and mining.

F. ACTION PROPOSAL

Without minimizing the significant progress of the development of water resources in Indonesia, in the present stage of REPELITA III, one must bear in mind that the problems encountered in earlier phases still remain, and must continue to be dealt with.

The following are action proposals to overcome the problems:

1. Manpower

The illiteracy of water users and the lack of knowledge of irrigation system management at the farm level, e.g. structures, the cause of losses, crop water requirements, legal aspects and administration, adversely effect target achievement. Therefore, efforts to improve the irrigation system must include education, with internal training programmes, and better information system. An orderly programme of water resources development in Indonesia only began in 1968, so that experience is limited. On one hand, there is a shortage of professional workers at the planning and design level. On the other hand, each project has its own characteristics in regard to problem-solving methods and administration. To overcome these problems, the exchange of knowledge between different projects will be very worthwhile. The proposed modes include guest lecturers from similar projects; internal seminars on problems and problem-solving methods in such areas as engineering hydraulics, coastal hydraulic and hydraulic structures design; and pilot projects in scientifical institutes or universities.

2. Institutional arrangements

A clear picture of water supply and demand requirements and their variations is necessary for effective water resources management. Moreover, water resources features depend also on the co-ordination of water users and planning efficiency. Therefore, the establishment of a national water board or clearing house in each region would be appropriate.

3. Action proposal for ESCAP or other United Nations bodies

(a) Manpower training programme

There is a shortage of professional planners and designers for water resources development in Indonesia. To overcome this deficiency, the transfer of knowledge in the form of regular training programmes among countries would similar conditions and water resources features would be most beneficial.

(b) Water resources management and administration

By establishing a national water board or regional clearing house, an effective and efficient system of inventory and information could be obtained in Indonesia. Guest lecturers from developed countries who could present material in this field would be helpful in establishing this kind of institution.

(c) Legal aspect

In countries such as Indonesia, where the traditional way of life is prominent, legal enforcement is necessity. At present, the law is still very general; how law enforcement will be accepted by the people deserves a study of its own. Site visits and orientation in other countries which have a similar historical background, or guest lecturers discussing such material, would be very useful to Indonesia.

(d) Technological and environmental aspects

Any further effort to realize the above targets would entail adaptation of modern technology to local conditions. For that purpose, the Indonesian Government has held several seminars and invited foreign experts to teach and train field staff workers in water resources development. The following seminars are still needed, because of the urgency of the matters involved: flood forecasting and warning system; environmental aspects of water resources; water pollution management and control; and data processing.

Research programmes are needed in the following areas: hydrology, including model basin research and basin response to rainfall or rainfall run-off relationships; experimental basins, including water-balance studies related to geographic and geological features of the watershed and to sediment transport; and crop water requirements, especially for wet rice field cultivation.

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VI. JAPAN

(NR.7/CRP.18)

A. HYDROPOWER RESOURCES IN JAPAN

Japan has a population of some 115 million (as of 1978) and a total land area of about 378,000 km². Annual precipitation from rainfall throughout the country averages 1,788 mm and reaches 674.9 billion m³ in total volume.

The precipitation varies seasonally. It is concentrated in the rainy season of early summer (June-July) and in the typhoon season from August to October. In the northern and central regions on the Japan Sea side, precipitation comes mainly from snowfall during the winter season. Japan is handicapped in utilizing river water because of the rapid outflow of rainfall or snowfall precipitation to the sea, brought about by the short length and steep grade of most rivers. The potential net reserve of available resources in Japan amounts to some 450 billion m³ in a normal year and to some 330 billion m³ in a dry year (see table 30).

Available water resources vary greatly among regions because of climatic differences, particularly in winter, between the Japan Sea side and the Pacific Ocean side, which are divided by mountain ranges stretching from north to south through the islands of Japan. Excessive concentration of population and industrial facilities in provincial areas around Tokyo and Osaka has led to a deficit in water resources, a problem which now confronts Japan.

Table 30. Precipitation and available water resources in Japan

	Annual average rainfall (*mm/year*)	*Annual precipitation* (10^8 *m³/year*)	*Net available resources (after deducting evapotranspiration from annual precipitation)* (10^8 *m³/year*)
Dry year	1 480	5 587	3 338
Normal year	1 788	6 749	4 494
Wet year	2 131	8 044	5 791

Note: The normal year is set at the average of the annual precipitation recorded over the past 18 years; the dry year is set at the second lowest precipitation, and the wet year is set at the second highest precipitation.

1. Administrative organizations involved in water resources

Among the ministries and agencies involved directly in water resources development are the National Land Agency (planning and co-ordination); the Ministry of Construction (river control and multipurpose dams); the Ministry of Health and Welfare (public water service); the Ministry of International Trade and Industry (industrial water supply and power generation); and the Ministry of Agriculture, Forestry and Fishery (irrigation, drainage and forestry maintenance). The government-financed Water Resources Development Corporation has been established under the joint supervision of those four ministries and one agency.

Projects on water resources development and water utilization are implemented by the various organizations as discussed below, according to purpose.

(a) Water resources development project

Construction and maintenance of water resources development facilities, such as dams, headwater channels and estuary weirs, are under the jurisdiction of different organizations, depending upon the purpose of each project. For instance, flood control and its related multipurpose development projects are undertaken by the Ministry of Construction; irrigation projects by the Ministry of Agriculture, Forestry and Fishery; and power development projects by electric power companies or the Electric Power Development Company. Development projects on river systems designated specifically under the Water Resources Development Promotion Act are mainly the responsibility of the Water Resources Development Corporation. Direct governmental involvement is limited to those projects planned on a relatively large scale, while other projects on a medium or small scale are assigned to prefectural governments or public bodies concerned with water utilization.

(b) Waterworks

As a rule, the waterworks are operated by each local municipality and its authorized co-operative under the Ministry of Health and Welfare. In many instances, these municipal enterprises depend for their water sources upon the multipurpose dams constructed and operated by the Water Resources Development Corporation, the Ministry of Construction and the prefectural government involved. In special cases, the waterworks enterprise constructs the dam to be used exclusively for its own water supply purposes.

(c) Industrial water supply projects

Each prefectural government operates an industrial water supply, in nearly all instances by permission of (or by application to) the Ministry of International Trade and Industry. The water supply is made available in the same way as the municipal water supply.

(d) **Irrigation and drainage projects**

The projects are normally undertaken by the regional office for land improvement, except for large-scale projects which are carried out either by the Ministry of Agriculture, Forestry and Fishery or by the prefectural governments concerned, after receipt of application from the regional office for land improvement. Although the available source of water is very often exploited by the enterprise itself, it sometimes depends upon a multipurpose dam built by the Ministry of Construction or the Water Resources Development Corporation.

(e) **Hydropower generation projects**

The projects are generally undertaken by nine electric power companies, each serving a block of the country, with the Electric Power Development Company as the nationwide electric wholesaler, and in some instances by prefectural governments or local municipalities. In case of power generation from a large dam, the company may itself construct the dam solely for this purpose or it may depend upon a multipurpose dam constructed by another organization. River control is under the jurisdiction of the Ministry of Construction or the prefectural government concerned. Control relevant to the preservation of water quality and over-all co-ordination with other ministries and agencies is assigned to the Environmental Agency. Surveillance and monitoring for water quality are carried out chiefly by each prefectural government. However, such monitoring services are also performed by the river administration authorities and by the river water users.

2. Present status of water utilization

The total water demand in 1975, as shown in table 31, accounted for about 26 per cent of the maximum available water resources in a dry year. During the 10 years from 1965 to 1975, domestic water demand rose about twofold and industrial water demand increased by about 1.4 times. Since 1975, domestic water demand has continued to increase further while industrial water demand (fresh water supply basis) has remained on almost the same level, reflecting a slow-down in production activities and rationalization of water use after the oil crisis of 1973.

In analysing water utilization by water sources available, river water ranks highest, with consumption reaching 64.9 billion m^3, or 74 per cent of the annual total supplies. This is followed by ground water, of which 13.8 billion m^3, or 16 per cent of the annual total, was utilized, and then spring water or pond storage, of which 10 per cent was used. In particular, municipal water (both domestic and industrial) shows greater dependence upon river water, particularly upon dam reservoirs.

Table 31. Trends in water demand in Japan (100 million m^3/year)

Purpose		*1965*	*1970*	*1975*	*1975/1965*
Municipal use . .	Domestic use	62.6	94.4	123.4	2.0
	Industrial use	126.5	179.7	182.8	1.4
Agricultural use		—	—	570.0	—
Total		—	—	876.2	—

Source: "Long-term water utilization plan in August 1978", the National Land Agency.

Notes:
1. Each figure is based on an intake-withdrawal basis. Industrial water is based upon fresh-water make-up supplies.
2. Agricultural water is calculated from general observations of farmland preparation and cropping status.
3. Domestic water excludes consumption for industrial plant use in the total supply available from the city water supply system.

3. Development of water resources

In Japan, reservoir ponds are traditionally developed for agricultural use. At present there are about 180,000 ponds of this kind. Development of water resources by dam construction, as is seen today, can be traced back to the 1930s. In the post-war period the multipurpose dam was established as the main object for development. As of 1975, there were a total of about 1,700 dams higher than 15 m, with a reservoir capacity for water utilization (as distinguished from reservoirs for power generation), whose total reservoir capacity amounted to some 3.6 billion m^3.

The Water Resources Development Promotion Act was implemented in 1961 to meet the need to establish rational water management for water utilization, especially in large city areas. Since that time, in an effort to cope with increased water demand, various water resources projects have been developed for certain specific river systems designated under the Act. So far, six large river systems including the Tonegawa and the Arakawa, running through the Tokyo metropolitan area have been designated for development.

The basic plan for Water Resources Development has estimated future water demand, target supply and construction of required facilities by the target year. Pursuant to this plan, development projects have been carried out mainly by the Water Resources Development public corporation, under governmental supervision and guidance.

Dams, weirs and channels at 23 sites have been completed, with development of additional water resources for 4.9 billion m^3 in municipal water supplies and 1.3 billion m^3 in agricultural water supplies respectively each year. Since the total municipal water resources newly developed by the Ministry of Construction, prefectures and water users, as well as by the corporation, may be estimated at about 10 billion m^3 for the 1961-1976 period, roughly half of the total is shared by the development projects related to the six designated river systems in the industrialized regions, where the population accounts for about 58 per cent of the nation's total and industrial production for about 62 per cent.

One difficulty involved in constructing a dam is obtaining full consent from the local community concerned prior to the start of a project; this is because the local inhabitants are forced to leave their own land, which will be submerged by the reservoir, and resettle in a new but strange area requiring a different life style. The Act on Special Measures for the Reservoir Area Development came into force in 1973 to help to resolve this problem. In addition to compensation to each owner for submerged land, the Act provides for the implementation of necessary measures for economic promotion of the reservoir area and for resettlement of the inhabitants in the area.

Ground water has been widely used for various purposes because of its good quality and low price. This has resulted in widespread ground subsidence in every part of this country, although at a slower pace recently. To cope with this situation, a study is now being made for legislation relevant to proper utilization of the ground water, including its conversion into river water. The total ground water consumption in 1975 was 13.8 billion m^3 throughout the country, which was shared among the sectors as follows: 52 per cent for industrial use; 27 per cent for agricultural use; and 21 per cent for domestic use.

As one new approach to water resources exploitation, a project for the desalination of sea water is under way, with 45 unit plants installed in 1978, and a total planned production capacity of 79,723 m^3/day. Among those, 14 units are being operated for domestic use on certain isolated islands to supply 7,738 m^3/day. Desalination is divided into two different processes: one is the evaporation process, applicable to sea water, and the other is the electrolysis or reverse osmosis process, applicable to brine water. Although production costs vary depending upon raw water quality, productive scale, the availability factor and the desalination method, it is within a range of 200 to 1,000 ¥/m^3 for sea water and 60 to 860 ¥/m^3 for brine water. In view of the energy saving, sea-water desalination by use of the reverse osmosis method has been receiving particular attention.

4. Long-term projections of water demand

In August 1978 the National Land Agency formulated and published its long-range water demand and supply plan, which aimed at the promotion of effective and efficient development and utilization of the water resource potential, on the assumption that the resources were of a finite nature.

This plan covers long-range projections of future water demand and supply by 1985 and 1990 with the perspective view up to the year 2000, under the third comprehensive national development plan, and includes matters essential to the development, preservation and utilization of water resources. The plan is, therefore, expected to be a guideline for governmental measures to be taken towards stabilization of the future demand and supply balance. Any future projects related to development of water resources by dam construction and expansion of various water supply facilities will be pushed forward within the framework of this plan.

Estimated water demand for domestic, industrial and agricultural uses by 1985 and 1990 are presented in table 32. The forecast of the future demand and supply balance by regions in 1985 is shown in table 33. As noted from the data, it is anticipated that the balance of water demand and supply will remain tight or unstable in major parts of Japan, such as the coastal zones of Kanto (Tokyo) and Kinki (Osaka), North Kyushu and Okinawa, where the total water deficit is estimated at roughly 1.5 billion m^3.

Table 34 shows the forecast of water demand and supply by regions for 1990. It is estimated that the total shortage will decline to 900 million m^3, though an unstable balance may continue in the Tokyo coastal zone and in some other regions. In the long run, the nationwide balance is expected to improve steadily and gradually in the years to come; however, since it has become increasingly difficult to develop water resources further by dam construction in those industrialized regions around Tokyo and Osaka, every possible effort must be made to rationalize water utilization and to conserve water in full recognition of the finite nature of water resources, so that the balance of demand and supply can be stabilized on a firm basis.

5. Major problems in water resources development and utilization

As stated earlier, in order to meet an expected increase in future demand for water resulting from improvements in living standards and growth of the economy, comprehensive, well-planned measures must be implemented to promote development of water resources, conserve water and rationalize consumption, and to co-ordinate all the competing users in order to

Table 32. Estimates of water demand in Japan

Units: 100 million m³/year

Area	*1975*					*1985*					*1990*				
	Municipal water			*Agri-cultural water*	*Total*	*Municipal water*			*Agri-cultural water*	*Total*	*Municipal water*			*Agri-cultural water*	*Total*
	Domestic	*Industrial*	*Subtotal*			*Domestic*	*Industrial*	*Subtotal*			*Domestic*	*Industrial*	*Subtotal*		
Hokkaido	4.1	12.3	16.4	43	59.4	7.5	18.0	25.5	46.3	71.8	9.1	22.0	31.1	49.8	80.9
Tohoku	10.0	18.8	28.8	158	186.8	16.5	30.2	46.7	171.7	218.4	19.7	36.4	56.1	175.3	231.4
Kanto	43.4	33.9	77.3	100	177.3	66.4	46.8	113.2	112.9	226.1	75.0	50.7	125.7	114.9	240.6
Tokai	15.2	37.2	52.4	41	93.4	22.7	53.7	76.4	45.2	121.6	25.5	59.5	85.0	47.5	132.5
Hokuriku	3.0	10.9	13.9	33	46.9	4.9	13.6	18.5	34.8	53.3	5.7	14.8	20.5	35.1	55.6
Kinki	24.4	26.6	51.0	47	98.0	33.5	34.1	67.6	52.7	120.3	37.1	36.3	73.4	52.9	126.3
Chugoku	7.5	17.7	25.2	51	76.2	11.7	25.6	37.3	52.3	89.6	13.4	29.3	42.7	52.4	95.1
Shikoku	3.7	9.9	13.6	24	37.6	5.8	13.0	18.8	27.3	46.1	6.7	14.4	21.1	27.3	48.4
Kyushu	11.0	15.2	26.2	72	98.2	17.7	23.8	41.5	75.6	117.1	20.5	28.8	49.3	81.0	130.3
Okinawa	1.1	0.3	1.4	1	2.4	1.6	0.5	2.1	1.2	3.3	1.9	0.6	2.5	1.6	4.1
Nation-wide total . . .	123.4	182.8	306.2	570	876.2	188.3	259.3	447.6	620.0 655.0	1 067.6 1 102.6	214.6	292.8	507.4	637.8 700.0	1 145.2 1 207.4

Notes: 1. Figures are on the intake base.

2. Agricultural water demand was calculated on the basis of the conditions of field improvement and planting. The demand in 1985 or 1990 is the sum of the demand in 1975 and the estimated demand increase through land improvement works which are expected to be completed by 1985 or 1990.

