Food and Agriculture Organization of the United Nations

INTEGRATED RURAL WATER MANAGEMENT

SUMMARY

This report of the Technical Consultation on Integrated Rural Water Management is structured on the three main themes of the Consultation: Policies, strategies and planning; Research and development; Capacity building. Each theme is introduced by a keynote paper, followed by a series of discussion papers on issues related to that theme, and by case studies illustrating country experiences. Examples of collaborative activities in water resources management within the UN system and in conjunction with external support agencies form a fourth component of the report. The summary of the Proceedings presents the Consultation's conclusions and recommendations for future action and collaboration.

INTEGRATED RURAL WATER MANAGEMENT

Proceedings of the
Technical Consultation on
Integrated Rural Water Management
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Preface

There is growing concern over the declining availability of freshwater, and the ever-increasing demands on the resource. The problem is further aggravated by the degradation of quality due to pollution. By the year 2000, world population is projected to reach 6 thousand million, and the forecast for 2025 is 8 thousand million or more. Already, with a population of 5 thousand million, water is a scarce resource in many parts of the world. Some eighty countries and about 40% of the world population suffer from serious water shortages.

At the same time, economic and social development cannot be halted, and should in fact provide opportunities for improvements in the quality of life. Without doubt, the great challenge is to eliminate poverty, for that is largely the reason why today more than 500 million people are under-nourished. It is estimated that more than one thousand million people do not have access to clean drinking water, and 1.7 thousand million lack adequate sanitation. The rural population remain the most vulnerable group. A vast majority of the 1.2 thousand million poor live in, or come from, rural areas. Similarly, most of those who lack safe drinking water and sanitation are rural dwellers.

In terms of water use, the rural sector accounts for the biggest share. In the developing countries, agriculture uses about 80% of the total freshwater withdrawals. This share is now unavoidably being eroded by urgent demands for urban and industrial use. The irony is that, even with so proportionately large a share of water, many rural populations lack an adequate supply to meet their basic needs and to produce, or to generate income for, food for their own growing numbers.

Two major causes contribute to this: (i) water is not efficiently used in rural areas, and particularly in agriculture where, often, 60% of the diverted water does not reach the crops, and (ii) water resources development and management for agricultural use and for drinking water supply, sanitation and rural industries are administered separately. Thus, the very survival of rural communities and the sustainability of agriculture depend on: integrating the planning and implementation of all water-related activities in the rural sector; ensuring drinking water supply and sanitation to rural households; improving water use efficiency in rural activities, and especially in agriculture; the conservation of water resources; safeguarding human health, with particular reference to water-related diseases; and the protection of water quality and the environment. Thus, integrated water resources management is the key to sustainable agricultural and rural development.

In many of the papers presented at the Consultation, and throughout the discussions, reference has been made to the UN Conference on the Environment and Development, and in particular to UNCED Agenda 21, Chapter 18, which relates to freshwater resources and integrated approaches to their development and management. For ease of reference, relevant excerpts of that chapter have been included as Annex 4 to this document.

Acknowledgements

This report on the Technical Consultation on Integrated Water Management is accompanied by the papers presented and discussed at the Consultation. The papers have been edited and condensed, where necessary, to keep within the limits specified for the publication.

The technical papers contributed by, and the active participation of Dr El-Beltagy (Egypt), Dr Alirahman and Dr Hadimoeljono (Indonesia), Dr Leon-Estrada (Mexico), and Dr Kodal (Turkey) are gratefully acknowledged.

The co-sponsoring organizations, UNICEF, UNDP, WORLD BANK, and WHO, and their representatives at the Consultation are greatly appreciated for their support and technical contributions to the meeting, which ensured a series of valuable discussions and the promise of useful follow-up activities.

The participation of representatives of other agencies of the UN system, IAEA, UN/DESD, UNEP, UN/ESCWA, UNIDO, and WMO, demonstrated the spirit of collaboration that characterized the meeting.

Thanks are due to the staff of the various departments of FAO who participated, Agriculture; Forestry; Economic and Social Policy; the Development Department and the Legal Office, and particularly to those who prepared and presented papers for the Consultation. Special mention is due to the Land and Water Development Division team that organized and ran the meeting, Ms Edith Mahabir-Fabbri, Ms Chrissi Smith-Redfern, Ms Marie-Claude Boucamus-Carducci and Ms Vilma Lorenzo-Riccardi, coordinated by Dr A. Kandiah. The Consultation report and technical papers were edited by Mr. T.H. Mather and prepared for printing by Ms. Chrissi Smith-Redfern.

Contents

Acronyms

ACC/ISGWR	UN Administrative Committee on Coordination - Inter-secretariat Group on Water Resources
CEFIGRE	Centre International pour la Formation à la Gestion des Ressources en Eau
CEMAGREF	Centre National de Machinisme Agricole du Génie Rural des Eaux et des Fôrets
CGIAR	Consultative Group for International Agricultural Research
CNA	Comision Nacional del Agua (Mexico)
ECLAC	Economic Commission for Latin America and the Caribbean
ESA	External Support Agency
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information Systems
IAEA	International Atomic Energy Agency
IAP-WASAD	International Action Programme for Water and Sustainable Agricultural Development
ICID	International Commission for Irrigation and Drainage
ICWE	International Conference on Water and the Environment
IFPRI	International Food Policy Research Institute
IHE	International Institute for Hydraulic and Environmental Engineering
IIMI	International Irrigation Management Institute
ILRI	International Institute for Land Reclamation and Improvement
IMTA	Instituto Mexicano de Tecnologia del Agua
IPM	Integrated Pest Management
IPTRID	International Program for Technology Research in Irrigation and Drainage
IRCWD	International Reference Centre for Wastes Disposal
IWRA	International Water Resources Association
JALDA	Japan Agricultural and Land Development Agency
LCBC	Lake Chad Basin Commission
NGO	Non-governmental Organization
PEEM	Joint WHO/FAO/UNEP/UNHCS Panel of Experts on Environmental Management for Vector Control
SCARP	Salinity Control and Rehabilitation Project
TCDC	Technical Cooperation among Developing Countries
TCP	Technical Cooperation Programme (FAO)
UN/DESD	United Nations Department of Economic and Social Development
UN/ESCWA	United Nations Economic and Social Commission for Western Asia
UNCED	United Nations Conference on Environment and Development
UNCHS	United Nations Centre for Human Settlement
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
Unesco	United Nations Educational Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WASH	Water and Sanitation for Health (USAID)
WHO	World Health Organization
WMO	World Meteorological Organization

Summary report and recommendations

OPENING SESSION

On behalf of the Director-General of FAO, Dr. Edouard Saouma, the participants were welcomed by the Director of the Land and Water Development Division, Dr. Wim G. Sombroek, who defined the objectives of the Consultation. These were the development of mechanisms to promote integrated water management; the identification of issues for concerted and coordinated action among agencies, countries and the donor community, including technical assistance to developing countries; and the establishment of principles and modalities for the preparation of guidelines for integrated rural water resources management.

To this end, the Consultation was structured on the three themes of policy, strategy and planning; research and the development of technologies; and capacity building. Technical sessions, in plenary, on each theme were to be followed by Working Groups for the drafting of recommendations.

The Assistant Director-General, Agriculture Department, Dr. H. de Haen, stressed the reasons for the emphasis of the Consultation on "Integrated Rural Water Management". While urbanization was growing rapidly, most of the low income countries are still primarily rural, and rural areas host the greatest share of the poor. Many lack the most essential things for day-to-day life, including fresh water, and it was in the rural areas that poverty and environmental degradation came together most acutely.

Integration could be considered as a process of joint planning, programming and programme implementation, in order to optimize the utilization of the resource through the application of social, economic, political and technical instruments. Issues deserving mention in this context were demand management, including technological solutions, and other mechanisms had an important role. The implementation of economic and technical measures called for human resource capabilities and institutions, and therefore capacity building must be a key component. All these issues were before the Consultation.

With regard to the assembly of representatives of various agencies of the UN system, Dr. de Haen praised the efforts of the ACC Inter-secretariat Group on Water Resources in its function of harmonization and coordination, and expressed continuing FAO support for the Group.

The Consultation was then formally declared open.

TECHNICAL SESSION I — Policies, Strategies and Planning for Integrated Rural Water Management

The keynote paper set out a concept of integration and raised various issues in water policy formulation with strong linkages to integrated water management. Where integration is seen as a necessary measure to meet evolving circumstances of population growth, production, natural resources management, environmental and health concerns, there is inevitably an implication for many policy objectives in various related sectors. This raised the comment that integration in water management could not realistically be treated in the rural context in isolation, but must be viewed holistically in practice. There was general agreement on this, but it was accepted that integration of water management in the rural sector could be considered and discussed as a distinct component, and appropriate measures and activities could be identified and defined.

Policies and strategies to ensure the efficient use of limited resources of water, under conditions of increasing demand, called for the management of the various demands through changes in production and use practices, and the reduction of wastage. To this end, the principle of demand management using economic and regulatory measures was recognized as an instrument with great practical potential. The modification of demand in the rural sector had also to be seen in its linkage with agricultural development strategies, with implications for crop selection and production and land use and management. The question of changes in existing patterns of water allocation, and possibilities of the transfer of allocations within the rural sector and between sectors, had major implications for the management of water, including its socio-economic valuation and the adjustment of established rights and legislation to adapt to the revised circumstances.

In terms of integrating management for the beneficial use of water within the rural sector, it was felt that insufficient attention was given to the potential for improving domestic water supplies in conjunction with water developments having a primary economic purpose, and that health and human well-being tended to be neglected. Environmental concerns arising from the effects of agriculture on water resources, and especially on groundwater, were becoming increasingly serious, but so also was the quality of water for agriculture and the resultant need for adapting production to this constraint. These issues could be amenable to solution only through a combination of technical, policy and legislation measures.

Legislation, if realistically reformulated and implemented, could be an effective tool to bring about necessary change.

Most water users in the rural sector are facing problems of the sustainability of their resources systems and services, whether for primarily productive or for social and health purposes. In response to this, the involvement of the communities involved in development and operation functions is being incorporated in the strategies of many countries, not only at a technical level, but in the overall management of land, water and agricultural production processes, with benefits to the generation of employment and incomes.

Policies and effective planning are dependent on the availability of suitable data, and the need for information systems and for the collection, analysis, exchange and sharing of such data is of prime importance nationally and on a broader base. Water resources and water use data are needed at national level for the assessment of present and potential shortages and constraints, and for the rational allocation of water among competing demands. At international river basin and global level, the information is required for monitoring regional and worldwide trends, droughts and floods, with particular reference to the impacts of climate change on water resources regimes. Data systems and mechanisms form an area where the UN agencies are already active, and can effectively respond to requests for support if enhanced collaboration is to be achieved.

The Consultation was given examples of policies, strategies and planning for rural water supply and sanitation in India, and of integrated water resources and rural development in Indonesia. These provided illustrations of the realities of mobilizing resources, and the effective use of surplus manpower in drought affected areas for water harvesting schemes and reforestation, and the benefits that can accrue from the practical application of integrated action among diverse agencies. They also threw light on the vital need to adapt approaches to the physical, social and cultural patterns of the area and communities served.

The "trigger" factor giving the incentive and impetus to the work of environmental and resource rehabilitation and rural water supply and sanitation in India was the promise of livelihood security and improved living standards of the rural community. This had greater political attraction than the benefits to purely physical conditions. Implementation called for action among various agencies, and it was found that work of this type demanded institutional restructuring if integration was to be achieved in the management of the water resources for domestic and economic use.

In the Indonesia case study, competition for limited supplies of water for non-agricultural use, and threats to water quality resulted in policy objectives and accompanying strategies targeting measures for high efficiency in overall water use. Irrigation service fees were, to some extent, determined by consensus among user groups, described as "a democratic process — but time-consuming". Because of the constraints of rice pricing, direct cost recovery was aimed only at operation and maintenance, with capital costs being recovered through general taxation.

The issues considered in the technical session were discussed in more detail by the Working Group on Policies, Strategies and Planning. The following recommendations, arising from the Working Group, were adopted by the Consultation.

RECOMMENDATIONS ON POLICIES, STRATEGIES AND PLANNING

- Following indications for future action in the keynote paper, it was proposed that initiatives be taken for support to policy reviews, reform and formulation at national level, with specific regard to the rural environment. Attention should be given to the preparation of suitable guidelines, approaches and methodologies for this purpose, leading to the strengthening of mechanisms for inter-sectoral coordination, and to the creation of appropriate legal and institutional structures for the implementation of national water management and conservation policies. Advantage should be taken of recent experiences of national and state governments, and current FAO and World Bank work on policy reviews.