Table 33. Estimated water balance between supply and demand in Japan, 1985

Units: 100 million m³/year[a]

Area		Increase in municipal water demand: Increase, 1976-1985	Planned reduction of ground water resources[b]	Unstable intake of river water[c]	Subtotal	Increase in agricultural water demand, 1976-1985[d]	Total increase in demand	Increase in water resources developed, 1976-1985[e]	Deficit in 1985[f]
Hokkaido		9.1	0.3	0.1	9.5	3.3	12.8	14.1 (10.4)	— (2.4)
Tohoku		17.9	0.8	0.5	19.2	13.7	32.9	30.7 (29.4)	2.2 (3.5)
Kanto	Inland	15.3	1.8	2.8	19.9	10.8	30.7	30.9 (25.0)	— (5.7)
	Littoral	20.6	5.9	16.3	42.8	2.1	44.9	40.0 (38.0)	4.9 (6.9)
	Total	35.9	7.7	19.1	62.7	12.9	75.6	70.9 (63.0)	
Tokai		24.0	7.3	2.8	34.1	4.2	38.3	41.9 (40.9)	— (—)
Hokuriku		4.6	1.8	0.9	7.3	1.8	9.1	10.0 (8.7)	— (0.4)
Kinki	Inland	7.1	0.3	0.5	7.9	3.8	11.7	10.8 (8.9)	0.9 (2.8)
	Littoral	9.5	1.5	7.3	18.3	1.9	20.2	19.4 (18.6)	0.8 (1.6)
	Total	16.6	1.8	7.8	26.2	5.7	31.9	30.2 (27.5)	
Chugoku	San'in	2.2	0.1	0.0	2.3	0.7	3.0	2.5 (2.5)	0.5 (0.5)
	Sanyo	9.9	0.3	1.2	11.4	0.6	12.0	14.4 (11.7)	— (0.3)
	Total	12.1	0.4	1.2	13.7	1.3	15.0	16.9 (14.2)	
Shikoku		5.2	0.9	0.0	6.1	3.3	9.4	11.2 (10.5)	— (—)
Kyushu	North	10.1	0.7	0.4	11.2	1.6	12.8	8.8 (6.8)	4.0 (6.0)
	South	5.2	0.2	0.0	5.4	2.0	7.4	5.8 (5.8)	1.6 (1.6)
	Total	15.3	0.9	0.4	16.6	3.6	20.2	14.6 (12.6)	
Okinawa		0.7	—	0.4	1.1	0.2	1.3	1.0 (0.7)	0.3 (0.6)
Nation-wide total		141.4	21.9	33.2	196.5	50.0	246.5	241.5(217.9)	15.2(32.3)

Notes:

[a] Figures are on the intake base.

[b] Planned reduction of ground-water resources is the amount for which diversion of source to river water is planned between 1975 and 1985 in areas where subsidence occurred.

[c] Unstable intake of river water is the amount of river water intake, such as temporary intake, which is likely to be difficult during the dry season.

[d] Increase in agricultural water demand is the amount of increase which will result from land improvement works expected to be completed by 1985. This includes the increase in demand due to diversion of ground sources or the increase due to stabilization of unstable intake of river water resulting from land improvement works.

[e] Increase in water resources developed includes the unused water which had been developed by 1975. Figures in parentheses are those obtained from water resources development which had commenced construction by 1978.

[f] Deficit in parentheses is that corresponding to the increase in water from water resources development which commenced construction by 1978.

Table 34. Estimated water balance between supply and demand in Japan, 1990

Units: 100 million m³/year[a]

Area		Increase in municipal water demand: Increase, 1976-1990	Planned reduction of ground water resources[b]	Unstable intake of river water[c]	Subtotal	Increase in agricultural water demand, 1976-1990[d]	Total increase in demand	Increase in water resources developed, 1976-1990[e]	Deficit in 1990
Hokkaido		14.7	0.3	0.1	15.1	6.8	21.9	25.5	—
Tohoku		27.3	1.3	0.5	29.1	17.3	46.4	49.6	—
Kanto	Inland	20.7	1.9	2.8	25.4	12.7	38.1	40.4	—
	Littoral	27.7	6.4	16.3	50.4	2.2	52.6	45.7	6.9
	Total	48.4	8.3	19.1	75.8	14.9	90.7	86.1	
Tokai		32.6	7.5	2.8	42.9	6.5	49.4	52.1	—
Hokuriku		6.6	2.1	0.9	9.6	2.1	11.7	13.4	—
Kinki	Inland	9.6	0.3	0.5	10.4	4.0	14.4	17.3	—
	Littoral	12.8	1.8	7.3	21.9	1.9	23.8	22.7	1.1
	Total	22.4	2.1	7.8	32.3	5.9	38.2	40.0	
Chugoku	San'in	3.2	0.1	0.0	3.3	0.8	4.1	4.6	—
	Sanyo	14.3	0.4	1.2	15.9	0.6	16.5	18.8	—
	Total	17.5	0.5	1.2	19.2	1.4	20.6	23.4	
Shikoku		7.5	0.9	0.0	8.4	3.3	11.7	13.6	—
Kyushu	North	14.0	0.8	0.4	15.2	5.1	20.3	19.3	1.0
	South	9.1	0.2	0.0	9.3	3.9	13.2	14.4	—
	Total	23.1	1.0	0.4	24.5	9.0	33.5	33.7	
Okinawa		1.1	0.0	0.4	1.5	0.6	2.1	2.2	—
Nation-wide total		201.2	24.0	33.2	258.4	67.8	326.2	339.6	9.0

Notes:

[a] Figures are on the intake base.

[b] Planned reduction of ground-water resources is the amount for which diversion of source to river water is planned between 1975 and 1990 in areas where subsidence occurred.

[c] Unstable intake of river water is the amount of river water intake, such as temporary intake, which is likely to be difficult during the dry season.

[d] Increase in agricultural water demand is the amount of increase which will result from land improvement works expected to be completed by 1990. This includes the increase in demand due to diversion of ground sources or the increase due to stabilization of unstable intake of water resulting from land improvement works.

[e] Increase in water resources developed includes the unused water which had been developed by 1975.

balance demand and supply of water. To comply with this need, the National Land Agency prepared its long-term plan for water demand and supply in August 1978. Its over-all system chart for stabilization of the demand-supply balance is shown in table 35. The planning strategies drawn up in the plan would naturally require joint efforts by the national government, prefectural authorities, local municipalities, water users and the general public. Among them, the strategies of particular importance are as follows.

(a) **Promotion of water resources development**

New projects for development of an additional 34 billion m³ per year must be carried out between 1975 and 1990. Further efforts must be exerted to promote development of water resources with due consideration to the declining number of optimum sites for construction projects, compensation for loss or damage, incentive measures for reservoir area development and harmony with environmental preservation.

(b) **Strengthening of incentive measures for reservoir area development**

The construction of a dam and reservoir may encounter resistance from the local community. For this reason, the living environment and the industrial foundation in the resettlement area close to the reservoir should be improved so as to provide stabilization of the community's livelihood and improvement of public welfare. Incentives may be offered under the Special Measures for Reservoir Area Development and the Fund for Reservoir Area Development. It is also important to introduce well-planned measures for improvement of forestry resources near the reservoir area.

(c) **Formation of a water-saving society**

With the recognition that water is a limited resources of high value, efforts must be exerted to form a community with water-saving attitudes. This requires rationalization of domestic, industrial and agricultural water consumption through introduction of water-saving technology, promotion of the use of recycled waste water and reduction in water leakages.

Table 35. Strategies for reducing the water supply and demand imbalance in Japan

Comprehensive measures regarding water supply and demand	Formation of water-saving society	Promotion of conscious water-saving by users (water day, water week, waterworks weeks, public relations)	
		Rationalization of water use	Rationalization of household water use (introduction of water-saving technology)
			Rationalization of industrial water use (stricter water control, improved production and manufacturing processes)
			Rationalization of agricultural water use (improvement in irrigation facilities, stricter water management)
			Promotion of leakage prevention (replacing worn-out piping and joints, early discovery and repair of leaks, stricter management of water distribution)
			Promotion of dual water supply system (individual recycling, collective recycling)
	Stable supply of water	Promotion of water resources development	Implementation of water resources development projects
			Measures for upstream areas
			Co-ordination with other development works (flood control works, forestry improvement works, electricity generation development)
		Utilization of other water resources	Conservation and utilization of ground water (prevention of ground subsidence, underground dams)
			Desalination of sea water (osmosis method, evaporation method)
			Use of treated sewerage (open recycling method, closed recycling method)
		Improvement of efficiency in water supply	Regional and community expansion, region-wide water supply, industrial water supply, promotion of land improvement works
		Conservation of environment	Minimum acceptable flow, improvement of flow regime, development of sewerage systems, measures against eutrophication

B. WATER QUALITY CONSERVATION

The results of water quality measurements in public water areas in Japan in 1978 showed that specific pollutants such as cadmium and cyanogen, which are toxic to human health, were present in excess of the environmental standard at a rate of 0.07 per cent in the total quantity tested. When compared with 1.4 per cent in 1970 and 0.17 per cent in 1975, the latest figure implies a remarkable improvement in water quality.

With regard to those items related to conservation of the environment, such as biochemical oxygen demand (BOD) and chemical oxygen demand (COD), the environmental standard for BOD (or COD) has been attained to 59.5 per cent in rivers, 37.6 per cent in lakes and 75.3 per cent in the sea. As a whole, the requirement has not yet been met in 38.3 per cent of the water areas. In particular, little improvement has been observed in the lakes, inland sea and inner bay, and in those water areas rapid entrophication has been observed, which is regarded as a cause of poor filtration or unpleasant odours in the city water supply system and a red tide in the sea.

Effluent control standards were established in 1958 under the water quality conservation law and the factory effluents control law, but these laws did not act as effective preventive measures in many instances because separate control standards were set up for each designated water area and no penalty clause was applied. For this reason, these two laws were replaced in 1970 by the water pollution control law, under which a uniform effluent standard was introduced nationwide, and was enforced under local regulations. Each prefectural governor is authorized to set up a more intensified control standard for the specified water area.

In 1973, as a result of severe pollution in the Seto Inland Sea, the Seto Inland Sea environmental conservation law (revised in 1978 as a permanent law) was enacted, with provisions for water quality control which require official permission for any effluent discharge into the Sea and also provide for environmental assessment measures. In 1978, in order to intensify control over water pollution in this wide semi-closed water area, the water pollution control law and the Seto Inland Sea environmental conservation law were revised so as to regulate total emission of COD into Tokyo Bay, Ise Bay and the Seto Inland Sea.

In recent years water pollution has been caused increasingly by organic matter related to chemical residue from sewage treatment plants and from non-point polluting sources washed out by rainfall from the urban, forest and arable areas. Since such sources of pollution are not covered by the control standards, necessary measures must be taken for survey and assessment of environmental impact from development projects. Furthermore, to prevent poor filtration and unpleasant odours from the city water supply system and any damage from red tide produced by enriched nourishment in the lakes, inland sea and inner bay, comprehensive measures must be taken to reduce pollutants such as phosphorus and nitrogen, which may cause enriched nourishment of the water.

C. RESEARCH AND PUBLIC RELATIONS

Research activities on development and utilization of water resources are carried out by concerned ministries, agencies and their annexed organs. Basic research activities are being conducted by the Agency of Science and Technology in the fields of conservation of resources and environment, and prevention of natural disasters.

The Survey Institute on Resources has conducted a survey on ground water by the use of several alternative simulation models to determine the ideal pattern for future ground-water control. The purpose of the research is to clarify various problems involved in practical use of the experimental method, the conditions for application of the method and the advantages and disadvantages of the method. As a result of this survey, relevant data were collected by each organization through monitoring of precipitation, evaporation, river discharge and ground water. On this basis, a summary could be compiled of additional needs for future monitoring of data and systematic control of information.

The Institute is now conducting a study to identify various problems incidental to the exploitation of water resources and a strategy for water resources control. Another survey is also in progress to determine the possibility of using the self-purification functions of forestry, farm land and water areas for sewage treatment. Furthermore, in view of the recent increasing trend in ground-water demand, a basic study is being made to help establish a rational utilization plan for ground water, including the allowable limit of dependence upon ground water. At the same time, a survey is being conducted to define the adaptability of a simulation model developed for one region for transfer to another region.

The National Research Centre for Disaster Prevention has published the following technical reports, which are intended to mitigate possible damage caused by rainfall: "Examples of return periods of rainfall for disaster countermeasures", "Developments of flood vulnerability estimation method by application of principal component analysis" and "Experiments on rain infiltration in soil".

With the aim of arousing interest and deepening understanding among the people as to the finite nature of water resources, the value of water and the significance of water resources development, the Government has set up a "Water Day" on the first day of August every year since 1977 and an annual "Water Week" for a week, starting on that day. Moreover, the first week of June has become the annual "Waterworks Week", with publicity activities to draw the attention and interest of the general public to waterworks for a better understanding. The "Green Land Campaign" is also one of the main publicity activities for the preservation of forestry resources, closely related to the recharging of water resources.

In October 1977, Tokyo provided the forum of discussions for the Symposium on Water Resources, the first international gathering of this kind in Japan, held for the purpose of exchanging research results and views on various themes related to effective utilization of water resources, thus contributing to future research and administration.

D. PRESENT STATUS OF INTERNATIONAL CO-OPERATION

As a part of international co-operation to developing countries, the Government has been extending its active co-operation, in the area of water resources as well as in other areas, by accepting a number of trainees from those countries and by dispatching many experts to those countries for technical and financial assistance. The Government still intends to continue its co-operative effort internationally in the field of water resources in line with the needs of developing countries. Japan's international co-operation in the field of water resources is characterized by its diversified objectives and patterns of co-operation. The technical and financial co-operation activities of Japan in 1979 may be summarized as follows: sixty-six persons from developing countries were accepted as trainees in group training courses (including seminars) and 28 persons in individual training courses. Twenty-six Japanese experts were dispatched to those countries on a long-term basis and 99 persons were sent for a short period. Grants-in-aid were extended to two projects and yen credit loans to four projects.

E. MUNICIPAL WATER SUPPLY

The water supply system in Japan has been expanding rapidly since 1955. As a result, the population served as of March 1979 has reached 104 million, or 90.3 per cent of the total population. The total water supply has reached 13.7 billion m^3 per annum. anticipation of a continuing increase in both population served and annual water supply, it is estimated that by 1985 the total population served will amount to 118 million, or 96 per cent of the population, and the annual water supply will increase to 20.76 billion m^3. The daily water requirement on a **per capita** basis remained at 363 litres in 1978.

It is estimated, however, that the **per capita** demand will rise to 482 litres per day, mainly because of an increase in demand for domestic uses, resulting from higher living standards and more widespread use of water-related home appliances, and for commercial and industrial uses, in order to keep pace with economic activities.

The whole country was troubled by scanty rainfall in 1978. Especially in the western part, about 11 million people were forced to contend with a suspended or restricted water supply for a long period. To avoid recurrence of such distress, the balance between water demand and supply must be improved on a comprehensive basis by effective measures for reducing water consumption and promoting dam construction for development of water resources.

1. Available water sources for public supply

Available supply sources in 1978 may be broken down into: 42.9 per cent from river discharge (run-of-river); 23.5 per cent from reservoirs (dam); 1.1 per cent from lakes; 7.4 per cent from riverbed water; 21.6 per cent from ground water through both shallow and deep wells; and 3.5 per cent from other sources. Although ground water may be generally well-fitted for a city water supply in its quality, excessive use of ground water has become a cause of ground subsidence. Therefore, any future increment in demand will have to be met mainly by surface water from the large reservoirs.

2. Waterworks expenditure and water rates

Operating expenditures for public water supply have been on the increase for years. The majority of the investment is financed by municipal bonds (loan financing from Government or financing corporations) and by governmental subsidies. In 1979, such financing amounted to 718.3 billion yen from bond issues and 128 billion yen from governmental grants-in-aid, including 59.4 billion yen granted for development of water sources related to the public water service system.

The water charge is averaged generally at 95 yen per m^3, although it varies with the supply system. Average spending for water consumption is 1,421 yen for each household per month, which corresponds to 0.7 per cent of monthly household expenses.

3. Region-wide water supply system

The water supply network in Japan has traditionally been expanded and improved independently for each city, town or village unit. At present, however, with further increases in water demand, the selected site for a new consuming terminal tends to be more and more remote from the water supply source. Therefore, the small waterworks enterprise, such as the local municipality, finds it difficult to develop a new source within its own financial and technical capability. It is for this reason that each individual unit of a water supply system existing today on a limited scale will have to be reorganized and merged into a region-wide integrated supply system with adequate financial backing and the technical capacity for the promotion of new supply source development projects.

By integration into the wide service network, it is expected that the unbalanced situation of water demand and supply by service areas will be ironed out and the facilities will be utilized more effectively and efficiently. To promote amalgamation of local supply systems into a region-wide co-ordination system on a well-planned basis, the provisions of the region-wide water supply plan were added in 1977 to the water works law. Today, this plan is being formulated for implementation in about 20 local areas and the region-wide supply system is expected to expand with an increasing number of projects as time goes on.

4. Water saving and leakage prevention

To cope with the rapid increase in water demand, a continuing effort to try to curb future demand increases for water has become essential. The Ministry of Health and Welfare has conducted a cost-benefit analysis of leakage prevention and has provided administrative guidelines for preventive measures against possible leakage, setting the target rate of availability at 90 per cent. The Ministry also makes a general appeal for everyone to save water, through Waterworks Week which begins annually on 1 June.

F. INDUSTRIAL WATER

Today, Japanese industry is undergoing structural change as a result of the shift from heavy chemical industry as a core to machinery and its associated assembling industry. In line with this change, the structure of demand for industrial water has shown a gradual alteration; the rate of increase in demand for water has slowed down as compared with the previous period.

As shown in table 36, the recent trends in industrial water consumption can be characterized as follows:

(a) Consumption of water by industry has increased year after year;

(b) Since an increase in the use of recycled water has been closely matched by the increase in industrial water consumption, the additional water needs in recent years have remained almost constant;

(c) Less ground water from wells is being consumed as the industrial water supply network is expanded.

On the supply side, the purpose of the industrial water supply system in Japan is to prevent subsidence resulting from excessive use of ground water and also to help develop basic industrial activities. At present, there are nearly 150 water supply systems across the country, the majority of which are operated by local municipalities. As noted in table 36, supplies through the industrial water supply systems amount to as much as 12 million m^3/day, nearly one third of the total daily water supplies to industrial plants. As a result of recent system expansion, ground subsidence along the highly industrialized coastal zone of Tokyo and Osaka has almost ceased.

Rationalization in the use of industrial water is indicated by the increase in the use of recycled water for industrial purposes.

The amount of recycled water used by the industrial sector in 1977 is shown in table 37. A large portion of the water used by the chemical and steel industries is recycled water. Some of the most modern steel manufacturing plants can use 95 per cent recycled water.

The level of recycling averages more than 70 per cent throughout all industrial sectors. The rationalized use of water at such a high rate of recycling has had a positive effect on the reduction of the unfavourable balance between demand and supply and the preservation of environmental quality.

F. INTEGRATED RIVER DEVELOPMENT BY CONSTRUCTION OF MULTIPURPOSE DAMS AND OTHER STRUCTURES

1. General outline of river development projects

The purpose of an integrated river development project is to construct a dam at an upstream site on the river, thereby controlling floods by storing flood discharge in a reservoir and releasing the reservoir water into the downstream during the dry period to fulfill demand for water in the dry season.

Table 36. Trends in industrial water consumption by available supply sources in Japan

Units: 1,000 m³/day

Year	*Sources*								
	Public water service		*Surface water*	*River-bed water*	*Well*	*Others*	*Make-up water*	*Recycled water (percentage)*	*Total*
	Industrial water	*City water*							
1965	4 444	2 780	7 281	3 554	12 679	598	31 336	17 826	49 162
	(14.2)	(8.9)	(23.2)	(11.3)	(40.5)	(1.9)	(100.0)	(36.3)	
1966	5 138	2 899	7 831	3 329	12 594	224	32 015	21 092	53 107
	(16.0)	(9.1)	(24.5)	(10.4)	(39.3)	(0.7)	(100.0)	(39.7)	
1967	6 622	2 945	7 496	3 227	12 937	291	33 518	24 180	57 698
	(19.8)	(8.8)	(12.4)	(9.6)	(38.5)	(0.9)	(100.0)	(41.9)	
1968	7 500	3 206	7 753	3 016	13 944	644	36 063	18 907	64 970
	(20.8)	(8.9)	(21.5)	(8.4)	(38.6)	(1.8)	(100.0)	(44.5)	
1969	8 729	3 271	8 019	3 207	14 473	916	38 615	35 790	74 405
	(22.6)	(8.5)	(20.8)	(8.3)	(37.4)	(2.4)	(100.0)	(48.1)	
1970	9 801	3 491	8 266	3 247	15 360	871	41 056	43 986	85 042
	(23.8)	(8.5)	(20.1)	(7.9)	(37.4)	(2.1)	(100.0)	(51.7)	
1971	10 395	3 876	8 292	3 188	14 915	1 271	41 937	53 310	95 247
	(24.8)	(9.2)	(19.8)	(7.6)	(35.6)	(3.0)	(100.0)	(56.0)	
1972	11 491	3 530	8 257	3 163	15 243	884	42 568	58 889	101 457
	(27.0)	(8.3)	(19.4)	(7.4)	(35.8)	(2.1)	(100.0)	(58.1)	
1973	11 437	3 880	8 397	3 131	15 326	1 086	43 257	70 658	113 915
	(26.4)	(9.0)	(19.4)	(7.2)	(35.4)	(2.5)	(100.0)	(62.0)	
1974	11 995	3 351	8 192	3 066	14 646	1 000	42 250	77 790	120 040
	(28.4)	(7.9)	(19.4)	(7.3)	(34.7)	(2.4)	(100.0)	(64.8)	
1975	11 945	3 152	7 921	2 925	13 622	628	40 193	81 432	121 625
	(29.7)	(7.8)	(19.7)	(7.3)	(33.7)	(1.6)	(100.0)	(67.0)	
1976	12 237	2 888	10 842		13 336	529	39 833	88 030	127 863
	(30.7)	(7.3)	(27.2)		(33.5)	(1.3)	(100.0)	(68.8)	
1977	11 967	2 728	10 654		13 063	549	38 960	92 747	131 707
	(30.7)	(7.0)	(27.3)		(33.5)	(1.4)	(100.0)	(70.4)	
1978	11 735	2 677	10 313		12 338	535	37 591	95 741	133 332
	(31.2)	(7.1)	(27.4)		(32.8)	(1.4)	(100.0)	(71.8)	

Source: Industrial statistics.

Notes: Plants which employ 30 persons or more.
Numbers in parentheses indicate percentages.

Table 37. Industrial water consumption in Japan by sector, 1977

Units: 1,000 m³/day

Type of industry	*Non-salt water*				*Purposes*	
	Total	*Make-up water*	*Recycled water*	*Return rate (percentage)*	*Product processing, washing water (percentage)*	*Cooling, air conditioning water (percentage)*
Chemical	43 563 (33.1)	9 172 (23.5)	34 391 (37.1)	78.9	5.4	90.7
Steel	34 017 (25.8)	4 171 (10.7)	29 846 (32.2)	87.7	9.9	88.0
Paper and pulp	15 890 (12.1)	9 948 (25.5)	5 942 (6.4)	37.4	80.7	12.7
Transport equipment	7 270 (5.5)	1 005 (2.6)	6 625 (6.8)	86.2	42.7	52.5
Oil and coal	6 006 (4.6)	949 (2.4)	5 057 (5.5)	84.2	2.2	92.7
Foods	5 157 (3.9)	3 800 (9.8)	1 357 (1.5)	26.3	30.1	53.4
Textile	4 413 (3.4)	3 566 (9.2)	847 (0.9)	19.2	29.5	59.0
Non-ferrous	5 062 (3.8)	1 342 (3.4)	3 720 (4.0)	73.5	21.4	74.3
Pottery and masonry	2 857 (2.2)	1 110 (2.9)	1 747 (1.9)	61.1	20.8	69.9
Others	7 472 (5.6)	3 897 (10.0)	3 575 (3.7)	47.9	15.8	69.6
Total	131 707(100.0)	38 960(100.0)	92 747(100.0)	70.4	20.3	73.7

Source: Industrial statistics.

Notes: Enterprises which employ 30 persons or more.
Numbers in parentheses indicate percentages.

Projects are now being diversified to include construction of flood control dams, development of lakes and ponds and adjustment of the river flow regime, in addition to construction of multipurpose dams. Further efforts are being made to tackle such problems as environmental improvement at dam sites, silt sedimentation in upstream areas and redevelopment of existing dam structures for new purposes.

Certain projects under the jurisdiction of the Ministry of Construction are summarized below.

(a) **Multipurpose dam construction**

Not only does the discharge in the main rivers of Japan reach an immense flow volume because of the nation's climatic and topographic features, but the rivers are also affected by large fluctuations in discharge between wet and dry seasons. Therefore, dams are constructed under a comprehensive development plan throughout the river system. According to the Specified Multipurpose Dams Act of 1957, the planning, construction and maintenance of such dams should be solely the responsibility of the Minister of Construction. However, the "right of dam use" has been created legally for those enterprises which deal with domestic water supply, industrial water and power generation, jointly share construction costs and correspondingly share the property rights.

In order to cope with the ever-increasing water demand on Japan's six main river systems, the Japanese Government has drawn up a basic plan for water resources development under the Water Resources Development Promotion Act and has assigned construction of certain dams and other facilities to the Water Resources Development Corporation. The Corporation has then taken charge of construction and maintenance of dams and water channels in line with principles and basic rules for project execution and management of facilities as set out by the governmental authorities concerned.

Under the provisions of the River Act of 1964, the Minister of Construction is authorized legally to be river administrator. He assigns part of his authorization to the governor of each prefecture; the Governor may then undertake construction of multipurpose dams or flood control dams through governmental subsidies.

(b) **Flood control dam construction**

A dam to be exclusively used for flood control may be constructed to maintain the regular river discharge and may be used solely for this purpose by the exclusion of any other specific joint users.

(c) **Development of lakes and ponds**

The purpose of such a development project is to create new potential water resources by enlarging the fluctuation between high and low levels of water in lakes and ponds. To meet the greater fluctuation, it becomes necessary to raise the embankment and remodel other structural facilities existing on the water surface, such as landing platforms for boats and fishery facilities.

(a) **Channel for adjustment of different river flow regimes**

The purpose of this type of project is to construct a water channel to connect two or more rivers, each of different flow regime, and to develop new potential water resources by adjusting the different phases of each flow regime between the rivers.

The total number of dams completed, those under construction as of 1980 and the economic effect from the completed dams are shown respectively in tables 38, 39 and 40.

Table 38. Dams in Japan, by category

Classification of dams	*Dam sites completed by 1979*		*Project sites in 1980*					
			Construction work		*Feasibility study*		*Total*	
	Projects	*Dams*	*Projects*	*Dams*	*Projects*	*Dams*	*Projects*	*Dams*
Ministerial jurisdiction	44	47	46	49	27	28	73	77
Constructed by corporation	13	13	13	13	2	2	15	15
Subsidized	148	148	113	113	83	84	196	197
Multipurpose	115	115	77	77	53	54	130	131
Flood control	33	33	36	36	30	30	66	66
Total	205	208	172	175	112	111	284	289

Note: "Dams" includes estuary weirs, lakes, retarding basins, adjusting river flow works and higher water utilization works.

Table 39. List of dams under construction in Japan in 1980

Classification	*Purpose*	*No. of projects*	*Effective storage (million m³)*	*Project cost (1,000 million yen)*		
				Joint share	*Public spending*	*Project cost in 1980 (joint shares)*
Ministrial jurisdiction	Specified multipurpose	73	3 423	3 221	1 510	193
Water resources corporation	. . . . . .	15	3 385	1 062	410	77
Government subsidized	Multipurpose . . .	130	1 562	1 648	1 145	107
	Flood control . . .	66	296	461	461	28
	Total	196	1 858	2 409	1 606	135
Grand total		284	8 666	6 393	3 525	406

Note: Public spending for dams under ministrial jurisdiction does not include feasibility study expenses.

Table 40. List of economic benefits from completed dams in Japan (by 1979)

Classification			*Ministerial jurisdiction*	*Public corporation*	*Government subsidized*	*Total*
Number of dams			47	13	148	208
Project cost (million yen)			(302 723) 466 989	(114 442) 240 621	(335 698) 486 752	(752 863) 1 194 362
Economic effect . .	Flood control	Flood inflow (1 000 m³/sec)	78	33	113	224
		Controlled discharge (1 000 m³/sec)	41	14	52	107
		Annual average disaster control (million yen)	14 860	1 483	20 347	36 690
	Power generation: Annual energy production (MWh)		7 403 987	1 533 604	4 558 689	13 496 280
	Domestic water supply (100 million m³/year)		7.4	19.8	16.3	43.5
	Industrial water supply (100 million m³/year)		5.6	12.9	13.4	31.9

Note: Figures in parentheses show public spending by Ministry of Construction.

2. Measures for reservoir area development

Unlike other public works, dam construction projects have a strong influence upon the inhabitants of the reservoir area and its environs. Therefore, it is essential that, parallel with the construction project, effective measures be taken for reducing the impact of dam construction on the population; this is generally called "measures for reservoir areas". The executing agency for the project is required to introduce improvements in the living environment for the inhabitants of the reservoir area, in addition to its obligation to compensate the people for loss or damage, under the 1973 Act on Special Measures for Reservoir Area Development. Forty-six dams designated under this Act are now under construction. The plan for reservoir area development with regard to those designated dams has been prepared by the National Land Agency after coordination with other ministries and agencies concerned. The specific projects included in the plan are entitled to receive governmental subsidies at preferential rates, if the project requires an extraordinarily large-scale reservoir. The same can apply to development projects for lakes or ponds on a large scale. At present, one lake development project is included in the scope of application under the Act.

To further complement the compensation or special measures for area development, a fund for reservoir area development has been set up in some areas by joint investment of the national government and the relevant prefectural authorities and local municipalities, and is being utilized for resettlement of the inhabitants in the reservoir area.

G. AGRICULTURAL WATER RESOURCES

Land improvement projects are executed in accordance with the provisions of the Land Improvement Act for improvement, development, preservation and collective control of farmland by bettering the water and land conditions.

The scope of such projects includes irrigation, drainage, farmland improvement, disaster prevention, road extension, arable site formation and reclamation by drainage. The programme has been in progress under the land improvement long-term plan, which is updated every 10 years. A total budgetary fund of 13 trillion yen will be invested for execution of this programme under the long-term plan of 1973 to 1982.

Land improvement projects may be undertaken by the national Government, prefectural authorities or local municipalities according to the scale of the project. An application may be submitted to either the governmental or prefectural authority concerned jointly by more than 15 persons who are actually engaged in farming of the land. The total project cost is principally borne by either national government or prefectural authority, but partially shared by those applicants as beneficiaries. In any event, the rate of grant-in-aid is legally stipulated according to the scale of the project. Financing for the beneficiaries' share of the total expenses is arranged through the assistance of the Government. With regard to the share of responsibility for maintenance of the facilities after completion of the project, either the national Government or the prefectural authority assumes responsibility for the facilities of high public interest, and the private beneficiaries take charge of all the other facilities.

As of 1979, land improvement projects were being executed in 363 areas under governmental management, in 6,416 areas under prefectural management and in 8,704 areas under municipal management. The total annual spending for execution of the programme reached 1,300 billion yen, ranking second to the road improvement programme in its share of the nation's total expenditure for public works.

Since then, the main objective of this undertaking has shifted from increased production of food to improved productivity of agriculture, as a result of which emphasis has been placed upon the farm rather than the paddy field. In particular, the improvement of the living environment in rural areas has been taken up as a part of the land improvement project in recent years.

H. HYDROPOWER GENERATION

With regard to the selection of exploitable sites for hydropower development, a small number of prospective sites remain for dam construction. However, there still remain some potential hydropower resources, as follows:

(a) Exploitation of sites on a medium or small scale;

(b) Inclusion of power generation as part of an integrated river development scheme (multipurpose dam);

(c) Abolition of existing power generating facilities with a low utilization factor of river discharge or re-development by improvement of flow regime;

(d) Exploitation of sites with low effective head.

With the improved living standard of people in recent years, the general trend is that the peak load has risen considerably, while the load factor is declining. Development projects for pumped-storage power generation will be further promoted to cope with such peak demand.

Because of its steep landscape and abundant rainfall, Japan has favourable site conditions for hydropower generation. For the past 100 years, concentrated efforts have been made for development of hydropower generating sources. By 1980, hydropower stations were in operation at 1,500 sites, with a maximum generating capacity of 27,000 MW. Stations with a total additional capacity of 10,000 MW are now under construction at 36 sites.

VII. NEPAL

(NR.7/CRP.10)

INTRODUCTION

The Himalayan kingdom of Nepal is traditionally an agricultural country, with nearly 90 per cent of the people engaged in agriculture. The present population is almost 13.6 million and is increasing annually by 2.02 per cent. Cultivable land is limited, amounting to nearly 2 million hectares in the Terai and inner mountain valleys.

Population increase and lack of alternative employment in the hills caused people to begin migrating to the Terai forests. Within a decade the forest area in the Terai had been reduced to 20 per cent and to 40 per cent in the hills. As a result, it has been observed that the number of landslides has increased, along with more severe soil erosion in the hills, causing flood problems in low-lying areas of the Terai in the south.