- In view of the considerable importance attached to demand management as an instrument for the improvement of efficiency, allocation and equity in water resources development and use, it was recommended that there be a review of national experiences in this subject, drawing on countries where it has recently been introduced.

- Bearing in mind that an adequate information base was essential to all resource management activities, it was further recommended that support be given to governments in information management and the building of information systems for the collection and analysis of data. A suggestion was made for the enhancement or establishment of "information system centres" at national level, as a component of this activity. Investment in information management at country level draws all national agencies into the exchange and contribution of information, and leads to improved inter-sectoral coordination, with mutual and overall advantages to integrated activities. There is a need to review current efforts to establish and operate information systems, at both national and global levels, in order to determine gaps and needs. Such action would assist in the development of a global water information system, which is being proposed and pursued by FAO.

- It is recommended that national policy reviews, reform and formulation, demand management principles, and considerations for national information centres then be tested on a pilot basis in selected developing countries, including giving assistance to national administrations. Egypt and Indonesia have expressed an interest in principle for such cooperation.

- With current attention being given to integration and coordination in national water management activities, it was recommended that similar attention be given to an intensification of coordination of UN system activities in this field through the mechanism of the ACC-ISGWR, which had been favourably reviewed during the Consultation. This proposal was accompanied by the suggestion that the ACC-ISGWR continue to take a positive role in stimulating inter-agency coordination.

FAO was requested by the Consultation to undertake initial action for the implementation of these recommendations within the UN system.

TECHNICAL SESSION II — **Research and Development**

This theme was discussed in a wide range of contexts, from the level of integrated river basin management, through scheme and system design and operation, to the development and selection of equipment and methods for data acquisition, irrigation and domestic supply. In all of these areas, the software and operational aspects, particularly the human element, were given high priority in a search for solutions to the common problem of diminishing quantities and qualities of water resources.

A key word in this session was "efficiency", with the objective of deriving optimum benefits from the resource through all possible measures. The UNDP/World Bank/ICID International Programme for Technology Research in Irrigation and Drainage (IPTRID) focuses on three R&D themes: Modernization of irrigation and drainage systems; Sustainability of land and water use; and Improving technologies for maintenance. In addition to the clear thrust for greater efficiencies, this aims at raising reliabilities of water supply, and so giving more incentive and willingness of the users to pay for an effective service. This aspect of improved reliability and its impact on cost recovery was also reflected in domestic water supply systems. It was noted that the "trigger" of water stress on communities had created an incentive for them to adopt improved technologies, opportunities for their involvement in the diagnosis and assessment of problems, and their participation in the introduction and testing of solutions — an important area of applied research in development.

There was general recognition of the necessity for a multi-disciplinary approach to all forms of research into improved on-farm water management (cropping patterns, improved genetic make-up with superior water-use efficiency, and agro-management techniques), and of the need to take into account the range of national objectives in optimizing the use of water which, in many cases, was for the maximization of production but in others could be to maximize the areas or numbers of people served, or for the creation of employment. These differing objectives would influence the selection of appropriate technologies and their application.

The frequent neglect of health consequences at the planning and design stages of water development projects, especially for irrigation, was an area calling for continued research. There were opportunities to incorporate safe domestic water supply into many such projects, at an acceptable cost, and for the modification of designs or operational practices that would safeguard the health of rural people in areas where water-related, often vector-borne, diseases were endemic. The efforts of the joint WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control (PEEM) were already reaching national and field level in this area of concern. It was suggested that this health and environmental linkage could benefit from the application of remote sensing and Geographical Information Systems (GIS) in the survey and monitoring functions for development, operation and management of natural resources. The technologies, already used in assessing physical potentials and changes, could also help in the identification of health hazards related to those conditions and circumstances, at little extra cost.

The pressure on freshwater resources, the increasing costs of their development, and the degradation of the quality of surface and groundwaters was forcing a shift to the use of lower quality waters where these could be utilized without excessive costs for treatment. This introduced the use of wastewater, brackish water and drainage waters as available resources, especially in agriculture, which had implications for possible decline in soil resources, impact on crop production and crop selection and association with human health problems. A number of initiatives for research and development into low-quality water use had already been mounted by the UN system, notably by WHO and FAO, through meetings and publications, and at field level. There were still many gaps in the knowledge required for site-specific management of low-quality water, and these extended to economic, environmental, health, social and cultural aspects. Referring again to the costs of water treatment, there was considerable scope for research into this subject for economical methods of restoring water quality, in order to supplement freshwater resources, particularly through aquifer recharge. In this respect, the selection of methods was closely tied to site conditions.

A recurrent issue in the Consultation was that of poverty, and the development of water resources systems that could be used by, and give benefit to the more deprived communities — a main thrust of the UN system generally. Considerable research has already gone into lower-cost domestic water supply and sanitation, especially in relation to the International Drinking Water Supply and Sanitation Decade, and with noteworthy achievements. There remain, however, widespread problems of service deterioration, of decline in sources and in the ability to sustain many systems, or at least to maintain an acceptable level of reliability. The routine monitoring of several key indicators, developed in the water supply and sanitation sub-sector, was held up as a possible model for application in the management of other water resources sub-sectors. It was suggested that research is required in the adoption of revised policies in the overall area of water management, allocation of funds, operational procedures, capacity building and institutions. Much is already being done but, with a growing need for increased effectiveness of rural populations to produce food, and to protect resources for the rapidly growing urban populations, there is a continuing need to enhance the quality of life in rural areas.

Within the overall context of water management, and associated research and development, the subject of drought was always apparent for its impact on the need to adapt technologies and multi-disciplinary operational techniques to deficiencies in supply. It was pointed out that flooding received less attention, although it was sometimes the cause of enormous losses to investment, crops and human life. Much could be done to alleviate this risk, through the application of meteorological and hydrological observation networks, advance warning techniques, design and operational procedures. Although it presented a complex and large-scale problem, technologies and communities could be mobilized and managed, in order to reduce losses considerably, as had been proved in China, and the reduction of flood damage was an important area for research and development studies.

The Consultation approved a short list of four researchable issues identified by the Working Group on Research and Development, noting the different scales of those issues, ranging from research into the feasibility of river basin management to more specific community and scheme levels. The fours areas for R&D are: (i) river basin management, (ii) water use efficiency, (iii) wastewater management, and (iv) optimization of system performance. Because of their diverse characteristics, each was considered in turn, and recommendations formulated individually.

RECOMMENDATIONS ON RESEARCH AND DEVELOPMENT

River Basin Management

The river basin framework for integrated rural water resources management involves the following elements:

- coordination of upstream and downstream aspects of water management;
- integration of multiple uses of water including irrigation and drainage, aquaculture and livestock, rural and urban domestic water use, industrial and hydropower water use, flood protection and environmental and health aspects
- conjunctive use of surface and groundwater resources
- integration of water quality and quantity considerations.

It is recommended that efforts be directed at research into, and the development, testing and application of:

- resource assessment and management methodologies, including the use of advanced technologies such as remote sensing, Geographic Information Systems, computer expert systems and isotope techniques;
- user-friendly modelling techniques for both large and small basin-wide analysis;
- appropriate economic evaluation methods and their application in basin-wide water management, which take into consideration social, environmental and health aspects;
- adequate incentives and mechanisms for inter-sectoral cooperation and community participation in the context of water allocation policies and the implementation of sectoral activities;
- ecosystem classification and innovative environmental management methods aimed at protecting the resource base and reducing the health risks associated with its development.

The World Bank will take initial action, within the UN system, in this overall R&D area. An initial contribution to ecosystem classification and human settlement issues relating to environmental management for health protection and promotion, in this context, will be the output of the technical discussion of the 12th PEEM meeting (incorporating a health component into integrated river basin management).

Water Use Efficiency

The Consultation recognized that a more efficient use of water resources in all sub-sector activities, but particularly in the irrigation sub-sector, is of paramount importance to sustainable management of the resource base. It is a key rationale for demand management. Inefficient use of irrigation water not only makes it necessary to divert and/or pump large amounts of water, in the process incurring high costs to governments and users, but it also results in environmental degradation with such phenomena as waterlogging, salinization and pollution, and in health risks, as apparent in, for example, the increased incidence of vector-borne diseases. In drinking water supply systems, inefficient and defective distribution as well as insufficient control at the users' level have resulted in unnecessary water losses and contributed to inadequate and inequitable service coverage.

In order to address these issues, the Consultation recommended that R&D activities be undertaken with the following objectives:

- technical improvements for the more efficient conveyance and distribution of water in both irrigation and domestic supply systems, with special reference to local adaptability, durability, cost effectiveness and easy maintenance; and
- the development and testing of improved on-farm irrigation methods that will contribute significantly to water saving. There should be an emphasis on the water-saving potential of different irrigation and cropping methods and practices, in combination with crop/soil management, soil hydroponic systems, protected agriculture and genetic improvement. These R&D activities in particular should include an assessment of the environmental and health effects of new technologies.

The Consultation further recommended that FAO take initial action in this R&D area, within the UN system.

Wastewater Management

The Consultation recognized the importance of low-quality water (including waste water, brackish water and drainage water) as part of the available water resources of countries in the arid and semi-arid regions of the world. It also recognized that further investigations are needed in support of the successful implementation of sustainable waste water re-use systems. In order to address existing knowledge gaps it is recommended that the following initial R&D activities be undertaken:

- for the countries in arid and semi-arid areas, develop guidelines for the establishment of sustainable low-quality water re-use systems and the upgrading of existing systems, and provide relevant information on policy, technological and institutional aspects and on pertinent environmental, health, socio-economic and cultural issues;

- assist countries in translating these guidelines into national standards and codes of practice for the use of low-quality water, taking into consideration local priorities and constraints.

On behalf of the UN system, WHO will take initial action in this R&D area.

Optimization of System Performance

The Consultation noted that the sub-optimal performance in all types of schemes, in the various water sub-sectors, results in high costs, declining services, environmental degradation and weakened benefits. There is a complex set of relationships among several key factors affecting this situation, including:

- Management: the provision of water services through operational control of human, physical and financial assets of the system;

- Maintenance: the preventive and remedial actions necessary to keep a system functioning at the level of performance for which it was designed;

- Financing: the willingness to pay for the desired levels of services by the users of the system;

- Institutional strengthening: the legal and policy framework which assigns responsibility to agencies to implement and coordinate their programmes;

- Technology application: the application of technologies that have been successfully used in one sector to other sectors, where such application has potential but is not yet adequately utilized;

- Innovative extension methods.

The Consultation believed that greater attention should be given to identifying and developing techniques in each of the above areas in order to improve the performance of water resources management systems.

Specifically, the Consultation recommended that a joint task force be organized by those agencies that have active R&D programmes dealing with one or more of the above key factors. This task force should:

- identify the detailed aspects of each of these factors needing special attention;
- establish a framework for cooperative action to develop the identified aspects;
- prepare guidance material for overall optimization of systems' performance.

WHO will take initial action in this R&D area, within the UN system.

TECHNICAL SESSION III — **Capacity Building for Water-sector Development and Management**

The basic components determining the capacity of the system were identified as human resources development (HRD) and the institutional structure. There had been considerable work over many decades by the UN system and large numbers of national, international and other organizations, aimed at both these components. It was, however, recognized that further improvement is needed.

The reason for this lay in the pressures and changes imposed by population increases, by proportionally greater increases in demand, and by the resulting decline in quantities of high-quality water. Technologies, data collection, management systems and the administrative, legislative and regulatory institutions had been unable to keep pace with this rate of change. Many of the interventions, whether national or external, had been placed within artificial, short-term time-frames, whereas continuity and monitoring were essential to this dynamic situation, and HRD had tended to assume that the problem would respond to the training of personnel and handing them the responsibility for action.

The starting point for reviewing the adequacy of institutional capacities had to be the ability to assess the scale and type of water resources and the various options and costs of developing these resources in an environmentally sustainable manner, to meet future assessed needs. This was essentially a multi-disciplinary task calling for the collaboration of representatives of the various sectors and communities involved, for they would all be concerned in the formulation and functioning of the system. Institutional development should, wherever possible, then build on existing facilities, taking advantage of corporate knowledge of the current status, and utilizing accepted and traditional structures which would be involved in future arrangements, even if modifications were needed. In fact, such modifications would call for the cooperation of the existing system and its personnel — both formal and at informal community level — if they were to achieve acceptability and cooperation.