In the light of these multifaceted problems and their unfavourable impact on the ecosystems of Nepal, the Government of Nepal has adopted the following new measures to correct the defects: (a) control of population growth; (b) conservation of land, forests and minerals; (c) development and conservation of water resources; and (d) development of alternative jobs.

To achieve these objectives, heavy investments are being made annually for various projects, and the results so far appear to be favourable to the investment.

A. WATER RESOURCES

Next to the land, water is the most important natural resource of the country. Nepal appears to be fortunate in having an enormous amount of water outflow through the Himalayan rivers. More than 6,000 rivers and rivulets, with a total length of 45,000 km, discharge about 107 billion m^3 annually. The annual average run-off coefficient inside the country is about 78 per cent, which gives an average flow of about 5,360 m^3/sec. This flow has been found to be more than sufficient to meet the demands of agriculture, drinking water and industrial purposes. In addition, Nepal has a theoretical hydropower potential of 83 million kW, which comes to 5.6 MW **per capita** at present.

The continuously increasing cost of petroleum products, and the fear generated by the fact that the world's reserves are declining, have caused Nepal to tap its own inexhaustible and renewable hydropower resources to the maximum and to try to substitute hydropower for hydrocarbons as far as possible in transport, irrigation and other industries.

To accomplish these objectives and also to speed the development work, Nepal has reorganized and created new institutions such as the Water Resources Ministry and the Local Development Ministry. The Water and Power Commission has been strengthened by adding scientific sections to its system, such as hydrology, meteorology and ground water units. To select economically viable projects, investigations in hydrology, geology and meteorology have been strengthened in recent years. For hydrological studies, 60 gauging stations, 32 cable ways, 16 gauge houses and 16 sediment sampling centres are in operation.

For climatological records, the following stations have been established: 25 rainfall, 16 automatic rain gauge, 2 synoptic, 2 agronautical, 3 agrometeorological, 3 snow gauge and 5 climatological stations. Daily weather broadcasts have been introduced into the mass media in order to inform the people. To smooth out the fluctuating hydrograph of rivers, research work has been carried out to determine the ground-water potential on the northern edge of the Indo-Gangetic basin by drilling 200 deep tube-wells. Engineering, geological and economic studies are being carried out for 10 major and numerous small projects in the field of irrigation and power development.

It is felt that beseides the departments and ministries, it is essential and practicable to have autonomous boards and corporations for successful execution and operation of projects. The Irrigation, Hydrology and Meteorology, Electricity and Drinking Water, and Sewerage Departments are working on the generation of new projects; most of the boards are busy with the execution of the projects; finally, the corporations are providing maintenance for the completed projects.

B. IRRIGATION

Erratic monsoons have always caused Nepal to have alternate years of prosperity and famine. To reduce these natural vagaries, it has become necessary to provide year-round irrigation. Studies of the river systems of Nepal indicate that nearly 72 per cent of the rainfall immediately becomes surface run-off. The high to low flow ratio is 100:1 in snow-fed rivers; 1,000:1 in medium-type rivers; and 10,000:1 in the case of small rivers. Nepal has to design its irrigation projects on the basis of these river characteristics.

Only 10 per cent of 2 million hectares cultivable land has come under irrigation. To increase the number of hectares irrigated, besides the run-of-the-river scheme, lift pumps and tube-wells — are also being developed in areas where this is economically feasible. Because of the fluctuating nature of the river flow, the command area varies up to 10 times between the rainy season and the winter season. To balance the command area and to control the water table, ground water is being tapped. At present thousands of small and large tube-wells are being sunk in the high pressure artesian belt of the southern plain of the Terai.

C. POWER

Though Nepal has huge hydropower potential, achievements in power development have been modest. At present only a fraction of the total power has been tapped. The major projects which have been completed generate only about 35 MW of power, while new projects will generate an additional 130 MW or more.

A decade ago the consumption of power was even less than the supply of 14 MW. But in recent years, owing to the increase in oil prices and growth of industries in Nepal, the demand has risen rapidly. To meet the unexpected demand, diesel generation has been put into the circuit and implementation of new projects is moving to meet the internal demand. The present status is 37.2 MW hydropower consumption and 22.5 MW diesel generation. Nearly 702 km of transmission lines of 33 kV and above have been constructed. To make development balanced, in addition to major projects, mini- and micro-power generation programmes catering to one or a group of villages in remote areas have been taken up. Many small projects have been completed successfully by the Micro Hydel Project Development Board.

D. DRINKING WATER

It has been found that the best way to help the common people in the villages is to provide piped water. In Nepal, villages are scattered, houses are far apart, and supply of piped water is costly and time-consuming. Until now only 11 per cent of the people have come under the piped-water scheme; it is planned that nearly 30 per cent of the population will have potable water within the next five years. Chemical and biological laboratories have been established to analyse the potability of the water.

In the Terai plain of the south, water-borne disease are controlled to a large extent by providing potable water, and this has also benefited the country by reducing imports of costly medicines.

Drainage is an important aspect of water management, with a direct impact on sanitation. Most of the irrigation and drinking-water projects now include drainage as a major component. In urban areas, sewage is treated before being channelled out into the river system. Nepal at present has limited industries, and development has not reached a stage where there is a pollution problem. However, necessary measures have been taken to take care of the pollution before the industries are established.

C. SOIL EROSION AND FLOOD CONTROL

Landslides and soil erosion have become serious problems, especially in mountainous regions which occupy two thirds of the land surface in the north. As a result of heavy rainfall, averaging 1800 mm annually, coupled with deforestation, the landslides are frequent and soil erosion is common. This has created a serious silting problem in reservoirs, loss of fertility in the hills and floods in the Terai. To correct these problems, a Department of Soil Water Conservation has been established. Now an afforestation programme is being launched, which includes preservation of existing forests. Engineering measures have been introduced in areas where the landslide problem is serious. Integrated watershed management, torrent control and land-use development projects are being initiated. Such projects need strong regional co-operation from adjoining countries which are facing flood and silting problems from the River Ganges. Unless catchment basins are managed properly, all the countries in the region of the Ganges will face the double problem of flood water at one time and meagre low flow at another.

F. TECHNICAL MANPOWER

Being a developing country, Nepal is always short of technical manpower. To train local technicians, an Engineering College and scientific institutions have been established under Tribhuvan University. Students are also being sent abroad in large numbers in order to meet the great need.

G. REGIONAL CO-OPERATION

Nepal has always shown a keen interest in the field of regional co-operation. His Majesty the King of Nepal has stated his interest in the co-operation of Asian countries for optimal utilization of the region's water resources. Nepal hopes that other countries will join it in sharing their water resources.

VIII. NEW ZEALAND

INTRODUCTION

During the last three years, New Zealand has continued to develop its water resources in traditional ways, for use in agriculture, hydroelectric power generation, industrial and community water supplies and waste disposal. The Water and Soil Conservation Act of 1967 and the Soil Conservation and Rivers Control Act of 1941 still provide the legislative base for the management of New Zealand's water resources. However, a revision and consolidation of this legislation is being drafted. A National Development Act was enacted in 1979 to enable specified consents, including water rights, to be obtained quickly for developments considered to be in the national interest.

A. LEGISLATION

Much effort has been expended in drafting the revision and consolidation of the legislation related to water and soil conservation activities during the past three years. To date this legislation has not yet been accepted in the Government's legislative programme, but it is expected to be introduced during 1981.

The main changes and purposes envisaged in the draft legislation are:

(a) The bringing together into one piece of legislation of the complementary nature of land and water use;

(b) A closer relationship between water legislation and land planning legislation;

(c) A simplified national organization;

(d) Statutory recognition of water management planning, including water allocation and water quality classification.

In 1979 the National Development Act was enacted. The objective of the Act is to provide for the prompt consideration of proposed works of national importance by the direct referral of the proposals to the Planning Tribunal, a judicial body, for an inquiry, report and recommendation to Government and by providing for such works to receive the necessary consents.

The body which would normally grant the consent for a water right, the local regional water board or the National Water and Soil Conservation Authority, gives a recommendation to the Planning Tribunal which, on inquiry and after hearing evidence, makes a report and recommendation on the consents to be granted.

It is too early to gauge what impact the Act will have on water resource management as only one application has been submitted so far. This application is for a 1,200-ton-per-day methanol plant.

B. WATER RESOURCES DEVELOPMENT

1. Irrigation and rural water supply

Between July 1977 and July 1980, five new irrigation schemes covering an area of 21,050 hectares were begun, bringing the total under construction as at July 1980 to 15 and covering an area of 65,500 hectares. During the same period 23 new rural water supply schemes covering an area of 260,400 hectares were started, bringing the total under construction as at July 1980 to 45 and covering an area of 541,300 hectares. While most of these schemes are for pastoral farming, one major irrigation scheme started in the period was for trickle irrigation for citrus and other subtropical fruit.

2. Hydroelectric power generation

The hydroelectric power generation capacity has increased from 3,362 MW in 1977 to 3,786 MW, as at August 1980. The proposed development plan for energy aims at an expected increase in capacity of 1,184 MW in the next decade.

During the period, encouragement was given to local-authority hydroelectric power development for schemes of less than 50 MW capacity. As of August 1980, ten schemes totalling 119 MW capacity were under construction.

3. Other energy requirements and development policies

In addition to the increase in hydroelectric power generation, a further 1,350 MW of thermal power generation capacity is planned for the next decade. The Government has also decided that natural gas should be converted into liquid fuels and that the country's aluminium smelting capacity should be increased. These developments will require careful examination of their effects on water quality.

4. Public water supplies

The five-yearly grading of public water supplies was carried out in 1980. This shows that 87 per cent of the total population is served by public water supplies. Ninety-four per cent of this population have completely satisfactory supplies.

Approximately 161,000 people, living in 384 communities of more than 200 people and representing 5 per cent of the population, are still without public water supplies. Approximately half this number, in 244 communities, are unlikely to receive a public water supply because of the scattered nature of the communities.

C. WATER MANAGEMENT PLANNING

Financial assistance of approximately $NZ 2 million over the three year period 1977-1980 has been provided to regional water boards for the production of water allocation plans. These are prepared in four stages: (a) existing water resources; (b) present demands; (c) future likely demands; and (d) allocation of the resource.

Nearly 100 projects have been assisted and about 20 have been completed. It has been found that while the information provides a sound framework for the allocation of the quantity of water and the issue of water rights, there is a need for a wider-based water management document which reflects and balances the policies and objectives both of the National Water and Soil Conservation Organization and allied agencies involved in the wise use of natural resources. This is likely to find expression in a water management statement which is proposed in the new draft legislation. It was noted in the country's statement to the fourth session of the Committee that it was proving difficult to find a satisfactory means of linking planning for the protection of water use with adequate provision for water of high quality where there was little public use.

As part of the draft legislation, it is planned to link water classification to the water management statement which will be mandatory. Water classification is to be optional, may be limited to a certain area and will define the principal use of the water so classified. Certain water quality standards will be set down for each class, but it is expected that some flexibility will be allowed for further classes with appropriate standards, to be suggested during the classification procedure.

D. TECHNICAL SUPPORT

Activities to assist in the efficient use and control of water resources have included:

(a) Development of telemetric flow measurements for flood forecasting and routine data collection;

(b) A regional flood frequency procedure;

(c) Long-range forecasts of average annual rainfall;

(d) Nationwide coverage of synoptic maps of frequency distribution of high intensity rainfalls;

(e) Prediction of the effects of rainfall deficits on agricultural production;

(f) Quality assurance programmes for water quality and hydrological measurements and development of assessed physical, chemical and analytical methods for testing natural waters.

Studies have also been undertaken to reflect the relationships between land use and quantity and quality of water run-off. A national coverage with maps and computer stored data of land resources covering such features as rock type, soil type, vegetation cover, slope and erosion has been completed.

E. INTERNATIONAL CO-OPERATION

Assistance has been given to a number of countries in the South Pacific region for the financing, design and construction of water supply and sanitation schemes. In addition, training has been given for water supply and sewage treatment operations where operator training facilities have been established. Training has also been provided within New Zealand for personnel from other countries.

Assistance has also been given to countries in the south-east Asian part of the region for a river basin study, pilot ground-water irrigation scheme, pre-feasibility studies for improving town water supplies, and provision of adviser and funds for extension work for village water resource development as well as planning for village water resource development. In the area of exchange of technical information, New Zealand has provided lectures for seminars organized by WHO in China and the western Pacific basin and background papers for the ESCAP Working Group Meeting on Water Data Systems. The country is also a participant in the Global Environmental Monitoring System air and water programmes.

Under the auspices of the Environment Committee of the Organisation for Economic Co-operation and Development, a group of experts from a number of countries is at present examining New Zealand's environmental management. This study is expected to be completed by December 1980.

IX. PHILIPPINES

A. WATER RESOURCES SECTOR REVIEW

Development of water resources in the Philippines during 1978 and 1979 emphasized the expansion of water supply and irrigation services and the maximization of the yield of natural supply systems. The programme concentrated on the construction of new facilities and the rehabilitation of existing ones. Major watershed programmes were completed close to scheduled plans.

The sector recorded positive though modest accomplishments despite the critical problems brought about by the fuel crisis. Delays in the implementation of projects were caused by over-all budgetary restraint, coupled with technical difficulties.

In 1978, out of the total investment programme of ₱2,584 million ($US 350 million), of which $US 155 million was in foreign exchange, actual disbursements only amounted to ₱1,468 million, which was only 57 per cent of the programmed outlay. Disbursements in 1979 amounted to ₱2,268 million, 65 per cent of the programmed outlay of ₱3,490 million. Water resources investments accounted for 21 per cent of government expenditure on infrastructure for the two-year period.

1. Policies and institutional reforms

Basic policies for the water supply sector were promulgated on 30 March 1978 in order to achieve the sectoral objective of providing an efficient and adequate supply of water. These policies called for the rationalization of the organizational structure of the sector, the formation of water districts, associations or co-operatives to operate and manager water systems and the encouragement of projects which emphasize self-help and self-reliance.

The Metropolitan Waterworks and Sewerage System (MWSS) took over the centralized water supply system in residential sub-divisions under its territorial jurisdiction. Likewise, the Local Water Utilities Administration (LWUA) reviewed its present rates and fees structure. The charter of LWUA was amended to provide direct government support to non-viable districts.

The National Water Resources Council (NWRC), in its role as co-ordinator of policies and programmes affecting water resources development, created a task force on rural water supply with the objective of evolving a rural water supply programme. This culminated in the creation of the Rural Waterworks Development Corporation (RWDC) through Executive Order 577, passed on 12 January 1980. This completed the rationalization of the water supply sector by covering cities and municipalities with less than 20,000 population, since LWUA is responsible for cities with population of over 20,000 and NWSS for Metro Manila and its contiguous areas. The same directive assigned NWRC the responsibility for formulation of framework plans and policies for water supply, and the Ministry of Public Works (MPW) as the agency responsible for development of integrated water supply plans and programmes consistent with the policies and plans of NWRC; the MPW serves as the principal implementing arm of RWDC for engineering and construction.

(a) **Flood control**

A Small Water Impounding Management Committee was organized at the same time, to facilitate effective and co-ordinated implementation of the programme for small multipurpose catchment basins and impounding reservoirs under the national infrastructure programme. Apart from arresting floods, these projects can also be used for irrigation and hydropower generation.

(b) **Irrigation**

A national policy for irrigation was adopted, directing that the Government should bear the cost of irrigation projects which require lower development costs and have shorter gestation periods. Furthermore, the integration of the field offices of the National Irrigation Administration (NIA) has brought all NIA activities under the supervision and control of the office of the Regional Director for an effective and efficient administration.

The Farm Systems Development Corporation (FSDC) embarked on a new programme for mobilizing and developing indigenous farmer-leaders to enlist more active participation from the Irrigation Service Association (ISA) farmer-members. The ISAs have proved to be viable, sound and economic units for farmer involvement in the operation and management of the system. The FSDC programme also provides for the production of other crops, rice-fish culture and livestock production to augment farmers' incomes.

2. Programme implementation

(a) **Irrigation**

The irrigation programme has been vigorously implemented and has stressed support for the food production programme of the Government; the alleviation of water shortage; conservation; and flood control through reforestation.

The total disbursement for irrigation in 1979 was ₱1,929 million (about 99 per cent of the programmed investment), which was an improvement of 50 per cent over the 1978 performance.

In terms of physical accomplishments, the total new area generated for irrigation was 46,408 ha in 1979. This was 55 per cent of the plan target, higher than the 48 per cent achieved in 1978. The NIA undertook rehabilitation works on existing systems covering an aggregate area of 56,227 ha, which exceeds the plan target by 2.2 per cent, in addition to the direct construction of irrigation facilities. As of the end of 1979, FSDC had installed 437 pump irrigation projects covering 48.341 ha; these had increased to 588 projects covering 60,298 ha by the end of 1979.