The creation of an environment in which water management institutions and personnel could function called for attention to a wide range of issues. Perhaps the crucial element was the establishment of suitable policy and legal frameworks, which also demanded the cooperation of many sectors. Discussions had highlighted a number of issues to be taken into account in this respect. The first of these was the identification of water as an economic and social good, with a value, and thus an appropriate charge for its use.

All these items, together with the services for data collection, exchange, analysis and dissemination necessary for rational management and decision-taking, require investment in operational facilities and in trained staff. This applies to each sector involved, whether responsible for agriculture, domestic water supply and sanitation, local industries or others with effects on the common water resource or with concern for environmental or health aspects linked to its management.

The development of human resources to meet medium and long-term demands of the complex and multisectoral system that this implies calls for action at various levels. The training of high-level professional and technical staff is perhaps less of a problem than that of middle-level and operational personnel, but the need for the development of abilities to operate in a multi-disciplinary context is increasingly important. For all personnel, HRD does not end with placement in a post. It has to be complemented by attractive employment practices, career structures and incentives to stimulate interest and enthusiasm.

It has to be recognized that institutions include not only formal organizations, but also less formal groups. These certainly include farmers' associations, rural water supply management systems at district or village level, and all relevant communal units with delegated responsibility for operating a water use system or an associated system of sanitation. Current trends to devolution are making this a more important element in water management, and it is proving basic to the sustainability of systems that the communities have a large measure of responsibility in operation, maintenance and cost-recovery, whatever the end use purpose.

This level of HRD has received appropriately great attention in recent years, which was justified in view of the large scale of the task. Features of the approaches include many initiatives to "train the trainers", in order to achieve the necessary multiplier effect. TCDC, technical cooperation among developing countries, has also provided a valuable means of transferring knowledge gained in similar circumstances. With regard to the health aspects associated with water supply and sanitation (among other rural concerns), it has been found that one of the most effective channels for creating awareness of measures to safeguard and improve human health lay in the education of young people, with transfer of the knowledge from them to adult members of the community.

The Consultation was informed of various innovative approaches now being applied, both in this respect and in the training of staff at executive and at policy and decision-making levels, through activities of the WHO Community Water Supply Unit and PEEM.

The starting point for discussion of this theme, by the Working Group, was the Strategy for Water Sector Capacity Building which was formulated in the Delft Conference of 1991, and was further elaborated in the Dublin Conference of 1992 as an input to the UNCED conference of Rio de Janeiro. Capacity Building consists of:

- the creation of an enabling environment for capacity building, with appropriate policy and legal frameworks; policy issues to be addressed include a focus on sustainable development, and water to be considered as an economic and social good, in accordance with UNCED Agenda 21, Chapter 18, on the protection of the quality and supply of freshwater resources;

- institutional development, preferably building on existing institutions; institutional development includes national, local, quasi-governmental, public and private institutions, and community participation;

- human resources development and the strengthening of managerial systems.

Key actors in capacity building include government at various levels, external support agencies, education, research and training and extension institutes, professional associations, national and multinational corporations, and the private sector.

RECOMMENDATIONS ON CAPACITY BUILDING

The Consultation adopted the following Recommendations:

- National Water Sector Assessments should be facilitated and supported by the UN system and bilateral agencies as a starting point for the identification of capacity building needs and priorities. A country assessment is the first step in the definition of capacity building programmes. In view of the wide variety of conditions in different countries, these programmes will have to be tailor-made. The assessments should, as much as possible, be carried out by national experts with the External Support Agencies assisting where required. Initial action has been taken in this area by UNDP, World Bank and UN/DESD in launching national water sector assessments in a number of countries. It is intended that other United Nations agencies participate in these assessments, in their fields of specialization, as the programme gathers momentum.

- National governments and support agencies should enter into long-term commitments to facilitate programmes for capacity building, which must be seen as a steady and continuing process. Relatively small inputs over a long period of time are considered to be more effective than larger inputs of short duration. For example, long term support to a water resources centre for research and education (e.g. through incentives, operational support, technical support, fellowships, information exchange, etc.) could induce such centres to become focal points for capacity building, including policy development, institutional development and human resources development.

- Water Sector Capacity Building should form part of Integrated Water Resources Management. When focusing on the rural environment, capacity building should also promote the integration of national development objectives.

- Opportunities should be taken for the networking of institutions, which is a powerful tool for capacity building, and in particular for the exchange of experiences and capacities between developing countries.

Actions already initiated, in capacity building, by UNDP, are in harmony with the above recommendations, and it is intended that other organizations of the UN system collaborate as appropriate.

MECHANISM OF COORDINATION AND COLLABORATION

In the course of the Consultation, participants were informed of the recent death of Mr. G. Arthur Brown, who had served so effectively as Chairman of the UN Inter-agency Steering Committee for Water Supply and Sanitation. Mr. F. Hartvelt, UNDP, expressed the sadness of members of the Consultation and of colleagues of Mr. Brown, who will be sadly missed.

The subject of the mechanism of coordination and collaboration among UN Organizations and between UN Organization and Member Nations and External Support Agencies in the water sector was dealt with in a Discussion Forum. Existing mechanisms were discussed with respect to four programmes, namely:

- the Water Supply and Sanitation Programme under the framework of the Collaborative Council (WSSCC) — with secretariat in WHO;

- the International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD) — with secretariat in FAO;

- the International Programme for Technology Research in Irrigation and Drainage (IPTRID) — with secretariat in WB; and

- the Panel of Experts on Environmental Management for Disease Vector Control (PEEM) — with secretariat in WHO.

Discussions were focused on coordination and collaboration on activities relating to programme formulation and implementation at national, regional and international levels and both within and beyond the umbrella of the ACC-Inter-secretariat Group on Water Resources.

The consensus of the Consultation was that the existing mechanism of formal coordination by the ACC-Inter-secretariat Group on Water Resources is adequate to promote the objectives of integrated rural water management within the UN system. At the same time, the Consultation was aware of the need for collaboration of a more technical and informal nature among relevant agencies in the system and with appropriate external support agencies and NGOs.

The Consultation considered that collaboration should extend to activities in support of government programmes in integrated rural water management. These should, in particular, have the objective of improving integrated rural water management at the country level.

The areas adopted by the Consultation, namely policies, strategies and planning; research and development; and capacity building; should form the basis for collaboration.

PRINCIPLES AND MODALITIES TO PREPARE GUIDELINES FOR INTEGRATED RURAL WATER MANAGEMENT

The Consultation had provided a preliminary framework for the identification of principles for the preparation of guidelines on integrated rural water management. It is intended that these guidelines will emerge from the implementation of the recommendations of the Consultation. Further discussion on the recommendations of the proposed guidelines and modalities will be undertaken at a second meeting on the subject to be held within two years.

CLOSING ADDRESS

Following the presentation and adoption of the Report and Recommendations of the Consultation, the Chairman of the Concluding Session, Dr. Wim G. Sombroek, invited Mr. Guy Le Moigne, Senior Adviser, World Bank, to give the closing address.

Mr. Le Moigne informed the Consultation of the now advanced status of the World Bank Water Policy Paper, which had benefitted, in its long drafting process, from comments by various UN organizations, including FAO, WHO and UN/DESD, from environmental organizations and NGOs.

There are many common features in the WB Policy Paper and in the themes and areas considered by the Consultation. Both proposed the development of a water resources management framework, with strong legal and regulatory mechanisms, and both emphasized the essential roles of incentive pricing, demand management and cost recovery in attaining efficiency and sustainability. Current trends to the decentralization of water services and the complementary need for coordinating mechanisms are issues of concern in the World Bank and in the Consultation, as also is the participation of water resources stakeholders, in integrated management processes in order to ensure sustainability of the resources and their uses. Similarly, the protection, enhancement and restoration of the quality of water, and of water-dependent ecosystems are common areas of attention, as is the provision of water supply and sanitation to the poor.

Many of the areas of action proposed by the Consultation - river basin analysis, information systems, education and human health, among others - are also found in the WB Policy Paper. The Consultation was informed that its work, and the report arising from it, were very timely at this point in the finalizing of the Policy Paper, and entirely in keeping with the current attitude of the World Bank for closer cooperation with FAO and other agencies with expertise that would complement that of the Bank.

Finally, Mr. Le Moigne complimented the organizers of the Consultation, and the participants, on their efforts and on the success of the meeting. He proposed that FAO initiate the identification of benchmark indicators, in collaboration with participating UN organizations, to assess progress in the implementation of recommendations for the next meeting, to be held within two years. However, he warned that integrated water management must be seen as a very long-term task, with population trends imposing drastic changes in water allocations, especially a shift from agricultural use, for many decades.

The Chairman thanked Mr. Le Moigne, and expressed his appreciation of the presence of senior officers of national governments, and their active participation as officials of the meeting and contributors of technical papers. The assembling and the joint efforts of representatives of many of the UN agencies with water programmes gave cause for optimism in future work, and he hoped for a number of informal meetings on the subjects and recommendations of the Consultation during the next two years.

Proposals were made for WHO or FAO as possible host agencies for a subsequent Consultation, and a decision will be taken at a later date, following informal discussions.

The various members of FAO who had been involved in preparatory work, in running the Consultation and in presenting the GIS and remote sensing activities of the Organization were thanked for their willing efforts and hard work.

The Chairman then declared the Consultation closed.

Technical Session I

Policies, strategies and planning

Policies, strategies and planning for integrated rural water management

The Dublin Statement on Water and Sustainable Development (ICWE 1992) provided guidance for concerted action to reverse the trends of overconsumption, pollution and rising threats from drought and floods. One of the fundamental principles of the Statement was that water has an economic value in all its competing uses and should be recognized as an economic good. The action agenda for implementation of the Statement, in respect of agricultural production and rural water supply, recognized the need to provide food for rising populations and to save water for other uses. Success in achieving these goals will depend on the adoption of appropriate policies and programmes at the local, national and international levels.

The regional missions undertaken for an assessment of progress and problems in implementing the Mar del Plata Action Plan, revealed that many water-related problems have their roots in defective policies and institutional arrangements, with economic and social aspects prominent in this respect (FAO/UN 1991). While the diversity of conditions on a global scale precludes the formulation of any general prescription for national policies, plans and strategies for water management in a rural and agricultural context, there is ample justification for the discussion of common themes, problems and initiatives. This may also be an opportunity to draw attention to a number of issues that sometimes appear to be overlooked in many of the technical, economic and theoretical treatises that are currently being directed at the introduction of **integrated water management.**

CONCEPT OF INTEGRATION

Before addressing the specific theme of Integrated Rural Water Management, it is necessary to place it within an overall context of water resources, for it is the resource itself that forms the common base which is affected by the combined demands of all users. As a corollary, the impact of those demands on the resource affects its capacity and value in meeting the many and varied user requirements. So, while focusing on rural and agricultural concerns, in this paper, the issues of actual or potential competition and conflict with other sectors,

KEYNOTE PAPER 1

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(urban development, industry, energy, navigation, leisure, wildlife and conservation), must be considered and weighed in any truly integrated approach to water resources management.

Integration may be seen as the consolidation of the interests of resource users - interests which may be actually or potentially in conflict. It is often viewed with suspicion where it implies a loss of established powers and, in most cases, the pressures for integration are political rather than technical. However, in general, integration aims at remedying fragmentation, duplication and the closed visions of organizations working within narrow mandates. Integrated rural water management should therefore provide mechanisms for the coordination and consolidation of differing and conflicting interests of intra-rural water users in order to achieve an efficient, environmentally sustainable and socially acceptable pattern of water use. The design of an appropriate water policy therefore involves the balancing of complementary and competing objectives.

Such a policy must be pro-active, taking into account the objectives of various sectors and users, at different levels, and anticipating potential problems. Furthermore, the attainment of integrated rural water management is dependent on political commitment and the cooperation of all organizations within the rural sector, where it should provide an important strategy for natural resources management and conservation, sustainable agriculture and rural development.

Some common principles for framing integrated rural water management policy are:

- trade-off among production, environmental and social objectives;
- rational and fair estimates of water values and water charges and an understanding of the economic aspects of rural water management policy;
- awareness of the entitlements and obligations of water users;
- appropriate frameworks for regulation and adjudication.

Historically, each interested party, or sector, had its own proponents and infrastructure, and managed its component water activities to its individual advantage. This situation has prevailed, and is still generally reflected in the sectoral structure and hierarchy of most national administrations. With the inherent and entrenched interests associated with such a management system, proposals for major changes to the traditional sectoral allocation of responsibility, control and associated power are bound to incur resistance and protest. It can be argued that no allocation system can be perfect, there will always be "winners and losers", so why this recent fashion for a shift to "integrated management", especially with so emotive an issue as water resources?