As of the end of 1978, FSDC had organized a total of 50, 608 farmers into 956 ISAs covering 137,161 ha. By the end of 1979, there were 1,449 ISAs covering 194,589 ha, with a membership of 73,826.

A shift towards communal irrigation was evident from the noticeable increases in new areas generated by communal irrigation projects, from 7,688 ha in 1978 to 23,530 ha in 1979.

(b) **Water supply and sewerage**

The thrust of the water supply and sewerage programme was the provision of an adequate safe and low-cost water supply complemented by proper sewerage disposal. Activities undertaken during the period were the long-range improvement of the urban water system in the Metro Manila area, the formation of water districts in selected provincial urban centres and construction/improvement of their water supply systems, and the provision of a potable water supply in the rural areas.

The programmed investment in 1978 was ₱434 million, of which $US 24 million was the foreign exchange requirement. Actual disbursements reached ₱284.4 million, or 66 per cent of the investment programme for the sector. A similar percentage was disbursed the following year, representing ₱324 million out of the targeted outlay of ₱746 million.

Construction and rehabilitation of infrastructure facilities which support the objective of narrowing the supply deficiencies in urban centres and rural areas were accelerated.

(c) **Flood control and drainage**

Flood control projects were implemented extensively to minimize the impact of floods during the rainy season. The programme was directed towards the construction of protective structures and other effective means, such as catchment basins and impounding reservoirs, not only for a first defence against floods but also for more productive purposes.

About 85 per cent of the programmed outlay for flood control and drainage was disbursed during the period, thus allowing for the completion of major drainage outfalls, mains and laterals in Metro Manila, and speeding up other projects in the flood-prone areas in the countryside, notably the Agno, Pampanga, Bicol and Cotabato rivers. These extensive flood control projects have relieved a number of low-lying areas from flooding. The investments amounted to ₱318 million in 1979, out of the programmed outlay of ₱372 million.

B. GROUND-WATER MANAGEMENT IN THE PHILIPPINES*

Background

Although it was specified in the 1935 Constitution of the Philippines that all waters belong to the State, the system of control of the exploitation of ground water still hinged on the old Spanish legal concept that ground water is private property. In other words, it worked on the presumption that a lond owner owns the ground water under his land and can drill a well within his property without legal limitations.

This system apparently had not considered the principle of hydraulic continuity of ground water, which implies that hydrogeologic stresses on one site may affect areas far beyond the bounds of one's land holding.

The present generation must have been aware of this, as evidenced by the fact that the principle that all waters belong to the State was reiterated in the 1973 Constitution. To emphasize this constitutional provision, the Philippines Water Code has defined more clearly the intents of the above-mentioned basic law.

The Code states that water, particularly ground water, can only be used through administrative concession. A person has thee right to use ground water only after obtaining a water permit from the National Water Resources Council. The granting of water permits shall be based on well-accepted principles of hydrogeology, within the limits of the availability of data. Therefore, different sets of technical tools should be organized/harmonized to suit each foreseen case.

For areas where ground-water exploitation is not so heavy and complicated, and available data are limited, control can be achieved by prescribing well spacing. In this method, distances between wells are divided into four discharge categories. For wells discharging 2 to 10 litres per second, the minimum distance between wells is 200 metres; from 10 to 20 l/sec, 400 metres; from 20 to 40 l/sec, 600 metres; and more than 40 l/sec, 1000 metres. It may be worth noting that this rule excludes domestic water supply wells designed for single-family use, which are less than 30 metres deep. These spacing prescriptions may be adjusted on the basis of the nature of land use, geologic and hydrologic data.

In areas where there are too many wells, spacing control is no longer realistic. Although the spacing criteria may still allow the construction of more wells, the regional availability of ground water may not allow it.

Thus, other criteria must be derived in order to have a well-balanced granting of permits. One of these is the control of withdrawal density, which may be derived from either the "safe yield" or the "allowed mining withdrawal" criteria for an area. It may be worth noting that ground-water mining in the Philippines may be allowed, provided that the life of the ground-water reservoir system is maintained for at least 50 years. The preceding may be augmented by the well optimal discharge theory; the control of interference by not more than 2 metres of additional drawdown; and the limitation of pump sizes.

1. Division of the country into comprehensible units

On the basis of certain hydrologic features, the country has been divided into 12 water resources regions. Each of these regions is divided into ground-water areas, which in turn may be sub-divided into smaller areas so that more detailed analysis may be undertaken. This has already been done in heavily-exploited areas such as Metro Manila and central Luzon. The ground-water areas generally have the same boundaries as the river basins. However, in some cases these boundaries may be altered if ground-water data and the geologic nature of the site require it. For example, in limestone formations, ground-water divides are normally not the same as those of surface water.

The following criteria are expected to be applied in each of the said areas.

(a) Safe yield and mining concepts

Safe yield is understood as the net inflow of fresh water to the underground reservoir system. Therefore, if the withdrawal in an area is maintained at the safe

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yield level, the expected problems arising from ground-water exploitation, such as salt water intrusion and land subsidence, may not occur. Safe yield may be defined in many ways, depending upon data availability. In the absence of good ground-water data, this parameter may be assumed as a percentage of annual rainfall.

As population increases and continues to concentrate in population centres, it is extremely difficult to peg withdrawal at a safe yield level. It does not seem practical to reserve ground water for future generations, when the present one needs it badly.

Along this line of reasoning, ground-water withdrawal beyond the safe yield limit or ground-water "mining" may be allowed for a certain period, until an alternative surface water development is completed.

The 50-year ground-water "mining" limit provided in the implementing rules and regulations of the Philippine Water Code is a step in this direction.

(b) **Allowed mining withdrawal**

Of paramount importance is the necessity to express the total amount of mining withdrawal with respect to the estimated period of exhaustion.

If we assume that:

Q_w = total mining withdrawal
V = total volume of ground-water storage
S_y = safe yield, and
t = estimated period of exhaustion in years,

then the following equations hold:

$$Q_w \cdot t = V + S_y \cdot t \quad \ldots\ldots\ldots\ldots \quad (1\text{-a})$$

$$Q_w = \frac{V}{t} + S_y \quad \ldots\ldots\ldots\ldots \quad (1\text{-b})$$

This relationship is illustrated graphically in figure 20.

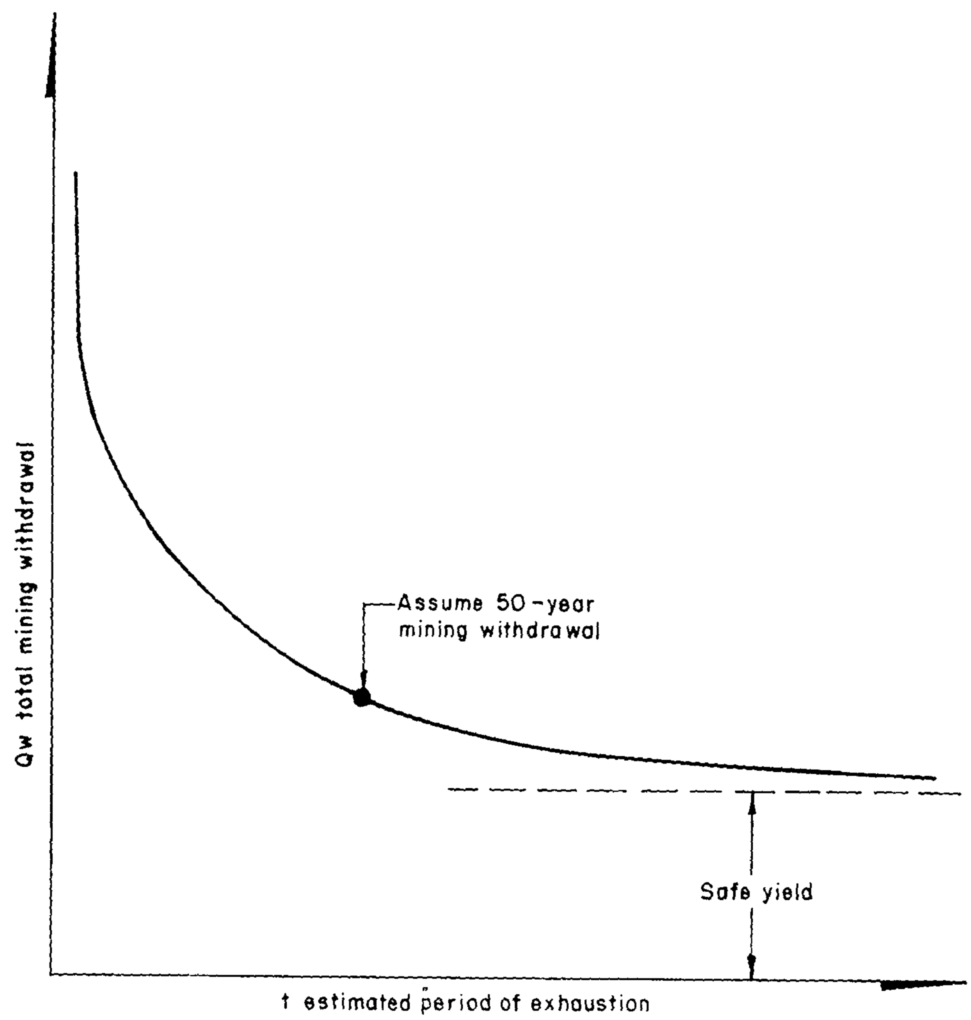


Figure 20. Relationship between safe yield, mining withdrawal and period of exhaustion

2. Ground-water control by withdrawal discharge density

Along with well spacing and/or interference requirement, the exploitation of ground water may also be controlled by well discharge density. For example in Metro Manila, a limit of 11 litres per second per km^2 may be observed.

It should be noted that the withdrawal discharge density (1/sec/km^2) may be derived from safe yield or allowed mining withdrawal. It might also be tied in with the mentioned optimal withdrawal.

Using the safe yield limit,

$$\text{the Withdrawal Discharge Density} = \frac{\text{total safe yield}}{\text{area}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Use the allowed "mining" withdrawal limit,

$$\text{the Withdrawal Discharge Density} = \frac{\text{total allowed mining withdrawal}}{\text{area}} \quad \ldots\ldots \quad (2a)$$

If the optimal withdrawal is included in the criteria, the optimal total number of wells may be predicted.

Using the safe yield limit,

$$\text{the optimal number of wells} = \frac{\text{total safe yield}}{\text{optimal withdrawal per well}} \quad \ldots\ldots\ldots \quad (3)$$

Using the allowed "mining" withdrawal limit,

$$\text{the optimal number of wells} = \frac{\text{total allowed mining withdrawal}}{\text{optimal withdrawal per well}} \quad \ldots \quad (4)$$

3. Ground-water evaluation model

From the foregoing concepts, ground-water management is technically achieved through the following:

(a) Control by well discharge density or number of wells, which might be based on safe yield, allowed ground-water mining withdrawal or optimal withdrawal concepts;

(b) Limitation of interference;

(c) Specification of pump size and horsepower.

The limitations of interference concept shall make use of the Theis non-equilibrium formula, which can be described as follows:

$$\text{Interference} = f(Q, r, T, S) \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

where Q = withdrawal amount;

r = distance from the point of withdrawal to the point where interference is defined;

T = transmissivity coefficient; and

S = storage coefficient.

Specification of pump size and horsepower requires estimates of the total dynamic head (TDH).

In this connexion,

$$TDH = H_0 + H_I + TD \quad \ldots\ldots\ldots\ldots\ldots \quad (6)$$

where H_0 = distance of static water level from the ground surface;

H_I = initial head needed to distribute the water; and

TD = total expected drawdown.

On the other hand, TD may be computed using the following relationship:

$$TD = S_I(Q_I, T_I, S_I, r_I) + s_i(Q_i, T_i, S_i, r_i) \quad \ldots \quad (7)$$

where S_I = drawdown caused by its own withdrawal, Q_I;

s_i = drawdown in a well caused by a nearby interfering well with discharge, Qi;

T = transmissibility coefficient;

S = storage coefficient;

C = well loss constant;

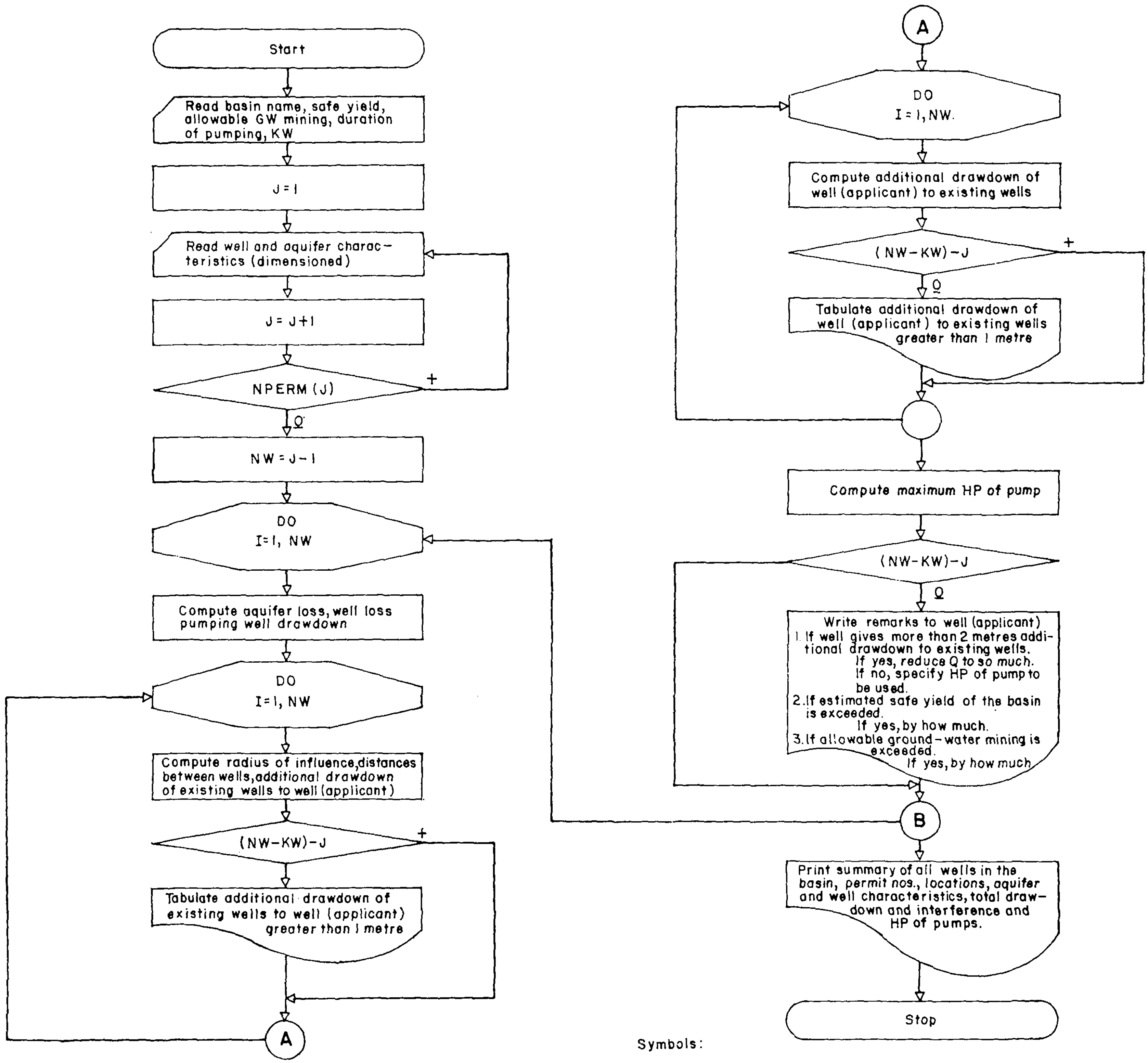
r_I = distance from a well to an interference well;

r_i = any finite but small distance from the centre of a discharging well.

The mathematical equations and the relevant provisions of the implementing rules and regulations of the Philippine Water Code, and the estimates of safe yield and allowed mining withdrawal have been programmed into a high-speed digital computer system. They constitute the ground-water evaluation model. The flow chart of the model is presented in figure 21.

4. Conclusions and recommendations

Two sets of systems to control ground-water exploitation in the Philippines may be implemented, depending upon the critical or non-critical status of the ground-water areas.



Symbols:

NW...... Number of wells pumping or observation wells/points.

NPERM.. Permit/reg./application No.

KW...... Number of wells desired to be printed. Their effects on other wells and vice versa. KW are last wells in the input deck and are usually No. of applicants.

Figure 21. Flowchart: ground-water evaluation model for the Philippines

Non-critical areas can be controlled manually by using the criteria of spacing, of interference and of withdrawal discharge density (say 11 litres per second per square kilometre). The said discharge density shall be set at the safe yield limit.

However, in critical areas where there are many wells and total withdrawal exceeds the safe yield limit, processing of applications for permits shall be facilitated by the use of a high-speed digital computer, along with the ground-water evaluation model. This method allows the inclusion of almost all the control criteria, such as (a) well discharge density; (b) limitation of interference; and (c) limitation of pump sizes.

Control by withdrawal discharge density prevents the construction of too many wells in a small area. The interference limit avoids the sudden and considerable effect of one well in relation to existing wells, but mutual interference may nevertheless gradually occur.

Along with the mentioned criteria, close supervision for good well design and construction must be carried out. To achieve this end, it is necessary to initiate a two-permit system for ground water, which would include a permit to drill and a permit to abstract and use.

In this case, a ground-water user would initially apply for a water permit. Applications would be subject to some initial evaluations considering the area's safe yield and/or allowed mining withdrawal. Ultimately, a permit to drill would be issued by the National Water Resources Council or its authorized deputies.

The necessary data and proposed plans and specifications of the well would then be submitted to the Council, which would store the information in its data bank and evaluate it.

The final amount of water withdrawal allowable on a particular well would be based upon data from a test well, and would be stipulated in the permit to abstract and use ground water.

X. SAMOA

INTRODUCTION

Western Samoa has a total area of 2,820 km^2 and consists of two large islands, Savaii (1,700 km^2) and Upolu (1,115 km^2); two small inhabited islands, Manono and Apolima; and a number of uninhabited islands. The total population (1976 census) is 151,982, of which 109,764 live on Upolu and 42,218 on Savaii.

Apia, the capital, is located on the northern side of Upolu Island, with a population (1976 census) of 36,500. Much of the town is low-lying, and untreated drinking water and unsanitary conditions created by the release of sewage into the environment present a health hazard.

The hydrology of Samoa is affected by three factors: geology, rainfall and topography. Reliable surface streams are only found on the eastern side of each island, where low permeable weathered volcanic rocks predominate, except for Savaii, where the volcanic rocks are new and so highly permeable that there are no run-off streams.

The water requirements are 200 litres per head per day for human needs, and 20 to 40 litres per head per day for cattle. Irrigation of tree crops is not necessary.

The total energy consumption in 1979 was:

Source	$MJ \times 10^6$	%
Petroleum	1,024	42
Electricity — diesel	285	12
hydropower	22	1
Firewood	1,108	45
Total	2,440	100

A. DEVELOPMENT OF WATER RESOURCES

1. Water supplies

The service to the public remains poor. Water is untreated and insufficient at various places. While 95 per cent of the population have at some time had access to a piped water system, it is estimated that only 85 per cent of the population now receive piped water, only 70 per cent of these receive it regularly throughout the year. Three factors contribute to this condition: breakdown of the piped system, with leaks and blockages resulting from poor construction, public abuse and poor maintenance; excessive wastage; dry season low flows in surface supplies.

Approximately 25 per cent of the population receiving water are served by pumped supplies, principally from boreholes and some coastal springs (mainly in Savaii); the remaining 75 per cent obtain their water from surface supplies. There is a general lack of storage in the older system; therefore, no water is supplied through pipelines during pump maintenance and repairs.

Borehole water supplies give superior water which does not require treatment. However, there is the problem of high salinity, especially at boreholes located on the western side of Savaii. Here salinity is approximately 1,000 ppm (WHO standards recommend 200 to 600 ppm).

Surface water supplies, especially in the urban areas of Apia, are often contaminated as a result of land clearing in the water catchments. Just recently a slow sand filter treatment plant of 2 million litres capacity a day was brought into operation to serve a sector of urban Apia. A proposed new scheme for Apia allows for rapid filtration and chlorination. The total cost is $US 12 million. A new water scheme for Apia is urgent, although some improvements have already been made. However, with the quality of water supplied well below WHO international standards, health risks will continue to increase.

Even though there have been significant improvements over the last two years, rural water supply service is still considered poor. Most of these supplies were operated and maintained by districts, but because of lack of proper maintenance, material and staff, standards were low. Nearly all of these systems have now been transferred to the Government.

2. Funding and overseas aid

New Zealand has given support to Apia water and sewage projects since 1976. The assistance amounts to approximately $US 250,000 every year, mainly for material, equipment and the provision of engineers and other staff. A New Zealand consultant has recently completed a feasibility study for the proposed Apia Water and Sewage Schemes. Future assistance after 1980 is uncertain. Australia has provided nearly $US 250,000 every year for rural water supply. This support will continue as on-going projects. The Netherlands has approved a loan of $US 800,000 this year for rural water supply. UNICEF has provided material for the programme of water-seal latrines, and UNDP and WHO have both provided technical and consultancy assistance. The South Pacific Commission has provided funds for certain small rural water projects.

3. Sanitation

In Apia there is still no sewage system, and most people use septic tanks and pit toilets. A large portion of the central town is low-lying, with a high water level. The two commonly used types of toilets create serious health risks through the release of organisms into the surface water.

A sewage system costing approximately $US 12 million has now been designed for the central town, although funds are not available as yet. The system will collect effluent from septic tanks and transport it to a central pump station where it will be pumped to an ocean outfall. Sludge from septic tanks will be disposed of in soaking trenches.

In rural areas the vast majority use pit latrines; however, a water seal has been incorporated into the construction of many of these in recent years, as a result of a programme which started in 1970 but only accelerated in 1976, when WHO provided technical assistance and most of the imported construction materials, such as cement and reinforcing steel. Targets of 2,000 to 3,000 sealed units per year were set from 1975 on. However, construction was slow, and the targets were not achieved. Nevertheless, the rural population response to this programme was tremendous, and a significant improvement in sanitation has been noted. The slow progress was a result of lack of materials and construction staff; the problem of digging through rock; and a general water shortage in certain areas, so that proper operation of these units was not possible.

4. Hydrogeneration

The estimated total energy used in Samoa in 1979 was 2,440 million mega-joules. Approximately 93 per cent of the total electricity is currently generated by diesel and 7 per cent by hydropower. A forecast of the future electricity demand has indicated a general increase of approximately 12 per cent every year.

It is evident from the figures above that certain measures should be adopted to reduce dependence on diesel for generation by increasing the use of hydroelectric and wood-fuelled power plants; to reduce distribution line losses; to formulate an economic price for power in commercial, industrial and domestic areas; to educate the public in the conservation of power; to formulate policies or regulations to promote the saving of power.

B. INTERNATIONAL DRINKING WATER AND SANITATION DECADE

The introductory meeting for the Decade was held on 30 January 1980. The Public Works and Health Departments were represented at the ministerial level. Other departments participating included those of Economics, the Attorney General, the Observatory, Agriculture, Forestry and the Pulenu'u (mayor) Committee. Out of the meeting a Working Committee was formed, comprised of the Chief Water Engineer; Chief of Public Health; Country Liaison Officer (WHO); local UNDP Representative; and representatives from the Departments of Economics, Agriculture and the Observatory.

The functions of the Working Committee were set down as follows:

(a) To review activities undertaken in the departments represented;

(b) To initiate programmes related to either water or sanitation;

(c) To formulate objectives, policy, programme, proposals;

(d) To receive and study requests and proposals from all sources;

(e) To refer recommendations to the appropriate Directors and Ministers for approval.

Activities proposed or already underway included:

(a) Finalizing the proposed Action Plan for the Decade;

(b) Monitoring all water resources for quantity and quality, which involves the Health, Public Works and Observatory Departments;

(c) Making a Samoan film for public education and promotion purposes;

(d) Arranging for a regional seminar on water and sanitation early next year in Apia, for which the local UNDP has already offered assistance funds;

(e) Launching of the Decade by incorporation into this year's Conservation Week, for which the theme is the conservation of water;

(f) Directing a request to the United Nations for funds for training health inspectors;

(g) Identifying national needs and ways in which the International Decade programme can assist.

National needs have been identified as follows:

(a) Staffing for project preparation and public education;

(b) Manpower recruitment and training;

(c) Assessment and long-term monitoring of water resources;

(d) Surveying existing water supply and sanitation services to identify real needs;

(e) Formulation of a national water policy and national sanitation policy;

(f) Revision of the Water Act and formulation of a Sewage Act;

(g) Expert advice on integration of ground water and surface water supplies;

(h) Control and licensing of water use;

(i) Protection of watch catchments;

(j) Public education in water use to prevent abuse and wastage;

(k) Improvement in standards of construction and maintenance;

(l) New tariff structure to tie consumer rating to operation and maintenance costs;

(m) Finance ($US 20 million) for Apia water and sewage schemes;

(n) Finance and rural water and sanitation;

(o) Finance to construct proper operation and maintenance facilities and material storage provisions.

The international agencies can assist Samoa in its efforts. UNDP can assume a central role in the promotion and co-ordination of United Nations system inputs. It may provide consultancy and technical assistance for such activities as project preparation, assessment of water resources and existing services and staff training. Various United Nations agencies may promote technical co-operation among developing countries in the transfer of technology and experience. Finally, assistance is needed to co-ordinate and finance international and regional co-operation in manpower training.

XI. SRI LANKA

(NR.7/CRP.6)

INTRODUCTION

Sri Lanka is an island republic of about 64,000 square km with a population of about 14.5 million. The country can be justly proud of its hydraulic civilization, which has flourished for a span of about 20 centuries. Traditionally, all rain water was trapped by an elaborate network of reservoir systems interconnected in a highly sophisticated delivery matrix.

The availability of remarkable engineering skills is clearly recognizable in the construction of irrigation reservoirs and channels which by reason of their gradient evoke the admiration of modern engineers with access to advanced instruments. Scientific management of the land and its systematic mapping can also be discerned from the intricate practices adopted to preserve the central mountain region of the country, with its luxuriant tropical forest cover, and the utilization of the lowland plains for arable and pastoral purposes. Over-all, the conservation of the land and water resources and their systematic development and utilization appear to be central to the approach adopted over the centuries. For a variety of reasons this civilization collapsed long ago, and it has only been during the past 35 years that deliberate and purposeful attempts have been made by successive governments to renovate the ancient irrigation schemes and inaugurate new projects to sustain the predominantly agrarian population of Sri Lanka.

Water use in Sri Lanka can be broadly classified into four categories: domestic water used by the general population; irrigation water used essentially for crops and animal husbandry; water used for industrial purposes; and water needed for power generation. The subject of water is consequently handled by separate ministeries mainly for administrative convenience. However, the conceptual approach regarding the over-all use of water nationally is that it is a single resource which has to be utilized within a general and integrated planning framework.

A. ACTIVITIES IN THE APPRAISAL, DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

The most significant aspect of recent water resources development activities in Sri Lanka has been the decision taken by the Government in July 1977 to accelerate the implementation of the largest and most ambitious water resources development programme ever to be undertaken in this country: the master plan for the development of the water and related land resources of the Mahaweli Ganga river basin, as well as of several other adjacent river basins.

The master plan, which was finalized in 1968 with technical assistance provided by UNDP and FAO, consisted of the establishment of a system of 15 multi-purpose dams and associated trans-basin diversion canals for the provision of improved irrigation facilities for double-cropping over an area of 100,000 ha of lands, and for the development of as much as 264,700 ha of hitherto undeveloped lands, located in the northern and eastern parts of the country's dry zone. The plan of development covered the equivalent of about 40 per cent of the total land area of the island, while the total installed capacity of the many hydropower plants included at the major regulation and diversion structures amounted to 960 MW. The implementation of the master plan of development was originally phased over a period of 30 years, commencing in 1970, with the various major reservoir/diversion canal components timed for completion in accordance with the country's projected demands for food and energy over this period. The large-scale opening up of hitherto undeveloped lands would in turn provide an opportunity to overcome the country's massive unemployment problem through the resettlement of poor families currently living in the densely populated wet lone areas and owning little or no land; these would be resettled on individual farming and housing allotments in the Mahaweli Project Area.

The implementation of the first of three phases of development had been scheduled for completion by the end of 1980, but only the first project of the first phase had been completed by 1976. However, in addition to the commissioning of a 40 MW hydropower plant, the construction of the Polgolla Diversion Complex for diversion of Mahaweli Ganga water to the North Central Province led to the realization of significant benefits in the form of additional water for double-cropping of as much as 52,600 ha of previously single-cropped lands, as well as for the opening up of over 28,300 ha of hitherto undeveloped lands.

The Mahaweli Development Programme in 1977 was designated as the lead project among the priority projects in the vanguard of the national development effort, since it would not only provide much-needed cheap power and save on expensive oil imports, but also would provide the assured water supplies essential for achieving higher agricultural output on an appropriate scale. The Government decided to accelerate the originally suggested pace of development of the Mahaweli master plan so as to complete a major part of its implementation in the shortest possible time.

After a careful review of the status of project preparation and designs, availability and requirement of capital and manpower resources and local construction capacities, and taking advantage of offers of substantial financial and technical assistance extended by the Governments of the United Kingdom, Canada, Sweden, the Federal Republic of Germany, Japan and the United States of America as well as by the World Bank, it was decided to proceed with the construction of five major reservoirs and power plants together with the associated canal systems more or less simultaneously, over a period of 5 to 6 years, commencing in 1978. This accelerated development phase would allow the development and settlement of as many as 129,500 ha of hitherto undeveloped lands, while the installed hydropower generating capacity that would become available in substantial blocks from about the year 1983 (amounting to a revised and updated total of 610 MW) would be adequate to keep pace with the recent sharp increase in national power and energy demands, which has been relying largely on hydropower alone.

The existing institutional framework was appropriately expanded and strengthened in order to equip it to undertake this enormous task. First, a separate

Ministry of Mahaweli Development was established, followed by the setting up of a Mahaweli Development Authority on the lines of the Tennessee Valley Authority in the United States. This authority not only oversees the implementation of the accelerated programme of development and co-ordinates the activities of the Mahaweli Development Board, Central Engineering Consultancy Bureau, River Valleys Development Board, State Development and Construction Corporation, the Department of Irrigation and a considerable number of foreign consulting engineering firms, but is also responsibe for ensuring the proper and effective coverage of other related matters, such as the maintenance and preservation of the environment and of valuable natural resources.

Along with the work on the accelerated Mahaweli Development Programme, water resources activities undertaken in Sri Lanka since 1977 also include progress made on several other major development projects located outside the Mahaweli project area, as well as considerable new development activities in the field of public water supply to urban and rural communities.

B. FOLLOW-UP TO THE MAR DEL PLATA ACTION PLAN

The progress made in the field of water resources planning and development in Sri Lanka since about 1965, when detailed studies for drawing up a master plan for the development of the water and related land resources of the Mahaweli Ganga basin were initiated, and subsequent activities connected with the implementation of selected segments of this master plan, could be regarded as having been in close conformity with several of the recommendation made many years later at the United Nations Water Conference, held in 1977. Experience and knowledge gained from the Mahaweli project studies led to general improvements in the planning, design and implementation of similar development projects in other areas of the country. A pilot project for rehabilitation and more effective operation of five existing major reservoir irrigation schemes was initiated in about 1976, solely with the objective of bringing about much needed improvements in land and water management.

Nevertheless, follow-up action for the implementation of the recommendations made at the United Nations Water Conference commenced in April 1977 with the formation of an Ad Hoc National Committee on Water Resources and the appointment of several working groups entrusted with the task of initiating action connected with the more important and urgent aspects of these recommendations. The following measures, which have been taken up since about the end of 1978, can be regarded as taken specifically in response to the Mar del Plata Action Plan.

1. Formulation and drafting of a comprehensive new Water Resources Act, to be presented to Parliament shortly, which provides for the establishment of a National Water Resources Council with well-defined responsibilities for drawing up a national water policy; co-ordinating water resources activities at the national level; examining and resolving disputes relating to the ownership, allocation and use of water resources; laying down and enforcing water quality and effluent standards; and estimating the demands for water for different purposes and preparing long-term programmes for satisfying these demands.

2. Drafting of a new irrigation law, also expected to be enacted shortly, to repeal the old irrigation ordinance and to include updated and more effective provisions for the control and regulation of water use in irrigation schemes, and dealing with abuses, control and regulation of the use of ground water for irrigation purposes.

3. Formulation and specification of appropriate policies for special attention to land and water management under irrigated cultivation, with a view to increasing agricultural production and productivity through the enforcement of stringent water management in all major irrigation schemes; rehabilitation and modernization of existing irrigation distribution systems to permit the introduction of water management procedures and to facilitate more equitable distribution of water; and improvement of operation and maintenance practices, supported by the revision and updating of the existing operation and maintenance regulations and standing orders, in the form of a comprehensive new manual.