The answer, already facing many communities and threatening millions of people in all regions of the world, is that without the introduction and application of the concept of **integrated water management** they will all lose in terms of resources, environment and quality of life.

This has an impact on all major policy objectives aimed at economic and social welfare. With the vested interests of established groups to consider, and the need to overcome obstacles of administrative and legal deficiencies, approaches must be pragmatic and comprehensive. But it is no longer a question of whether to integrate the management of water resources, but how, and to what extent, and within what time frame this can be achieved.

The management of water in a rural context has a distinct, and often vital rôle in determining the status of the resource and its potential use, through its association with land. The contribution of precipitation to usable water resources is largely dependent on catchment conditions of topography, geology, soil, vegetation and land use, the last of these providing a variety of opportunities to modify flow patterns to surface and sub-surface water-courses and storages. Rainfed cultivation of field crops or forestry often has the first call on water use, and an effect on downstream quantities and discharge régimes. Soil loss, and consequent sedimentation, which are strongly influenced through land management practices, can have a profound effect on qualities, values and costs of water to users lower in the system, by impeding natural drainage, blocking constructed hydraulic networks and reducing reservoir capacities.

Irrigation, the major abstractor in so many agricultural based economies, offers a low return per unit of water, in comparison with most competing users, and may create problems for subsequent use through the degraded quality of return flows. The same is true of primary crop processing and is certainly the case in intensive livestock enterprises, where the incidence of pollution of surface and groundwater has recently become prominent in many of the more developed agricultural areas, and equal in severity to the impact of some urban industries. With conservation areas often located in close proximity to rural activities, local populations may, by tradition, assume a right to exploit these facilities and resources for local benefits, in conflict with those desired by more remote groups.

On the other hand, rural communities are also affected by other water users, sometimes by the physical encroachment of urban and industrial development on agricultural land, with drastic changes in water abstraction, supply and use; problems of effluent management; and the disruption of employment and settlement patterns.

It is clear that any integration of water management must consider rural, urban, industrial and all other users. But the rural sector, in perhaps a majority of countries, has a unique feature that distinguishes it from all others — a primary rôle in the management of land resources and their sustained productivity. This places the sector in a position of influence on overall water availability and quality, and on the conservation of aquatic ecosystems. It should therefore exert an equally powerful influence in the formulation of water management policies and strategies.

ISSUES IN WATER POLICY FORMULATION

Policy objectives

The purpose of a water policy is to ensure the continued and sustained supply and value of water resources in meeting current and future needs, in harmony with the national political, socio-economic and developmental frameworks. This implies that policies have long-term implications, but must be adaptable to the dynamics influencing and modifying those needs. This feature must also be reflected in the structures and institutions responsible for implementing those policies, and through them achieving the most appropriate allocation of water resources, the optimization of their use, and their conservation and protection.

Many societies have already reached a state where the quantity or quality of surface or groundwater is imposing limits on present services or proposed development, and others are approaching a similar situation. They are faced with a common problem — existing policies, and the mechanisms and institutions for implementing them, may not provide the necessary means to facilitate evolution in the patterns of water use. This calls for a change in those policies, to remove constraints to the development, management and conservation of water resources.

In Malaysia, recent rapid economic development, coupled with population growth, called for such a change in policies to permit the integrated development and management of the country's limited water resources. For this purpose, a National Water Resources Study was carried out, and completed in 1982. The results of the Study include the establishment of a National Water Policy; a realistic water pricing policy; strengthening of the water administration and institutional framework; and the streamlining of legal provisions. (Malaysia 1992).

Whereas in Malaysia the incentive for a water policy arose mainly from the recognition of approaching shortages in specific regions, and high costs of future water development, other countries with already more intensive water use are particularly concerned with deteriorating water quality. The severity of water contamination, and the costs for its correction incurred by all users, have recently given rise to the formulation of relevant policies in most of the industrialized world, and generally to the adoption of the "polluter-pays" principle. This is a useful management tool where the source and effect of the problem can be identified and correlated, but these conditions tend to be limited to industrial or municipal "point sources" contaminating surface waters.

A far more difficult situation to define and to correct is that of "non-point source" pollution, for which agricultural practices are largely to blame. The problem becomes especially grave when groundwater is affected. Contamination from fertilizers, pesticides, animal wastes and crop-processing effluents may not be recognized before serious damage has been caused to groundwater quality. Sources cannot easily be identified, and remedies are likely to be costly, or very slow to take effect, and perhaps not even technically or economically feasible. In a number of countries, such as Germany, Turkey and the United Kingdom, the law permits the designation of water protection zones where certain activities are banned completely, or tolerated only to a limited extent.

Groundwater management in both industrialized and developing countries is an issue of great concern to water policy-makers, planners and legislators, not only with regard to pollution, but also in respect of resource sustainability. Over-pumping in excess of recharge rates is common in many areas where groundwater is used for irrigation. Examples of this can be found in northern China, in Tamil Nadu and Gujarat in India, in Yemen and in the United States of America. In the USA, roughly a fifth of the nation's irrigated area is watered by pumping in excess of recharge. (Postel 1989).

Such overdraft depresses the water table and increases pumping lifts, and the costs of installation and abstraction. It may also induce recharge of the aquifer with low-quality drainage water or cause salt-water contamination near coasts, as is happening in Argentina, El Salvador and Mexico. In France, an examination of existing legislation showed it to be of little avail in dealing with many urgent hydrogeological problems. Laws which completely ignored the real physical characteristics of groundwater, for instance, would not lend themselves to proper regulation of groundwater use; neither could they help in dealing with problems such as run-off from non-point sources; the same was true for accidental pollution. Sanctions against breaches of law were inoperative and required strengthening to stimulate efficient preventive measures on the part of potential polluters. (UN/ECE 1989).

Many groundwater sources have been developed for domestic and municipal supplies, because of their quality, and so have a high value. Inappropriate allocation of such water for low-value usage in agriculture, with possible — perhaps irreversible — damage to quality, must be given prominence in future rural water management and associated policies and planning. The general issue of resource allocation among users in the rural context is of course at the heart of integrated water management, and basic to the formulation of policies, strategies and plans to achieve that objective.

Apart from specific uses of water for productive purposes and for domestic supply, it is relatively recently that the concept of water as a resource in its own right has been recognized, with emphasis on its prime quality and the various functions to be maintained or restored. This has led to the "ecosystems" approach to water management, and the principle that aquatic systems should be protected in their natural state is becoming increasingly evident in national water policies. While the approach is aimed at benefitting a wide population, it is the rural communities that are most closely associated with these management practices - possibly at times with a degree of sacrifice in respect of potential productive or development options that may be foreclosed by such decisions.

Forecasting demand

In formulating policies and strategies for water management, one of the basic criteria is that of the assessed demand and its prediction over appropriate planning time-frames. In the past, where water resources or costs have not been too severely limiting, programmes for the development of additional supplies have usually served to meet predicted needs.

However, there are many recent examples of excessive development planning due to over-estimates in forecasting. There are also many cases where excessive supply (or at least excessive application) has created problems and damage, notably in irrigated agriculture, and where high investment in development has been accompanied by an unacceptable level of wastage. Agriculture is commonly criticized for its low efficiency in water use, but it is not alone in this. A review in 1992 revealed average losses of 23.7% from water mains in systems supplying domestic, municipal and industrial users in England and Wales. (Bolton, 1992). Such figures indicate an important area for consideration in assessing and meeting demands.

An extremely serious problem is the potential that urban migration from rural areas creates for high levels of future water use. A 1987 study in Beijing, for example, suggests that domestic water use will increase by nearly a factor of three during the period 1984-2000 (Chinese Research Team 1987). This reflects an expected 24% increase in population and a 126% increase in *per caput* water use. Yet existing water sources for the Beijing-Tianjin area are already fully utilized: increased urban water use will require inter-basin transfers or the reallocation of water away from agriculture. In this case, and in others like it, demand management will be an important component of the ultimate solution.

While recognizing the increasing scarcity of water resources, and the need for change from a water development to a water management approach, it must be realized that continued development of additional supplies may, in some circumstances, be entirely justified, with no feasible development alternative, as exemplified by the Sardar Sarovar Project (SSP) in India (Seckler 1992). The SSP, one of the largest irrigation and hydropower projects under construction in the world will divert 12 000 million cubic metres of water per year from the Narmada river to provide 1200 MW of hydro-power; improved access to domestic water for 40 million people; and the irrigation of 1.8 million ha of land. Even assuming the attainment of only 70% of the irrigate area, the SSP will provide food for some 18 million people, or about one year's increase of population. The example shows how important it is to continue progress in the same direction of development, and unfortunately there is no major alternative to irrigation development in India.

Demand management

The management of demand, through the more economically efficient supply and use of water, and through changes in production practices as well as the reduction of wastage, is a vital issue in resource management strategies and planning. It requires, of course, that all users recognize and accept that water supplied to them has a value, whether utilized by them for production or as a medium for waste disposal, and has a cost that must be met if the resource is to be sustainable for continued use. The OECD report on Water resources management — integrated policies (OECD 1989) noted that there is growing evidence of demand policies being used to close prospective supply-demand gaps.

Various measures can be applied to modify demand, usually for its limitation but, in certain desirable development circumstances, to encourage greater use, as for example the promotion of domestic water use in poorly-served communities, for its potential health benefits. Regulations can be imposed restricting water use, e.g. the zoning of land use and agricultural practices or certain crops, as in the limitation on paddy production in Malaysia; exclusion of industrial processes of heavy water-demand or potentially degrading to recipient waters; limits on withdrawals in periods of shortage, either in occasional emergencies or as a component of a standing drought-management policy. Such regulations tend to be selective and confrontational and, unless the reasons for their introduction are fully understood and accepted, they are likely to raise protests that may be detrimental to the image of a political group imposing them.

In general, the current trend in the introduction of demand management strategies is towards the wider application of the **User-pays Principle**, recognizing at the same time national and local historical and social backgrounds. The essential element in the User-pays Principle is that an incentive is provided for the user to economize in the use of the service or of the natural resource. An example would be the provision of credit, or financial assistance for the introduction of water-saving technologies. However, problems arising from the difficulty and costs involved in measuring quantities of water may make this a distant goal in the case of most irrigation agriculture in developing countries. Under Islamic principles, water is considered a free good, but payment for the service of delivering water to the user is acceptable.

ECONOMIC ASPECTS OF INTEGRATED WATER MANAGEMENT

Current FAO economic research in the agricultural and rural sector has confirmed that water-using sectors in many countries are reaching a significant transition point. Most countries have only limited technically-, financially- and environmentally-viable investment options for water supply projects, and a litany of contentious water-related issues is now calling for a different vision on the part of the policymakers.

In today's rural water economies, policymakers must concentrate more on the demand-side and on user-focused approaches, with a view to the reallocation of existing supplies, encouraging more efficient utilization and promoting sustainable development. As the costs of new supplies begin to exceed potential economic benefits in the least-productive existing uses, reallocation, rather than the development of new supplies, (if indeed such supplies exist), becomes the least-cost solution. This will require a structure of incentives, regulations, permits, restrictions and penalties to influence and to coordinate rural water uses.

As economies and populations grow, competition for finite resources will increase among rural users and between rural and urban users. Undesirable third-party effects from water quality degradation or other interferences will become more frequent, and the values of non-consumptive in-stream uses such as amenity use and fish and wildlife habitat will rise.

There is need to develop a framework for the analysis, design and integration of rural water policies. The objective must be to broaden the understanding of how existing and proposed economic policy instruments can influence rural water use across economic sectors; between local, regional and national levels; and among rural households, farms and rural industries. This process should start by establishing an understanding of how the rural water sector is linked to the national economy and how macro-economic policies affect water resource allocation and overall water demands in the economy. An obvious example of this is public spending and investment on irrigation projects, in the pursuit of a national food self-sufficiency goal.

Agricultural development strategies also affect water use indirectly. For example, to achieve rice self-sufficiency, water-intensive inputs and credits are often subsidized, influencing the demand for water and for private investment in irrigation through price policies. The effects are (i) **inter-sectoral**: the agricultural sector is provided with an economic advantage, (ii) **intra-sectoral**: water for rice gains an economic advantage over water for other crops, and (iii) **distributional**: rice producers with more land gain over those with less, as well as (iv) **environmental**: increased pesticide and fertilizer use are likely to affect water quality.

Policies in one sub-sector affect water use and allocation in the others. Water yields are influenced significantly by policies for wood production and rangeland management in the upper and middle watersheds. It therefore becomes important for water managers to recognize and to integrate with management policies in sub-sectors such as forestry and livestock.

Many developing countries are implementing fundamental changes in macro-economic policies. The direct implications for water managers can be expected to include a shrinking share of government budgetary resources for new investments, reductions in irrigation subsidies, increased efforts at cost recovery and more emphasis on improving efficiency in the use of existing supplies. With increased competition for government investment budgets, as for example when the choice may be between investment in irrigation or hydropower, there is an additional social opportunity-cost of irrigation water in countries dependent on imported energy sources.

In summary, basic water policy questions include: how does the rural water sector fit into the overall economy; how are macro-, sectoral and other related economic policies changing water resources allocation, and are such policies possibly having unintended negative effects on water use and management?

Water and price

The real **value of water** is slowly being recognized. Once considered a classic free good, it is now becoming scarce, and acknowledged to be increasingly valuable. Even the supply and delivery have sometimes remained free, because governments have chosen to subsidize the services. A reorientation of this attitude is to be expected, as these subsidies are now coming under scrutiny.

Despite structural adjustment, almost all public irrigation systems in the developing world are, for a number of reasons, still subsidized. Whereas, notwithstanding subsidies, the beneficiaries remain low-income farmers they are not the poorest of poor. Therefore equity arguments for imposing service fees can be added to the arguments for general subsidy removal associated with macro-economic adjustment programmes.

The removal of water subsidy implies some kind of service fee to an agreed level of cost recovery. However, important financial policy issues need to be addressed before full cost recovery is attempted. The fundamental role of water prices is to help determine the allocation of a limited resource among competing uses and users, implying both efficiency and equity objectives. In practice, agricultural or rural water supply prices are seldom set by market forces but rather by a publicly owned utility or a regulated private water company. Each charging system, be it flat rate charges, marginal cost pricing, average cost pricing and the ability to pay has different implications for allocative efficiency, equity and fairness in apportioning costs. There is a general convergence of opinion on the notion of an opportunity-cost pricing system based on transferable water rights. The practical problem is a legal one, with government reluctance to surrender, assert and protect water property rights. Fundamental changes in pricing schemes can have significant but different effects, with different reactions from different consumers. The main differences in attitudes can be expected from domestic consumers, on the one hand, who would normally accept equitably designed water charges, and from irrigation and industry on the other, being unable to adapt rapidly to a rational charging system, since earlier, lower charges have already been capitalized into land or other fixed assets.

COUNTRY EXPERIENCES

While common issues for integrated policy have an analytical value, for national water managers, actual country experience of processes for policy review and change provides probably more relevant information than do general prescriptions. In this way, the variety of differing national and local conditions for policy reform is fully acknowledged, and as a consequence emphasis is placed on the need for national water policy reviews drawing on country experiences. It was from this viewpoint that the Natural Resource Management Group of the Organization for Economic Cooperation and Development examined measures to improve the integration of policies within the water sector and other government agencies (OECD 1989).

One observation, based on more than 50 country reports and about 100 case studies, was that the opportunity for government agencies and individuals to initiate and to strengthen evolutionary changes towards an integrated approach is often provided by a **catalyst**. This may be a local, national or regional water resources problem, a financial crisis, or other event which disturbs the status quo. Within the OECD member countries, the "**trigger factors**" that have led to effective integration are, ranked in order of importance: (1) Crises;

(2) Interest Group pressure; (3) New research or data; (4) Political change; (5) Planning process change; (6) Staff change; (7) Administrative reorganization; (8) Macro-economic change; and (9) Other triggers.

The indication that "**crises**" were a common trigger factor confirms that, unfortunately, water policies are reactive and seldom pro-active, which again underlines the need for water policy reviews well in advance of the occurrence of such crises.

The **crises**, representing a major shift in the policy formulation circumstances, were occasioned by events such as a serious pollution spill, a drought, radical changes in agricultural markets, or a similar major new external stimulus to the decision-making institutions. These crises created both the imperative for policy change and the **political cohesion** to accept change. Interest Group pressure was identified as the second ranking factor although often acting in combination with the first. Perhaps particularly noteworthy was the impact of the collection or release of new data or research results on the effects of poor policy coordination.

The crisis trigger, and recognition of the influence of interest group pressure on policy are both evident in the Murray Darling Basin in Australia (Alexander, 1989), where the environmental and socio-economic dangers have required a drastic overhaul of state and federal legislation, administration and representation, in establishing the Murray Darling Basin Commission and the Ministerial Council. The Natural Resources Management Strategy is not only promoting community participation but, through its concept of Communities of Common Concern is aiming to encourage projects which are, in effect, **community-driven**.

The results of the OECD study show that moves towards changes and integration in water management are unlikely to come from the water resources agencies themselves. External stimuli are needed, and indeed are essential to create the social, economic and political environment in which institutional change is seen as necessary.

The high ranking of **research and data** is confirmed in the report of the UN Regional Commission for Europe, on Water use and water-pollution control: Trends, policies, prospects (UN/ECE 1989). Several governments have commented that integrated water management makes heavy demands on multi-disciplinary research. When planning, elaborating and implementing policy, it is often necessary to choose from a set of options. Optimal choices may be difficult, because of gaps in knowledge. Important research activities in this field are now seeking viable answers. Great attention is therefore being paid to the collection of data on water, in order to provide a solid background for policy formulation. It is becoming increasingly necessary to have access not only to data of the conventional type, but also to have a continuous flow of information on the state of the aquatic ecosystem.

Drought is often the trigger factor for a review of water resources policies and strategies. The depletion of groundwater in southern England, following four years of low rainfall, with severe restrictions on agriculture in particular, and strong protest from environmental groups on the drying-up of water courses and wetlands, has led to the study of major regional water transfers.

This envisages conveying water from northern rivers and reservoirs, using existing river systems and canals, wherever possible. A predicted increase in population in the water-short area is also stimulating this study, as is the possibility that drought may become a permanent feature of the British climate. These strategies are expected to take at least ten years to come to fruition, while water companies evaluate options and resolve the planning and financial issues associated with the major capital projects. Time is needed too, for detailed environmental impact assessments of the effects of the abstractions from northern rivers, and of the different chemical characteristics among river waters. (Bolton 1992).

In the meantime, the water companies are introducing short-term measures to increase capacities and to boost supplies in much the same way as they have done in dealing with droughts. These include efforts to eliminate mains leaks, the recharge of aquifers, and methods for charging customers for the amounts of water used, which has not been a general practice in the UK.

As the 1987 drought situation unfolded in India, the Central Government (GOI) launched a series of innovative measures to provide relief to the affected areas (GOI 1989). The states also broke new ground in meeting the complex needs of the situation, and several voluntary agencies stepped in to help in the drought-relief measures. The GOI identified the following major thrust areas for priority attention in providing relief; employment generation; provision of drinking water; fodder availability; supply of essential commodities; drought proofing. In addition, action was undertaken to improve the infrastructure for power generation and distribution, irrigation, public distribution systems and the status of health and nutrition of the people affected.

To ensure that employment generation resulted in durable and productive assets, the GOI laid down priorities for the selection of works: (i) tubewells; (ii) ponds; (iii) field channels; (iv) soil conservation and water-harvesting works; (v) road-building, where road links did not exist. Emphasis was placed on the proper use of available water resources, so as to insulate agriculture from the vagaries of the monsoon, and on increasing the irrigation potential by creating an additional 164 000 ha, within two years, under this programme.

The experience of Australia, as one of the countries currently taking a coordinated national approach to water resources management, could be of broader interest. Australia's approach is being facilitated by the development of national strategies to address a range of eight major issues including mechanisms for achieving integrated water resources development and management; integrated catchment management; a national approach to water quality management; a strategy for ecologically sustainable development; drinking water quality; market based pricing policies; and salinity.

It is considered that there will be considerable benefits from these strategic approaches, some of which, such as those for water quality management and salinity will accrue only in the longer term. One however is singled out for immediate benefits - the strategy for **market based pricing policies**, which is being applied to an overall policy for sustainable food production and rural development.

State governments have recognized that achieving sustainable agriculture is dependent upon establishing economically viable land uses in the longer term, underpinned by the efficient use of water in the irrigation sector. The move to long-term sustainability is being achieved by reforms to policies for charging for the delivery of water; the costs of drainage; establishing the value of water; and implementing transferable rights. Transferable water rights are a necessary adjunct to water pricing, breaking the tie between land and water, and allowing water to be transferred to areas where it can be used most efficiently. Experiences with temporary transfers of water rights have been generally favourable, despite initial misgivings on the part of some users. States are now considering schemes for the permanent transfer of water rights between users. (Australia 1992).

IMPLEMENTATION OF INTEGRATION

The main active factors in the implementation of integration are: administration/institutional, legal, and economic. These will be treated in some detail in other papers to be presented to the Consultation, but can be very briefly summarized in the terms of the OECD integrated policies report.

For integration to occur, it must be given political credibility and legitimization through political commitment, and the organizational structures involved must be considered with regard to the management functions to be carried out. Processes and mechanisms must be created to facilitate positive attitudes, discussion and interaction among participants within the organizational structure. Emphasis is placed on the importance of both formal and informal strategies, to encourage integration among people working in related agencies, and on the need for high quality staff with a broad base of expertise, and skills of interagency communication, negotiation and bargaining.

A significant amount of legislation enacted in the past decade shows that functional integration of water resources administration is a goal that is being pursued in the developed and developing world alike. What varies is the depth of integration sought, and the level of government at which it is pursued. Integration of water management responsibilities at central government level in Ethiopia had been attained in 1981, following the consolidation of virtually all water resources management activities under a National Water Resources Commission. Similar integration is reflected in Jordan's Water Authority. Integration of water management functions at river basin level appears in countries such as Italy, Jordan, Kenya, Nigeria and Spain (Burchi 1991).

Regarding legislation, any legal reform must recognize the nature of the existing legal system, if reform measures are to be accepted and supported. Legislation must support the objectives of maximum economic efficiency of water use, compatible with environmental interests and with equity considerations.

One of the economic aspects of integration is the cost of its implementation, which should be exceeded by the derived benefits if integration is to be pursued. Appropriate financing and economic instruments are generally held to be more effective than regulations alone, in achieving the efficient allocation of water resources.

Other important aspects in the implementation of integrated policies are the recognition of national circumstances in pursuing reforms, and the setting of clear integration objectives. Flexibility and time are necessary to give agencies the capability to respond to changing conditions, and this includes the periodic review of legislation to match the evolution of technical and managerial issues affecting water resources.

These features are all generally relevant to the implementation of integrated policies for water management, and therefore to the rural context, in view of the common resource. But, as with the need to recognize national circumstances, it is equally important that the problems, constraints, and perhaps opportunities linked specifically to the rural environment should be given appropriate weight. It is, after all, the rural community and its various

MANAGING RESOURCES OF THE MURRAY DARLING BASIN

The resources of the Murray Darling Basin are vital to the economic and cultural development of Australia. Competition for the use of these resources has reached a point where sustainability is under question. Major physical problems relate to the critical dependency of over one million people on the quality and quantity of domestic water supply; vegetation decline and land degradation; rising groundwater levels in saline sediments; and the loss of flora and fauna. In addition, much needs to be done to conserve the Aboriginal and European cultural heritage of the Basin.

In 1914, agreement was reached among three state governments (Victoria, New South Wales & South Australia) and the federal Government, to form the River Murray Commission (RMC) to manage the quantity of water in the river. Only in 1983 was the RMC legislative agreement altered to include water quality as a management objective. Since then, the creation of administrative arrangements for integrating resource management over the whole Basin has been swift. The **Ministerial Council** was formed in 1985. By 1986 all state governments had passed legislation establishing the new **Murray Darling Basin Commission** and a new **Agreement**.

Bureaucracies rarely know best. The **Ministerial Council** is very conscious of the need to obtain independent community-based advice on the numerous issues which it must consider. To achieve this, a **Community Advisory Committee** has been established consisting of representatives of existing state and national bodies, such as the Australian Conservation Foundation, as well as regional representatives. The Committee has a direct link with the Council, and may consider any matter of community concern with the Basin.

The Ministerial Council and the Commission have prepared a **Natural Resources Management Strategy** to address the diverse problems of the Basin's environment. A feature of the NRMS is the way in which it promotes community participation. The **Strategy** establishes the concept of **Communities of Common Concern** in the Basin. These are groups who are experiencing the effects of resource degradation. The emphasis is to support community-driven projects where the community, through a CCC, is basing its solution on a united approach developed by all stakeholders. (Alexander 1989).