4. Initiation of a national water management programme funded by the United States Agency for International Development, accompanied by the establishment of a separate water management unit in the Department of Irrigation, under which work has been commenced on the rehabilitation and modernization of the irrigation distribution systems of the Gal Oya Project with the assistance of foreign consultants, prior to introducing effective water management procedures; similar attention will be progressively extended to several major irrigation projects in other parts of the country; and provision has been made for the training of future operation and maintenance and water management personnel, both locally and abroad.

5. Initiation of measures for improving the existing standards and procedures for the assessment of water resources, through the gradual and planned expansion of the data-collecting network, commencing with the installation of automatic water level recorders at important locations in selected river basins; installation of additional electronic computation facilities

for the progressing, analysis, adjustment and future storage of hydrological and other related water-resources data; the training of personnel in the use of isotope techniques in the field of hydrology; and recent participation by a senior engineer of the Department of Irrigation in a course in statistical computer techniques in hydrology and water resources, held at Colorado State University.

6. Examination of the functional organization of the Department of Irrigation with the assistance of foreign consultants, with a view to bringing about improvements in future activities of this important Government agency relating to the planning, design, appraisal, implementation, operation and maintenance of water resources development projects and programmes.

Problems and constraints that have been encountered in the course of follow-up action on the recommendations made at the United Nations Water Conference are those that may be expected to be common to most of the countries in the ESCAP region; the more noteworthy are shortages of qualified manpower, partly arising from the continued emigration of local talent in search of more lucrative employment abroad; institutional deficiencies caused partly by a lack of qualified manpower and partly by a need for improvements in the functional organization of the existing institutions; and shortage of financial resources, caused primarily by oil price increases and accompanying world-wide inflation, which, in turn, is a constraint to obtaining needed equipment.

C. TECHNICAL CO-OPERATION AMONG DEVELOPING COUNTRIES

The facilities available in the developing countries of the ESCAP region for providing mutual support in implementing the Mar del Plata Action Plan are well known, and Sri Lanka has availed itself of them from time to time as the need arose. Engineers from the Department of Irrigation have been sent to the International Rice Research Institute in the Philippines to study rice irrigation and water management, and arrangements have been finalized to send an engineer to the Republic of Korea to participate in a course in water management.

Furthermore, it is believed that the more recent activities in Sri Lanka connected with the programming and implementation of the accelerated Mahaweli development project, the on-going programme of rehabilitation and modernization of existing irrigation schemes, the national water management project, revision, updating and consolidation of the existing water legislation would be of more than ordinary interest to other developing countries in the ESCAP region.

The Government of Sri Lanka cordially welcomes representatives of ESCAP member Governments to visit Sri Lanka and acquaint themselves more fully with the various water resources activities mentioned here.

D. RURAL COMMUNITY WATER SUPPLY AND RURAL SANITATION IN RELATION TO OVER-ALL MANAGEMENT OF WATER RESOURCES

(NR.7/CRP.7)

1. The nature of the problem

A primary social objective of the Government of Sri Lanka is to improve the quality of life of its people, particularly those who are handicapped financially or by the physical conditions of their living. Equal opportunities have ti be provided for all sections of the population, so that all may benefit from economic growth. With this end in view, the Government will continue to provide special support measures to the old, the indigent and the needy, while health and education facilities will be available to all. In short, the Government's investment strategy seeks to achieve large-scale expansion of employment and a high rate of over-all growth and progressive improvement in the balance of payments, while safeguarding the living standards of the poor in order that an improvement in the quality of life be available to everyone.

Provision of safe water for drinking in adequate quantity, throughout the day and the year, and within reasonable access to homes, in areas where safe water is not yet available, falls within the broad social objective to improve the quality of life. Similarly the provision of sanitary latrines where unsanitary methods of excreta disposal are in use, and particularly where no latrines at all are available, falls within this greater social objective. It is also directly linked to the Government's objective of creating a house-owning democracy. The provision of drinking water and sanitation must normally be pursued together, as otherwise the sanitary latrines may remain unused for lack of adequate water, particularly in rural areas deprived of suitable sources of water.

The magnitude of the problem can be assessed from the 1971 census figures. Those show that in regard to water supply in urban areas, about 16 per cent of the population was supplied through house connections, while another 29 per cent had access to yard connection and public standposts. Therefore, 55 per cent of the urban population had no access to a piped water supply and had to depend on other sources, normally unprotected wells and other unsafe sources. In rural areas the position was even worse, with only 5 per cent having access to piped water supplies, leaving

95 per cent to obtain their supplies from sources which could be unsafe as well as unreliable. In the estate sector, about 75 per cent of the population had access to piped water supplies. The position was even worse than these figures depict, for piped sources themselves often supplied inadequate quantities, and were at times unsafe.

As to sanitary excreta disposal, the 1971 census figures indicate that in urban areas 42 per cent of the housing units had flush toilets or water seal latrines, 38 per cent had bucket or pit latrines and 20 per cent had no latrines. In the rural sector, 42 per cent of the housing units had no latrines, while 45 per cent used pit latrines. In the estate sector, 42 per cent of the housing units had flush or water-seal toilets, another 42 per cent had pit or bucket latrines, while the balance had no latrines. Piped sewerage exists only in Colombo, and that system is old and heavily overloaded.

To remedy this situation in the shortest possible time, a co-ordinated effort is required not only for the provision of services, but for imparting health education and for obtaining community participation, particularly for the maintenance of services.

2. Goals and objectives

In water supply the ultimate goal is to provide a safe, adequate and reliable supply of water within easy access to the entire population. The targets for the International Drinking Water Supply and Sanitation Decade (1981 to 1990) for the water supply sector are as follows:

(a) Urban water supply: to provide 100 per cent coverage for the population through piped water supplies, in order to meet the minimum safe water requirements.

(b) Rural water supply: to provide 60 per cent coverage for the population, the supplies being predominantly through protected wells, to meet the minimum safe water requirements.

These targets will cover an urban population of about 4.7 million by 1990, and a rural population of about 8 million, so that approximately 73 per cent of the projected population of 17.4 million will be provided with the minimum requirements of safe water.

The term "safe water" refers to water from chemical and bacteriological contamination, and satisfying a stipulated national minimum standard for water quality. Minimum safe water requirements would cover the amount sufficient for physiological and sanitation needs — (drinking, cooking and washing). The supply must also be accessible to the population covered in terms of both cost and the effort expended by the individual in obtaining water. In the case of piped supplies, it must also be reliable throughout the day to provide the required supply and in the case of supply from wells, the supply must be reliable throughout the year.

As regards sanitary excreta disposal, the targets for the Decade are as follows:

(a) Urban areas: To provide 100 per cent of the population with a sanitary method of excreta disposal by 1990, partly through improvement and expansion of piped sewerage in Colombo, partly through the conversion of existing unsanitary latrines into sanitary latrines, and partly through the provision of the required facilities where they do not exist.

(b) Rural areas: To provide 50 per cent of the population with a sanitary method of excreta disposal by 1990, through the conversion of existing pit latrines into water-seal pit latrines or other sanitary latrines and by the provision of new facilities.

In recent years there has been an emphasis on urban water supply schemes, but this will be increasingly shifted to rural areas over the Decade while giving due priority to developing areas, such as the industrial processing zone. In the case of sanitation, the emphasis on urban areas will be continued during the Decade.

The targets set for the Decade in respect of water supply will be related to minimum levels of service, namely public standpost supply in the case of piped supplies, or community wells in other areas. Service levels above this minimum will be charged for directly. Charges will be levied at a progressive rate to cover operating and maintenance costs and a contribution to the repayment of capital, in addition to providing some cross-subsidy for poorer consumers. However, where it is found that a community is unable to generate income to pay for the water supply, direct subsidies will be provided to both urban and rural communities so placed. In the case of urban sewerage, the tariffs are likely to be based only on operation and maintenance costs.

3. Decade policies, strategies and investment programme

The policies to be adopted for the International Drinking Water Supply and Sanitation Decade are outlined below:

(a) The population projections referred to above must be accepted in establishing the priority of this sector as compared to other sectors where competing demands for investment arise.

(b) In water supply, the emphasis on urban services in recent years will be increasingly shifted to rural areas over the Decade, while in sanitation the emphasis on urban areas will continue.

(c) Where it is found that a community is unable to generate income to pay for water supply, the total capital investment will be borne by the Government and where necessary, direct subsidies will be provided to both urban and rural communities so placed.

(d) Excluding the cases noted in (c) above, rates will be charged directly according to the amount consumed, the tariff system being a progressive one where private connections are charged increased rates at high levels of consumption, while supplies through standposts will be charged directly on the basis of property rates.

(e) The level of tariffs will be such as cover operation and maintenance costs, and a contribution to capital, in addition to providing some cross-subsidy for poorer consumers.

(f) Standards for water quality will be worked out to provide the minimum safe water requirements targeted for the Decade.

(g) While a standard design for community wells will be adopted and tested, necessary changes will be made on the basis of experience gained in their use by the community.

(h) Measures for reducing water wastage will be vigorously pursued in all areas.

(i) Co-ordination of sector activities at the centre as well as in the districts and divisions will be pursued during the Decade and necessary institutional arrangements made.

(j) A programme will be worked out in consultation with all the Ministries involved to provide adequate water storage along river basins to meet the increasing demand for drinking water.

(k) The participation of voluntary organizations in sector programmes and activities will be promoted and necessary institutional arrangements made for this purpose; attempts will also be made to involve consumers in planning, execution and operation of projects.

(l) The private sector will continue to encouraged to undertake investigations, design and construction of projects.

(m) While the National Water Supply and Development Board (NWSDB) will increasingly take responsibility for operation and maintenance of water supply schemes, suitable institutional arrangements for this purpose will be examined early, and the technical, financial and other problems related to operation and maintenance will be studied to evolve suitable remedies.

(n) An independent institute coming under the Ministry of Health will be established for monitoring water quality, and the regular quality control by the NWSDB will be strengthened.

(o) The immediate preparation of suitable designs for sanitary latrines suitable for water-scarce areas will be undertaken.

(p) A water demand forecast will be prepared and a long-term programme for storage and supply of water will be worked out in consultation with the other ministries involved.

(q) The adequacy of the legal provisions for a positive approach to sector programmes will be examined and necessary changes made.

(r) Measures will be introduced to generate an adequate supply of manpower for sector programmes.

(s) Local production of equipment and materials required for sector programmes will be promoted.

(t) A continuing dialogue with donor agencies will be maintained in order that the increased level of aid to the sector for the Decade can be properly co-ordinated with planned activities.

The over-all strategy for the sector will involve action in the following areas: construction of new supplies and augmentation of existing ones; improvement of existing supplies; and health education and public information.

Need will be the criterion for the selection of priority schemes, and the first objective will be to provide a basic minimum level of service, by the most cost-effective means, to the relevant population. To achieve the targets envisaged, it will be necessary to build up the capacities in the sector, especially as follows:

(a) Construction capacities of the NWSDB as well as of the private sector need to be strengthened and expanded.

(b) The manpower needed to meet sector requirements must be trained in adequate numbers, taking into consideration the exodus of skilled staff, while simultaneously making employment in sector agencies attractive to the staff.

(c) A forecast of material requirements and assessment of equipment requirements for Decade programmes must be made, and stocks of materials maintained, while a scheme is worked out early for setting up a plant hire operation on a commercial basis under government control.

(d) While the bulk of the rural population to be covered will be supplied with safe water through protected wells operated with hand-pumps, the technical feasibility of cost-effective alternatives must be examined to meet a situation where community acceptance of this level of service may not be available, e.g., providing water on tap at the community well.

(e) Information already on hand from various agencies regarding water availability must be made readily available, and surveys of springs and other sources undertaken on an intensive scale.

(f) Close liaison must be maintained among the different agencies involved in order to conserve and store water to supply the requirements of water supply schemes while providing water for irrigation.

(g) Communities must be closely involved in planning, construction, operation and maintenance in order to maximize the health benefits of sector programmes during the Decade.

(h) A study must be undertaken regarding operation and maintenance of water supply schemes, within the framework of information on operation and maintenance activities and their shortcomings in existing schemes, in order that effective methods may be implemented.

(i) A demand forecast for drinking water must be prepared in order that long term programmes for storage and supply of water may be planned for early implementation.

The investment programme for the Decade is based on a total estimated investment in the sector of Rs 5,600 million (at 1979 prices)[1] during the Decade, with an annual investment in the region of Rs 560 million and Rs 500 million in 1980. Investment in the sector will therefore account for about 5 per cent of the Government's total capital budget.

This level of annual investment will be used on a rolling programme of 2 to 3 years, with the first year's programme included in the annual budget. Projects will be identified on the basis of selection criteria incorporated in a questionnaire prepared by the Ministry of Local Government, Housing and Construction. The Government agents submit lists of completed questionnaires, assisted in this process by local officials and representatives of local communities. These lists extend to about 50 projects, and over 1,000 questionnaires for the island are being processed. The country-wide list of priority water supply will be prepared by the Ministry of Local Government, Housing and Construction. Further priority lists will be obtained over the coming years, so that the rolling investment programme will be continuously supplied with projects. A similar procedure will be followed in the case of the community wells programme in the rural sector.

The investment programme for operation and maintenance of schemes has to be worked out on the basis of information collected on material, manpower and equipment needs for proper maintenance and operation.

In the provision of sanitary latrines the Ministry of Health will first have to determine the appropriate designs for latrines in areas where water in adequate quantity is not likely to be available. In order to maintain the level of construction required to achieve the Decade targets, approximately 76,000 latrines have to be constructed or converted per annum, compared to a level of about 12,000-15,000 each year at present. This calls for a radical change in approaches, which will have to be examined by an appropriate committee and the methods and strategies recommended adopted for implementation during the Decade.

In health education, the immediate action required is for the Ministry of Health, with the assistance of other agencies, to prepare a campaign for the dissemination of information regarding environmental health, based on an assessment of the appropriate media to be used and the most effective timing of such a campaign.

As regards foreign assistance for this investment programme, it is desirable that donor agencies should consider financing a greater share of the costs, both local and foreign, as compared to the present practice which is often limited to financing about two thirds of the cost of a project (often only the foreign exchange component). The activities of donor agencies should be based on the plan for the Decade and assistance should be geared to implementation, whether in the operation of existing system or investigations, designs and construction of new systems. Particular attention must also be drawn to the rapidly changing nature of the situation, so that it is important that donor agencies should be flexible and rapid in responding to sectoral needs.

[1] Rs 15.569 = $US 1.00 (1979 period average).

XII. UNION OF SOVIET SOCIALIST REPUBLICS

(NR.7/CRP.16)

A. DEVELOPMENT AND USE OF WATER RESOURCES*

Introduction

About three million large and small rivers run through the territory of the USSR. Almost as great is the number of lakes, ponds and reservoirs. The total annual river run-off exceeds 4,700 km^3. There are huge quantities of ground water and water stored in glaciers and snowbanks.

Since only 340 km^3 of water are used annually for the needs of the national economy, it might seem that the water resources are sufficient even in the case of a large increase in water use. However, the shortage of this valuable natural resource is growing into a highly acute national economic, social and ecological problem, demanding great material resources for its resolution.

This is explained by the fact that the powerful Siberian rivers, the Ob, the Yenisey and the Lena, and the full-flowing European rivers, the Pechora, the Severnaya-Dvina, the Onega and others of the northern slope, discharge over 4,000 km^3 of fresh water or 86 per cent of the flow volume into the oceans of the world annually. Moreover, they run in the northern and eastern regions of the country, where water use is negligible. On the other hand, the southern slope, with its well-developed industry, more than 85 per cent of the population and almost all the irrigated lands, possesses only 14 per cent of the water resources.

It should be pointed out that besides the unfavourable location of (rivers in the USSR territory, flow utilization is also hampered by its uneven distribution throughout the year. Most of the flow (60 to 70 per cent of the annual volume) falls in spring.

In order to supply the population and branches of the national economy with water, the Soviet Union is carrying out large-scale construction of hydraulic structures for the regulation and territorial redistribution of the river flow. More than 2,200 reservoirs have been built in the country, each storing over 1 million m^3. Among them, 250 store over 50 million m^3. About 40 km^3 of water are redistributed annually among river basins via large canals over 4,000 km in length.