"interest groups" that will determine the degree of acceptance and support that will be given to the proposed integration and reform of water resources policies and management. The process may also take some time, as described in the example on Managing the Resources of the Murray Darling Basin.

The consequences or impacts of introducing the integration of water management with other government policies may be classified as positive or beneficial (benefits), and adverse or negative (costs). Clearly, there should be benefits from the integration that outweigh the costs. Many of the impacts are difficult to quantify, but the OECD study on integrated policies attempted an assessment of experience. The results can be only indicative, rather than definitive, but the overall findings are positive.

The more important cost increases related to staffing, capital, and charges for water resources, and the benefits were highest in relation to standards, social and environmental aspects.

INTEGRATION IN THE RURAL CONTEXT

While the rural environment may appear at first sight to be relatively stable, it is ultimately subject to the same factors that induce change on a national basis. This means that it is also susceptible to international influences if it generates produce, income, or other assets beyond the local communities. Examples are: agricultural products with an external market; tourism; and internationally valued resources such as shared water resources or unique environmental features.

One of the factors with the strongest impacts and demands on the development and use of water resources is that of **population change**, which is now tending to place a stress on national resource management in most developing countries. The 1990 End of Decade Review of the International Drinking Water Supply and Sanitation Decade (WHO 1992), estimated the population in the developing countries to rise by 882 million between 1990 and 2000. This includes a estimated 312 million increase in the rural population.

In all regions, population estimates increased and, while the proportional increase was greater in urban areas, there was still a marked rise in the rural population, with the exception of the Americas, where it was estimated to remain almost constant. The direct implications of this for rural water management are two-fold. Firstly, there is an expected increase in absolute demand, to meet the greater numbers and any *per caput* increase. Secondly, urban competition for resources will create pressure for changes in allocation.

There are also secondary effects on the rural communities, in the conversion of agricultural land for urban housing and industry, with possible water quality impacts on rural users downstream from urban development. Population increase can be expected to induce greater demands for food production, energy and amenities, all of which may put further pressure on the allocation, management and conservation of finite water resources. One way or another, sectoral requirements must be adapted to water resource availability.

The **improvement of efficiency** is a key factor in water management. There are many components involved in determining the overall efficiency of national, regional or basin water resource allocation and use, and many options for the assessment of efficiencies, because of the range of uses of water and its different values for each of these uses. Common measures of efficiency relevant to rural and agricultural use include the ratio of volumes delivered to meet crop water needs on irrigated land, compared with volumes abstracted from the source; crop production per unit of irrigation water; value of product, or revenue per unit of water; employment or income generated per unit. As the measure of efficiency shifts from the purely physical ratio, the diverse factors introduced, (such as agricultural inputs, additional investments, labour, materials and markets), must also be considered in estimates of the potential value of water and the efficiency of its use in terms of the value derived. Limitations on water resources, or excessive costs for their development, will call for policy decisions to optimize benefits from the resource.

The experience of the Government of Malaysia in integrating a National Agricultural Policy and a national Master Plan for Water provides a good example of a hierarchy of efficiency measures. These range from technical innovation, through crop selection and zoning, to improved management systems, sector priorities and inter-sectoral transfers. Special attention is given to water quality, allocating poorer quality waters to irrigation and emphasizing soil conservation techniques and improved management of farm chemical residues to preserve water quality and to address environmental and health issues.

Complementary factors in the attainment of overall resource use efficiency, in the rural context, include **rainfed agriculture and the management of catchments** (for example in production or amenity forestry). The latter with its overall benefit to the entire water-using community, may offer a source of employment and income to people in the upper catchment. Both watershed management and rainfed agriculture have rôles in maintaining or modifying hydrological régimes, and have potentials for impacts on sediment loads, with implications for scheme operational costs and, where reservoir storage is involved, on the effective life of a development. These factors may be decisive in investment planning.

Another complementary and beneficial rural activity, often with minimal consumptive demands, is that of **fisheries** — both capture and aquaculture. Some control requirements, such as base flows, flood management or minimum storage, may impose constraints on water users but, in general, fisheries activities tend to be subordinated to major water uses. The value of the industry, or pressure from interest groups such as sport fishery, may however determine policies and priorities.

Considering production as a measure of water-use efficiency, it is equally important to take account of any **degradation of resources** resulting from that use. One of the main concerns in countries with extensive irrigated agriculture is the loss of productive land through soil salinization, sometimes of similar magnitude to the rate of new development. Strategies combining corrective measures with preventive techniques are called for, and one of the most effective is that of improved economy in the application of water, avoiding excessive use and consequent waterlogging. The gains are therefore two-fold in this case, and most of the major irrigation countries (China, Egypt, India, Pakistan), have strategies for land reclamation and water economy, to safeguard or to recover major investments in land and water development for agriculture.

The **pricing of water** is generally considered as one of the most effective means for gaining economy in its use, and therefore achieving an improvement in overall efficiency. Ability to apply a pricing system is largely dependent on the satisfactory performance of the water delivery system, the feasibility of measuring supplies, charging for the service accordingly, and recovering those charges. This would apply in cases such as pumped irrigation supply from surface or groundwater, and where delivery to the crop is by some system giving a high degree of control by the farmer, so enabling him to achieve economy in water use and consequent savings in the cost of his supply.

Young (1992) illustrates a more common situation in major Egyptian irrigation schemes where, under current conditions, the cost of monitoring and measuring water deliveries limits the ability to apply volumetric water charges, and charges sufficiently high to elicit any change in water use would reduce farmers' net income and have an adverse impact on farm land values. Therefore, for this and similar cases a higher degree of cost recovery would be achieved by a flat area charge.

Experience in the Philippines gives a more optimistic view of the financing of irrigation schemes (Svendsen 1992). By 1979 the National Irrigation Administration had achieved its goal of overall financial viability, and since 1981 no operating subsidy has been received from the national treasury. Few other irrigation agencies in the developing world have been able to reach this stage.

The broad policy outlined in the following, boxed statement is in accordance with the goals set in the **Agenda for action on sustainable agriculture and rural development**

(SARD), endorsed by the FAO/Netherlands Conference on Agriculture and the Environment in April 1991 (FAO/Netherlands 1991). It defines the responsibility of farmers and rural populations in maintaining production and protecting the environment. In both functions, water is a vital element, and its proper management in these contexts should receive appropriate reward. In the Asia-Pacific region, several countries have adopted a strategy of watershed management in rainfed agricultural areas, with these same objectives.

If, to be sustainable, agriculture must meet the challenges of food security, provide more employment and better incomes and contribute to the eradication of poverty, while at the same time conserving natural resources and protecting the environment, then the status and rôle of farmers in our societies must be commensurate with these responsibilities. The terms of trade between the agricultural sector on the one hand, and industry and the tertiary sectors on the other should better reflect the services rendered by agriculture to the general public. Similarly, the terms of trade between agricultural producers and those who process, market and consume agricultural products — urban dwellers in particular — must be changed to take better account of the cost to farmers and other rural people of natural resource conservation and environmental protection. Furthermore, North-South and East-West adjustments in commodity prices should be effected in such a way as to enable farmers to make a sustainable living from agriculture without being forced to cause further environmental degradation and depletion of the resource base. (From: Sustainable Development and the Environment: FAO Policies and Actions, Stockholm 1972 - Rio 1992, FAO 1992.)

In India, watershed improvement programmes have been aimed at soil moisture conservation; increased surface water storage and groundwater recharge; erosion control; and improved crop management, with programme management responsibility at the level of the benefitting communities or families. Most of the watershed projects launched during the past two decades have been quite successful. One, of 776 ha, at Tejpura, in Uttar Pradesh, returned a benefit-cost ratio of 3.42 after the completion of the work, (soil conservation, crop cultivation practices, afforestation and pasture improvement). Gross annual income per hectare rose from Rs1669 to Rs10 863, with gross family income up from Rs2878 to Rs18 725. Benefit-cost ratios of 3 to 5 in watershed-based rainfed agricultural areas have been reported from the Phillipines and Thailand (Singh 1990).

In irrigated agriculture, with considerably higher investment costs, the problem of cost recovery within the reach of farmer incomes has already been noted, and this is aggravated by a history of subsidized water supply which has come to be accepted as a right. Further distortions to true farm budgets arise from subsidies on fertilizers and other agro-chemicals and inputs to farming. The correction of these artificial adjustments, (aimed at national level food self-sufficiency), by increasing product prices to establish an appropriate farmer income, has obvious impacts on national consumer food prices, and on the competitiveness of exports.

For the most part, strategies to improve the situation for the benefit of both the farmer and national agricultural and development agencies, are aimed at the reduction of costs of scheme operation and maintenance through the devolution of many of the management activities to associations of farmers or water-users; improving irrigation performance and efficiencies; diversifying to higher value crops, where feasible; and raising crop yields and cropping intensities. Recent activities of this type are reported by the International Irrigation Management Institute (IIMI 1991).

POLLUTION AND ENVIRONMENTAL IMPACTS

The mobility of water in the hydrological cycle, and the multiplicity of its uses, means that each use, or management process, has the potential for an impact on some or all others. These impacts may be positive, for example improved watershed management or reservoir storage may offer benefits for better domestic and agricultural supply, for inland fisheries, amenity purposes, flood control and the protection of land, crops and dwellings. For most consumptive uses, including agriculture, and for processing purposes, there is a negative impact, through the reduction of quantity or quality, that forecloses options for other uses or imposes additional costs.

The negative impact of agricultural activities has become a major concern in many developed countries, but it is not limited to that group. Experience in the Latin America and Caribbean region, and reported by ECLAC (1990), serves as an example which is also replicated in other regions. Several South American countries, including Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru and Venezuela and water bodies in Central America and the Caribbean have experienced severe agriculture-related water pollution, with pesticide residues posing one of the problems. Several of the pesticide products in use in the region have been banned or restricted in a number of European countries and in the USA.

Abstractions from rivers for irrigation and other purposes can alter the annual hydrograph and thereby indirectly affect water quality. Under certain circumstances, this may lead to saline water penetration into deltas or estuaries, and the problem may be aggravated if abstractions are made during periods of low flow. This has been observed in the River Guayas, Ecuador, where saltwater intrusion has precluded the river's use as a source of water supply and as a recipient of domestic and industrial effluents for the city of Guayaquil, during low flows. Abstractions also reduce the amount of water available for the dilution of domestic and industrial effluents, and thus give rise to an increase in the intensity of pollution.

So, while governments have the power to enact legislation concerning policies affecting water pollution and water management, the implementation may not be effective. A likely "trigger factor" for a change to stronger policies and functioning institutional measures in the region may well arise from serious human health hazards, due to bacterial contamination of domestic water from sewage effluents - one of the major water management problems.

That, however typifies retro-active policies and legislation. Recently, recognizing that principles of environmental impact assessment (EIA) at the project level could be applicable to the environmental assessment of relevant policies, plans and programmes, a Task Force of the Senior Advisers to ECE Governments on Environmental and Water Problems reported that "a well prepared and timely environmental assessment of policies, plans and programmes can anticipate and highlight potential environmental problems, prevent delays, assist in long-term planning and prevent or simplify litigation" (UN/ECE 1992).

DRINKING WATER AND HEALTH

When the chairperson of the World Conference on the Environment and Development, Mrs Gro Harlem Brundtland, Prime Minister of Norway, addressed the 41st World Health Assembly in May 1988, she said "Recently, I was asked why health was not discussed as one of the major challenges confronting the community in **Our Common Future**. My reply is this: ultimately the entire report is about health." While accepting that human health may be implicit in the environmental context, the nature and relative importance of this connection may not often be clear to planners and decision-makers. As a result, it is only marginally apparent in the development policies, strategies and programmes of most governments and agencies, although the majority of these devote resources to specific health projects (Mather and Bos 1989).

The International Drinking Water Supply and Sanitation Decade, 1981-1990, was a period of accelerated and concerted efforts by governments of the world's developing countries to expand water supply and sanitation to the underserved populations. During this period, there was a marked increase in the rural populations of developing countries served with a water supply classified as "adequate and safe" by individual national authorities.

From 1980 to 1990, the developing world's rural population rose from 2303 million to 2658 million, while the number provided with a water supply, (as classified above) increased from 792 million to 1570 million (WHO 1992). For the most part, this was achieved through specific sectoral projects for water supply. It is seldom that advantage is taken of major investments in agricultural water development — particularly for irrigation — to incorporate a community water supply. More often, the people living on such projects, and rural poor in adjacent marginal settlements, derive their domestic water directly from the canals, drains and storages of the system, with the risks to health inherent to untreated water, and the likely contamination from agricultural chemicals.

In view of the current **Poverty-reduction Strategy** adopted by the World Bank (World Bank 1990; 1992), there would seem to be a strong case for encouraging policies for the integration of measures for the benefit of health and the quality of life in rural communities, within investment programmes for water projects targetted primarily at economic development. This concept is already embodied in various countries' policy documents. For example, the National Water Policy of the Government of India states: "Water resource development projects should, as far as possible, be planned and developed as multi-purpose projects. Provision for drinking water should be a primary consideration."

CONCLUSIONS

The need for the integration of water management policies, strategies and plans in a general, or in a specifically rural context, arises from the pressures imposed on a limited resource base by increasing populations, changing patterns of settlement, and the tendency to expand demands on the basis of past practices. The result has been that more people require greater food production, therefore agriculture demands more water; rising urban populations call for more domestic water supply, both to meet greater numbers and an increase in *per caput* consumption; industry demands greater quantities of water; and all sectors degrade water quality and value at an increasing rate.

Rural communities and agriculture can have a powerful, and beneficial influence on water supplies, through the joint management of land and water resources, but this imposes a cost on those communities, which is seldom acknowledged. At the same time, economic returns per unit of agricultural water are very low when compared with those for other uses. There is thus an inevitable move to transfer water to higher value uses, disrupting allocations and patterns of use that have become traditional, and often embodied in legal rights.

Basic to the solution of problems of water management, and the integration of policies and plans to satisfy the needs of rural and other sectors, is the establishment of a **population policy** that aims at a sustainable rate of population growth, and decisions regarding the size at which growth should stabilize. This must be accompanied by an appropriate policy for **human settlements**, with rural areas and populations providing national security in food and other agricultural products. If the drift from rural to urban centres is to be controlled, incentives must be provided through improved **rural incomes**, again requiring major policy decisions, and a higher **quality of rural life** - with better services for domestic water supply and health protection as important components.

These decisions on population, and on the changes in water rights and allocations, and associated legislation, require **political acceptability**, to be feasible. They must also find response in **community acceptance** of change, and a willingness to adopt new principles and priorities for the efficient management of water resources. This cannot be achieved overnight, and a gradual process of change, calling for pragmatism, compromise and flexibility must be accompanied by campaigns of **public information, education and open discussion**, or other modalities consistent with culture and tradition, to reach solutions.

Institutional weaknesses and inadequate **data bases** for physical, social and economic information have proved a common impediment to sound water management. The integration of policies and plans will demand better **institutional structures** with better communication in and among sectoral water agencies, and improved performance by **high quality staff**. This implies system reorganization, and the **development of human resources** at many levels, recognizing that the **water-using community** is, arguably, the most essential part of the system.

Finally, the results of the integration process must be **continually monitored** - which again will call for openness and public involvement, to ensure **accountability** in the responsible agencies - and, where necessary, the revision and further modification of policies, strategies and plans to suit **changing circumstances**.

FUTURE STUDY AND ACTION

The implementation of integrated water resource management, whether rural or multi-sectoral is primarily dependent on political commitment and the intervention of decision-makers on issues of policy. It is therefore suggested that the Consultation consider three main objectives in any proposals for future study and action:

- Initiatives for and support to water policy reviews and reform at the national level;

- The creation of appropriate institutional structures, data bases and legislation to support a system of integrated water management, giving particular attention to the needs and problems of the rural sector;

- Developing the capabilities of technical and managerial staff of the responsible agencies to provide sound advice to policy-makers on the physical, economic and social issues that are crucial to the effective functioning of a system of integrated water management.

Within this broad framework, consideration could also be given to some more specific activities, such as:

- The development of methodologies for the establishment of improved communication and cooperation in and among sectoral agencies concerned in, and responsible for functions within an integrated water management system.

- The development and promotion of agency skills and mechanisms for the provision of advice to decision-makers.

- The promotion of public awareness and education on the need for integrated rural water management, and of community involvement in the formulation and implementation of appropriate policies and measures.

- The preparation of guidelines for policy review and reform, drawing on recent experiences of national and state governments, and with reference to current FAO initiatives.

- The possibility of assistance to governments through regional networks of UN system Member Countries.

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A framework for analysis to enhance efficiency in agricultural and urban water use

Fresh water resources are scarce and to a large extent finite. Although surface water may be considered a renewable resource — the life cycle of surface water circulation is in the order of one year — surface water constitutes only 1.5% of all terrestrial water resources (124 000 km^3); the vast majority is groundwater (8 065 000 km^3 or 98.5%) which has a life cycle amounting to several thousands of years and which therefore - at a human scale - is virtually unrenewable (see Figure 1). However, in global terms, groundwater is being consumed at a much higher rate than it is being recharged. Comparing groundwater resources with a safe deposit box (see Figure 2) from which more resources are being extracted than are received, then it becomes immediately clear that such an activity is not sustainable.

At the International Conference on Water and the Environment held in Dublin in January 1992, there was a general agreement on this topic, which led the Conference to adopt the statement that water should be regarded as an economic good, as a principle for future action in water resources management.

The Dublin conference was one of a sequence of conferences (New Delhi, Delft, Dublin, Brussels) which eventually led to the UNCED conference in Rio de Janeiro, in which the emphasis and the attention of the water managers gradually changed over time.

In New Delhi (1990) the emphasis was on the right of access to safe water. Four guiding principles were recommended in striving for universal coverage by the end of the century:

- protection of the environment and safeguarding of health through the integrated management of water resources and wastes;
- institutional reforms, human resources development and participation of women as prerequisites for sustainable development;
- community management to empower and equip communities to own and control their own systems;

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FIGURE 1
Water resources life cycles

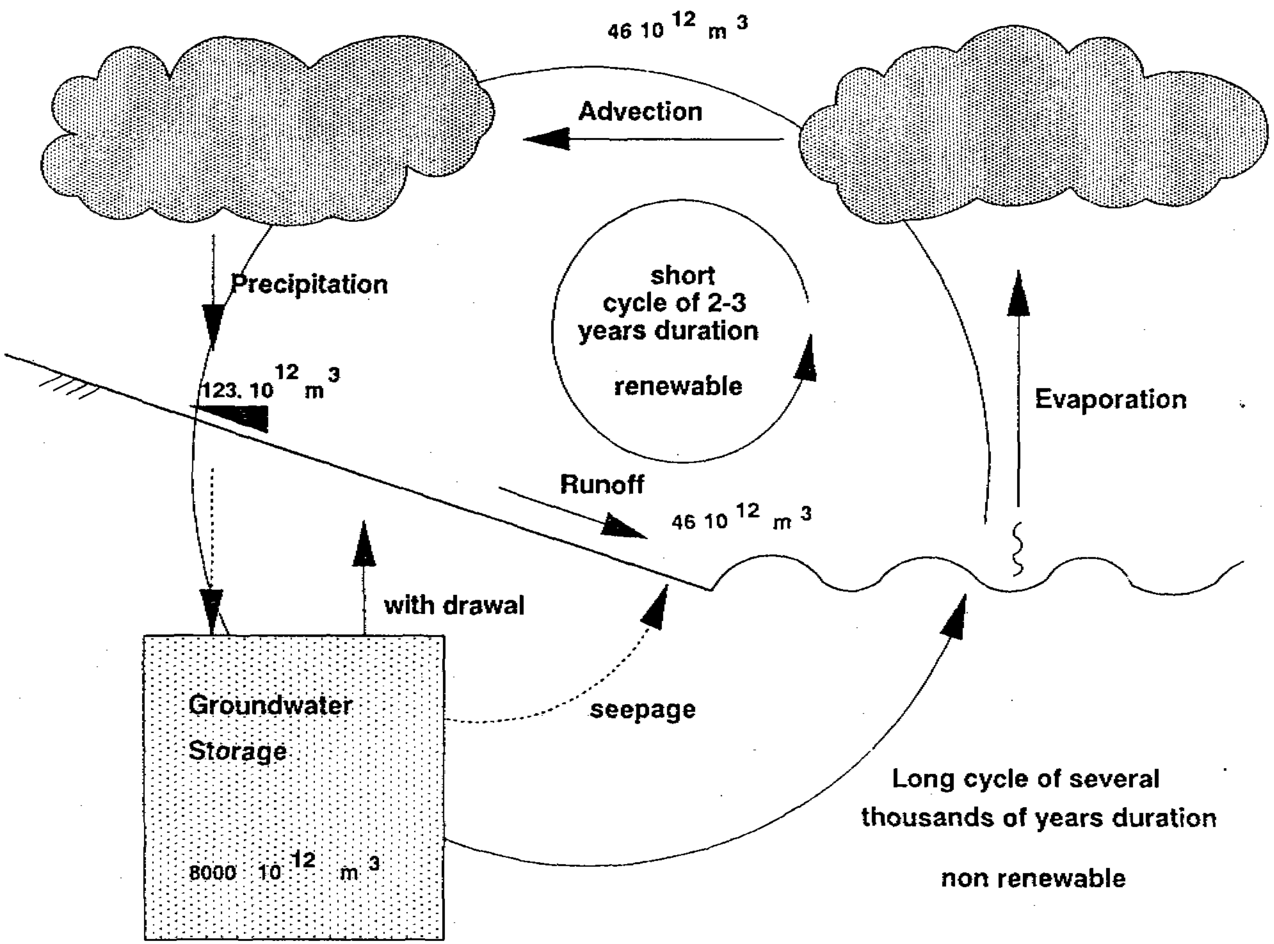
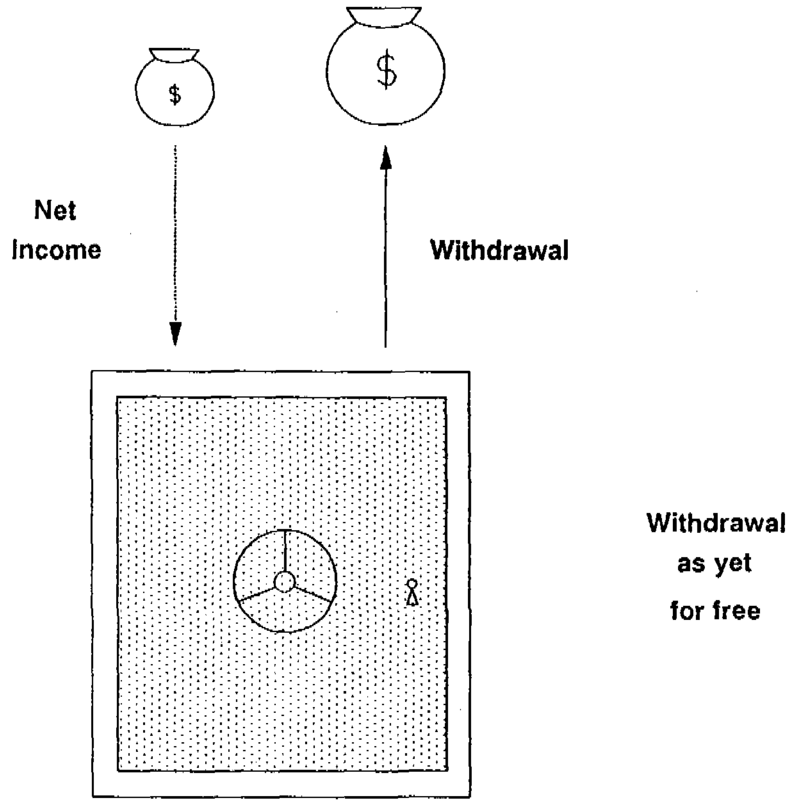