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1. Interbasin flow transfer

In recent years, the country has launched operations for setting up hydraulic networks for large-scale interbasin flow transfer. The Irtysh-Karaganda and Severo-Krymsky canals have already been completed, while the Dnieper-Donbass, the Glavnyi-Kakhovsky and the Karakum canals are still under construction. Construction of the interbasin Volga-Ural canal has been started. The Volga-Don and Danube-Dnieper canals are being designed; pre-design work is under way for the partial transfer of the flow of northern and Siberian rivers to the southern regions of the country.

The national economic, social and ecological importance of these projects can hardly be overestimated. A brief description of some of them can serve as convincing evidence of this.

Construction of the Severo-Krymsky canal has exerted a great transformation of the natural environment of steppe regions in the Crimea and Kherson District, the Ukrainian Soviet Socialist Republic. This powerful waterway, which delivers the Dnieper water at a rate of about 300 m^3/sec, has permitted the growing of rice in the Crimea and has ensured a sharp increase in the production of rice, fodder, vegetables, grapes and other fruit crops. The farms receiving the Dnieper water produce on average 4.6 tons/ha of winter wheat, 5.4 tons/ha of rice, 18.5 tons/ha of vegetables, 55 tons/ha of fodder root crops and a lot of other produce. The new waterway provides the towns of Kerch, Feodosia, Simferopol, Sevastopol and Yalta with water.

The Dnieper-Donbass canal is a sophisticated hydraulic complex for interbasin flow transfer. This multipurpose water project is a good example of how complicated problems in hydraulic engineering are being solved. The interbasin canal will drastically improve the industrial water supply in Donbass and will allow irrigation of 165,000 hectares of arable lands.

The Kakhovsky main canal carrying the Dnieper water to the steppes of the Kherson and Zaporozhyie districts, the Ukrainian Soviet Socialist Republic, is unique both in conception and implementation. Here, in the Dnieper-Molochnaya interfluve, the Kakhovskaya irrigation system, the largest in the USSR and Europe, is being constructed. Lifting 530 m^3/sec of water to a height of 25 m, the world's largest pumping station delivers water from the Kakhovskoye reservoir to the 130-km long Glavnyi-Kakhovsky canal.

The Karakum canal, which transports water from the Aral Sea to the Caspian Sea, is the largest artificial waterway in the world, and the largest scheme for inter-basin flow transfer in the USSR. The canal diverts 465 m^3/sec of the Amudarya water across 1,000 km of one of the hottest deserts in the world. This waterway is unique not only for its extent, but also because the water runs hundreds of kilometres through the desert by gravity. The socio-economic significance of the Karakum canal is considerable. The dream of the "great water", cherished for centuries by the Turcoman people, has come true. Irrigated areas in the canal zone will reach one million hectares. Water will be supplied to 7.5 million hectares of pastures. The canal will serve as a transport line, a basis for fishery development and a recreation zone. Around the main canals, regions of irrigated farming will spring up.

In Povolzhye, operations have been started for the construction of the Kuibyshevsky canal which is to enter the Orenburg District and irrigate 300,000 ha in the future. The first construction stage of the Saratovsky canal stretch has been commissioned and is already irrigating more than 90,000 ha. The Komsomolskaya irrigation system is being built over an area of over 150,000 ha. Operations are under way on the Bolshaya-Volgogradskaya system, its design irrigation area constituting 116,000 ha.

In the North Caucasus, lands are being cultivated near the Bolshoy-Stavropolsky canal designed to irrigate 200,000 ha. The Krasnodarskoye reservoir, which stores 3.1 billion m^3 of water has come into service. The Azov plains are being developed for rice growing on an area exceeding 100,000 ha.

In Central Asia, a new large cotton-growing region covering over 300,000 ha has been set up in the Golodnaya Steppe. The Karshi Steppe development is progressing well, the irrigated area of the first and second stages totalling 350,000 ha. In South Kazakhstan, rice is largely grown in the desert land development areas of the Kzyl-Orda and Chimkent Districts. Irrigation of lands under sugar beet is widespread in the Dzhambul District.

2. Land reclamation

As to land drainage, it appears worthwhile to mention the development of the Polessiye lowland in the Byelorussian Soviet Socialist Republic. The total area of lands to be reclaimed here exceeds 2.7 million ha, of which more than 1.1 million ha have been drained.

Trends in the development of the USSR water economy are determined by five-year and annual plans. The year 1980 concludes the tenth five-year plan period (1976-1980). Great attention has been paid in the plan to the development of land reclamation, which is an essential means of intensifying agricultural production.

In 1976 to 1978, 2.4 million ha of new irrigated land and 2.2 million ha under drainage were put into operation in the USSR. In 1979, irrigated and drained lands, constituting about 10 per cent of the arable lands and areas under permanent crops, yielded 32 per cent of the gross farming produce of collective and state farms in monetary terms. The total area of irrigated and drained lands in the country has reached almost 30 million ha. Each hectare of drained lands yields 1.5 times more produce, and each irrigated hectare 5.5 times more produce an average than a rainfed one. In 1979, the average yield (in tons/ha) of farm crops under irrigation was as follows: grains, 3.2 (rice, 3.92); raw cotton, 2.96; vegetables, 18.0; and sugar beet, 31.0.

The modern reclamation system comprises a sophisticated set of structures including, according to 1979 data, over 400 irrigation reservoirs storing more than 20 km^3 of water in total; 1.3 million km of irrigation and drainage canals; 1.5 million hydraulic structures on canals and reclamation networks; and pumping stations with an installed capacity of 5.6 million kW.

Recent years have been marked by an appreciable rise in the technical level of land reclamation. Today, 92 per cent of new irrigation networks are built with linings, concrete canals and pipelines. Sprinkling, one of the most advanced irrigation methods, is applied on three quarters of the irrigated lands put into service. In land drainage, subsurface systems prevail. The programme for the introduction of automation and remote control in reclamation is being implemented, and work is under way to promote the use of lasers and other innovations in irrigation and drainage construction.

Land reclamation is practised in almost all regions of the country, and even now about 40,000 collective and state farms have irrigated and drained lands. More than 1.5 million people in the USSR are engaged in the construction and operation of reclamation systems. Reclamation organizations have 30,000 excavators, about 37,000 bulldozers, 25,000 scrapers and a considerable amount of other machinery.

3. Water management

The high rate of economic development, growth of the population and improvement of living conditions have caused a marked increase in water use, bringing about the problems of water delivery over long distances, distribution of water resources under deficit conditions and water conservation. These circumstances have called for further development and improvement of state guidance in the field of water use and conservation. Therefore, in 1971 a new water law was passed, "The Basic Principles of Water Legislation of the USSR and Union Republics". This law contains the most general and fundamental regulations concerning water use and conservation, including requirements for effective and multipurpose utilization of water resources.

The Central Committee of the Communist Party and the Soviet Government have outlined an extensive programme of work in environmental control. Much thought has been given to the problems of rational use of water resources and their protection against pollution, littering and depletion. The steps taken so far to conserve nature and enhance control over water management have made it possible to reduce the pollution of rivers and improve their sanitary condition.

Measures for water supply of the national economy, meeting the water demands of the population, and prevention of water pollution and depletion are determined by master plans for multipurpose use and conservation of water resources, drawn up for each river basin.

The data used for long-term planning of the water economy indicate that even at present, deficient water flow is observed during dry years in some river basins of the country's southern slope. A further steep rise in water use by the national economy, and the need for placing stringent requirements on the quality of river inflow to inland seas in order to maintain the hydrochemical and hydrobiological balance appropriate for fisheries, will add greatly to the deficit of water resources in the southern part of the country. It is planned to solve this problem by partially transferring the flow of northern and Siberian rivers to the southern river basins.

About 100 scientific centres in the country are engaged in studying the impact of the planned flow transfer undertakings on the natural and anthropogenic environment. Scientists and designers are thoroughly investigating the possible changes in such spheres of the natural environment as atmospheric circulation and precipitation, evaporation, the processes of waterlogging and salinization, the state of floodplain and **taiga** lands and the structure of soils.

The accomplishment of objectives associated with interbasin redistribution of the flow of the country's major rivers will play a decisive role in the dynamic development of all branches of the national economy. The great practical experience gained by the country in the field of interbasin flow transfer points to the feasibility of these measures.

4. International co-operation

Much importance has been attached in the Soviet Union to international co-operation in this field, and particularly to the implementation of the Mar del Plata Action Plan of the United Nations Water Conference held in 1977. The USSR is actively participating in the work on water problems within the Council for Mutual Economic Assistance, and the collective co-ordinated efforts are already bearing fruit.

The USSR also co-operates with many other countries on the basis of bilateral agreement. The USSR Ministry of Land Reclamation and Water Management alone maintains contacts in the field of water resources use and conservation with more than 50 foreign countries.

The economic, scientific and technical co-operation of the USSR with developing countries is based on the principles of equality, sovereignty, non-interference in internal affairs and mutual benefit. Soviet assistance is primarily distinguished by a comprehensive approach to the solution of water management problems. Soviet organizations carry out designing and survey work, deliver equipment and materials and train national specialists in the field of water management.

USSR co-operation with Asian countries can be exemplified by assistance in constructing water supply systems and other projects in Mongolia, the Jalalabad irrigation system in Afghanistan, hydraulic complexes on the Euphrates River in Syria, various water projects in Iraq and other countries.

The USSR takes part in the realization of projects under the United Nations Development Programme. Co-operation with the United Nations Environment Programme is active. Soviet specialists make their contribution to the work of the United Nations regional commissions, and particularly to ESCAP. In compliance with the ESCAP programme, the Soviet Union has held the following seminars for specialists of developing countries: the seminar on measures to improve irrigation efficiency at the farm level in 1979, and the seminar on the improvement of irrigation performance at the project level in 1980. Soviet organizations take part in the water projects of UNESCO, WMO, FAO and other international organizations.

B. WATER USE IN INDUSTRY*

(NR.7/CRP.17)

The "Guidelines for the development of the national economy of the USSR for 1976-1980", approved by the USSR Government, set forth the tasks of environmental control and rational use and renewal of natural resources, including water.

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Constant growth in water use and waste-water disposal by industrial enterprises has brought about the need for a new approach to the problem of water supply in cities and industrial centres.

Thus, it is planned to develop and promote technological processes which reduce the amount of pollutants and ensure maximum wastes recovery, and create a system of water use on a closed cycle.

In the USSR, annual, five-year and long-term plans for the conservation and rational use of water resources in industry have been drawn up within the framework of general state plans for social and economic development of the country's national economy. The principal plan indices are water use, water recycling, water re-use, waste-water treatment plants in operation, capital investment in construction of treatment plants and rational utilization of water.

The targets of conservation and rational use of water resources have evolved specifically for economic branches, ministries (departments), Councils of Ministers of Union Republics, and for water management regions. The lower level for management planning in industry is classified as an enterprise, the higher being represented by a ministry.

The USSR Ministry of Land Reclamation and Water Management works out master plans for conservation and rational use of water resources on the basis of plans made by industrial ministries. When planning the level of water use and waste-water disposal in industry, it analyses the trends in the main indices and the factors causing changes, and outlines effective measures which permit a considerable reduction in water use, in the disposal of raw waste water and in capital investment and operational costs of water resources systems. Master plans for the conservation and rational use of water resources submitted by the State Planning Committee of the USSR are approved by the Soviet Government.

The water recycling factor is one of the most essential indicators of the technical level of water use in industrial branches. The factor is determined as the ratio of the volume of water recycled and reused to the gross water used in production. This indicator measures the efficiency of water supply systems from the viewpoint of water conservation.

The evolution of water recycling systems has been largely a result of two factors. The first is the insufficiency with scarce water resources and those fairly rich in water but with a dense urban population and a high industrial potential. The second factor is that in a number of technological processes, economic savings may result from the recovery of valuable raw materials, reagents and power resources from waste water returned to production.

At present, the volume of recycled and reused water in the country constitutes about 62 per cent of total water use. The widest application has been found by water recycling systems in such water-consuming industries as chemicals, ferrous metallurgy, coal mining and pulp and paper and in heat-power and general engineering. In 1975 the water recycling factor in these branches reached 0.74 on average, and by the year 2000 it is expected to rise to 0.86.

The water recycling factor in the coal- and gas-extracting industries has stabilized at a rather high level, owing to the long-established production technology and fairly complete utilization of water recycling potential, whereas other waster-consuming branches are expected to raise this index gradually and smoothly.

For example, in heat-power engineering, the introduction of coolers combining convective and evaporative cooling holds the greatest promise. When the air temperature is low, such coolers can work as air-condensing installations, having practically no water losses, or as conventional evaporative coolers in warmer seasons. With the use of combined-action coolers, water consumption has been tentatively estimated to be reduced annually by 40 per cent.

In the chemical industry, the capacity of water reuse and recycling systems can be increased several times by putting certain water-consuming processes on closed water supply cycles. This applies primarily to the production of plastics, where the recycling factor can be raised up to 0.9 and source water used only to compensate for losses in recycling systems.

In the pulp and paper industry, the water recycling factor averages 0.5 at present (being as high as 0.75 in advanced enterprises). In the future, source water use in this branch can be reduced by employing water recycling in the production of wood pulp, as well as in the sprinkling systems of paper machines.

In general engineering, the water recycling factor is the same as in the pulp and paper industry. A promising way to raise the figure is to introduce water recycling for cooling the most water-consuming equipment, such as compressors, high-frequency current installations, welding machines and cupolas. For such equipment, there are various advanced water recycling systems which are basically suitable for enterprises of any general engineering type.

When planning the development of water recycling systems, it is essential to consider the following measures for making them more efficient:

(a) Stimulating rational water use at the enterprise level;

(b) Working out scientifically-determined quality requirements for source water;

(c) Making wide use of conventionally clean water after cooling;

(d) Utilizing municipal and industrial waste water in industrial water supply systems after necessary additional treatment;

(e) Setting up closed cycles of water supply with local waste-water treatment;

(f) Revealing the potential for new advanced water use systems in the most water-consuming technologies (e.g. evaporative cooling for furnaces);

(g) Setting up systems of water recycling in water-deficient regions of the country.

Determination of the admissible waste-water load on water courses is a problem of great concern in industrial enterprises. In order to maintain river water in good condition, it is essential that the concentration of pollutants in water bodies should be kept below the maximum admissible level.

However, long-term planning of waste-water disposal with regard to the maximum admissible concentrations is a very complicated task. Therefore, it appears reasonable to set criteria for the anthropogenic load on a water course by the main pollutants.

To this end, when assessing the interactions in the "waste-water-river" system, such parameters should be analysed as the amount of pollutants entering a water course from industrial sites and the average annual levels of river flow and velocity, as well as the length of the stretch from the point of waste-water disposal to the nearest major water users, the self-purification capacity of the river, and maximum admissible concentrations of impurities in the water body.

The standard waste-water load on a water course is calculated for individual pollutants. The figures obtained for waste-water loads on water courses are used for ranking the relevant river stretches in water management and the principal sources of water-course pollution by industrial waste water.

Subsequently, measures for the reduction of the waste-water load to the standard are outlined in the long-term and current plans for the load curtailment.

One of the most effective ways of decreasing the amount of both total source water and waste water used is to create closed water supply systems. In many cases, construction costs of such systems can be lower than those of through-flow ones envisaging waste-water disposal in a water body.

However, even if direct expenditures on the creation of closed water supply systems are higher than those needed for through-flow systems as a result of specific production features, the final economic effect of recycling will be better, since closed systems guard against damage of water bodies by waste-water pollution.

The provision of closed water supply systems with zero waste-water discharge is advisable where there is a great waste-water load on water courses; where the water body is unique in its natural significance (Baikal Lake); and where the water body is of great economic importance (the Volga, Ural rivers, etc.).

The promotion of closed water supply systems envisages considerable curtailment of specific water use in production by introducing low water-consuming and non-water-consuming technologies, rating water use and disposal, developing local systems of waste-water treatment and using municipal waste water after tertiary treatment to feed industrial water supply systems.

Development of such closed systems is particularly urgent for the chemical, pulp-and-paper and oil-processing industries. Accomplishment of this objective calls for basic changes in production technology waste-water treatment methods and evolution of processes which result in low waste-water formation. Extensive introduction of water recycling in chemical technologies, substitution of air for water in cooling, improvement of technological production processes and application of local waste-water treatment are the principal measures to reduce water consumption in the chemical industry.

The Pervomaisky chemical plant project involves the fullest combination of these measures. An added economic effect of the measures is the recovery of valuable substances found in the waste water.

Thus, when planning water use in industry, primary consideration should be given to the balanced development of water supply and disposal systems, which would not cause a decline in the quantitative and qualitative indices of water use.

For planning purposes, the volume of source water withdrawn for production purposes and the amount of impurities discharged with the waste water into a water course should be measured.

Long-term planning of standard indicators for source-water use and gradual restriction of waste-water discharge into water courses are tasks of vital importance.

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