FIGURE 2
Groundwater bank



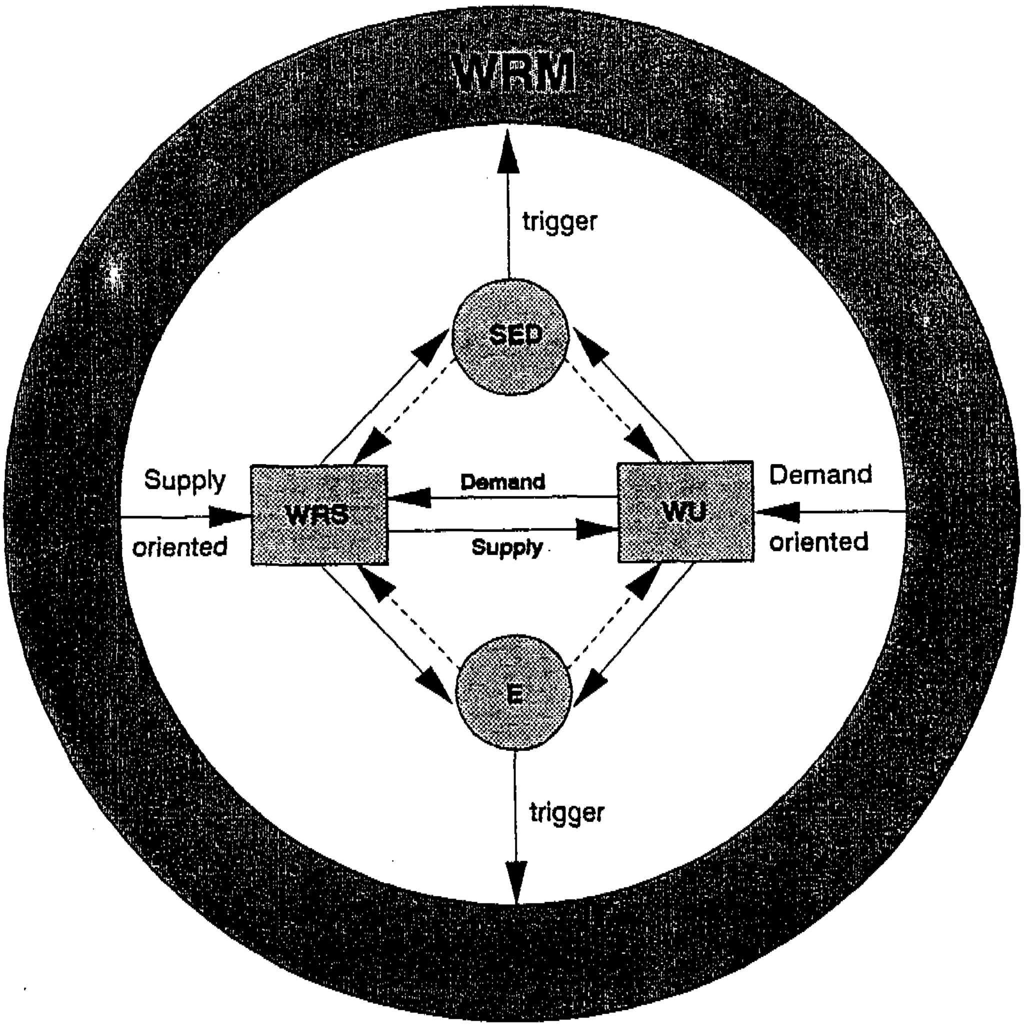
- adoption of more effective financial strategies for the long-term sustainability of the sector.

In Delft (1991) the emphasis was on the necessity to create the institutional capacity for the water sector to implement this goal and to manage water resources in a sustainable fashion. Countries and external support agencies were recommended to implement capacity building at three levels:

- the sectoral level, in which an enabling environment should be created for the effective management of the water sector and sub-sectors;
- the institutional level, in which institutions should be developed so that the collective skills of staff can be effectively used in the achievement of the institution's objectives;
- the individual level, where comprehensive human resources development strategies and programmes should lead to the enhancement of skills of individuals in accordance with institutional needs.

In Dublin (1992) the emphasis was on sustainability and the need to consider water as an economic good. Four guiding principles were adopted:

FIGURE 3
Sustainable water resources management



- fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment;
- water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels;
- women play a central part in the provision, management and safeguarding of water;
- water has an economic value in all its competing uses and should be recognized as an economic good.

In Brussels (1992) finally, the attention was aimed at methods to increase the efficiency of water companies in order to supply more water to the unserved urban poor. In this sequence of conferences there is an increasing awareness that the market mechanism is the main instrument to motivate both water users, and the suppliers of water-related goods and services, to enhance the efficient use of water resources.

The scarcity of water is being felt worldwide and is becoming more pronounced. In some cases water scarcity is the result of over-exploitation of the resource, aggravated by the occurrence of droughts, in other areas it is caused by pollution. If pollution is considered as a form of water utilization (assimilative capacity), then water scarcity is a problem of both quality and quantity which can be summarized as a situation where demand exceeds supply of water.

Water Resources Management (see Figure 3, after Koudstaal, Rijsberman and Savenije, 1992) governs the interaction between the Water Resources System (WRS), which supplies water related goods and services, and the Water Users (WU). This interaction has an impact, and is supported by, the state of the Socio-Economic Development (SED) and the state of the Environment (E). Water Resources Management (WRM) interferes with this interaction through both supply-oriented and demand-oriented measures. In the past, most of the attention of water managers has been dedicated to supply, the main task being to match the ever increasing demand projections with options for water supply. As a result, in many parts of the world, the most attractive alternatives for the development of water resources infrastructure have already been implemented and in many places it is hard to think of feasible alternatives for a further increase of the supply. When put against the sharp increase in water demand, which is occurring and expected to increase even more during the coming decades, the problem of water shortage takes dramatic proportions. In short, a further growth of demand is no longer sustainable and merely postpones the solution to the problem to be attempted by future generations.

DEMAND MANAGEMENT

As a consequence, leading water resources managers believe that further development should be based on the principle that water is finite, and consequently that attention should be shifted from supply-oriented measures to demand-oriented measures. The activities involved in influencing demand are generally referred to under the title of demand management. Demand management, as is stated in UN/DESD's contribution to the Dublin Conference on "Legislative and Economic Approaches to Water Demand Management", is probably the most important instrument that water resources managers have to develop and use during the coming decade.

In summary, the reasons why water managers and decision makers at all levels (national, provincial, local) should try to control demands for water are:

- the use of water is ever increasing, whereas resources are limited;
- water resources are deteriorating rapidly, either through over-utilization or pollution;
- the costs of developing new resources are increasing, since the cheapest sources of water have already been developed;
- financial constraints limit investments;

- shortages are already occurring worldwide and;
- the environmental carrying capacity of water resources systems is limited.

The aim of demand management is:

- to limit water demands,
- to safeguard the rights of access to water for future generations,
- to ensure equitable distribution,
- to protect the environment,
- to maximize the socio-economic output of a unit volume of water, and hence
- to increase the efficiency of water use.

Demand-oriented measures include an array of technical (water conservation, cropping), economic (subsidies, tax and price policy, water tariffs), administrative (licenses, regulations, policing, capacity building), legal (water law, water rights, fines), operational and political instruments, which will be different for each country depending on the physical characteristics, administrative system, and cultural environment.

In managing the demand, decisions should be taken on where, in which sector, and how water demands can be reduced. Implicitly, there will be conflicts between competing users, and trade-offs will have to be made between the benefits obtained by allocating the water to different users in the context of the national economy. In this respect the main conflicts are expected to arise between, on the one hand, agricultural use and, on the other hand, industrial and urban use. Already in many parts of the world these conflicts occur and seldom are they solved in a planned fashion. In this respect it is important to note that the market mechanism is the main motivation for the farmers to take action and that it is also considered as one of the most important instruments to enhance water efficiency in urban and industrial water use. Hence economic and macro-economic aspects play a very important role in demand management.

OBJECTIVES OF THE INITIATIVE

The intentions of this initiative are:

- to prepare a framework for analysis for planning and decision making to increase the efficiency of agricultural and urban (including industrial) water use through demand management,

- to work out approaches that could lead to improved demand management under specific conditions,

- and eventually to apply the methodology in a number of selected cases.

The framework for analysis will be a systematic approach to evaluate the need for demand management as well as the alternative measures that can be implemented. The framework will guide water resources planners, as well as water resources organizations, in the introduction of demand management approaches in their organizations. It will consist of a number of steps in demand management analysis and detailed descriptions of how to apply these steps. In addition, a large number of technical, economic, legal, administrative and operational measures for demand management will be worked out with emphasis on agricultural and urban water use, showing clearly the relationships with actions required in other fields, their possible effect, the time required for the measure to become effective, the level of complexity, and the relation with competing uses in a macro-economic perspective. The framework should be flexible and adaptable to a wide range of institutional, political and cultural situations.

The framework for analysis thus aims at being an approach for water resources planners and managers to analyse the options available for more efficient water use in agricultural and urban water supply. More specifically, the objectives of the initiative are:

General objectives

The study aims at contributing to integrated water resources management in the maximization of net societal benefits by giving increasing attention to demand management. It aims at assisting countries to organize the management of their water resources in a sustainable manner and to facilitate decision making on the allocation of scarce resources by giving increased attention to the management of water demand.

Specific objectives

To develop a framework for analysis to enhance the efficiency of agricultural and urban water use, paying attention to the technical, economic, administrative, operational, legal, political, cultural and environmental aspects.

Subsequently, it is the intention that the methodology be applied to selected developing countries in order to arrive at a set of implementable recommendations.

Scope of the initiative

The study will follow the line of thought initiated by the conferences held in New Delhi, Delft, Dublin, Brussels and Rio de Janeiro, and will build on the papers prepared by UN/DESD for the 1992 Dublin Conference on "Legislative and economic approaches to water demand management" and "Water and sustainable development", which provide a good basis for setting up the analysis.

The study is divided into two phases. The first, with a duration of six months, has a more theoretical character, in that it aims at developing a framework for analysis on the basis of scientific research and practical experience. The second phase entails the application of the framework to a selected number of countries. Since each country has different physical, administrative, social, political and cultural characteristics, it is impossible to develop a blueprint applicable to each situation. Therefore the framework to be developed during the first phase should have a highly flexible structure which allows the application of the methodology to a widely varying range of situations.

To avoid phase one being too theoretical, problem identification will start with the analysis of practical experiences gained with aspects of demand management, and the problems faced by policy makers and managers. For instance, situations occurring in Yemen, Bangladesh or Pakistan where conjunctive use of surface and groundwater has led to a situation where demand management has become a necessity, or the situation in Southern Africa where over-exploitation of surface water resources has led to serious water shortage on an international scale will be used as reference cases in the development of the methodology.

In the second phase the methodology should be applied to a limited number of selected countries, both to refine and to evaluate the framework for analysis and to yield implementable recommendations. The present description concentrates on the first phase. The details of the second phase will be worked out at a later stage.

Eventually the experience gained in applying the framework for analysis should lead to a publication in the form of a handbook containing both the concepts and the application of the methodology, which would help water managers to set up their own analysis and to take appropriate actions to enhance water efficiency in their particular situation.

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Institutional and legal issues in rural water management

Laws and the institutions which administer them may constrain or facilitate the process of social adaptation to changed circumstances. In a somewhat oversimplified sequence, as the pressure for economic and social change translates into the review of policy and a re-ordering of society's priorities, implementation of society's revised agenda requires laws and administering institutions — at the governmental and non-governmental level — attuned to the new needs of such agenda. If they are not so attuned, laws and institutions will act as a hindrance to change and will stifle economic and social development.

Laws and institutions for water resources development and management in general, and for rural water management in particular, are no exception to this rule. As pressure on essentially finite amounts of available water resources mounts in response to economic growth and changing patterns of social behaviour, and as dwindling public treasury finances become increasingly incapable of meeting all of the water sector's demands in the urban and in the rural context, the pressure for social adaptation to scarcity of natural and financial resources tends to expose the weaknesses of the legal system and the underlying issues. This paper will explore these issues and sketch action-oriented recommendations to address such issues.

LEGAL AND INSTITUTIONAL ISSUES OF WATER MANAGEMENT IN THE RURAL CONTEXT

Access to water and security of water rights tenure

The rural dweller needs water primarily to satisfy his domestic requirements, to irrigate his field and to water his stock. Water, that is, must be accessible to him in a physical sense but also in the legal sense of the accrual of a secure right, that is, a **right which is legally defined and enforceable**. A water right can be viewed as the legal instrument of securing access to water, and it displays its full force and effectiveness at times of conflict. Enforceability of water rights in a rural context hinges on means of effective, inexpensive and swift **adjudication**, which tends to be the hallmark of customary systems of water-related dispute resolution, as opposed to litigation before the courts of law. At the same time, a

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water right cannot be inviolable under all circumstances lest adaptations of use patterns and relevant water rights to new circumstances be made impossible. In other words, when a **re-allocation** of water resources from a given user to another user in another economic sector is counselled by public policy goals, access and security must give way in return for fair **compensation**. Access and security issues are of particular relevance in the rural context in the light of growing competition for scarce water from ever-expanding cities, at the expense of irrigated agriculture in particular.

Efficiency of water use: mobility of water rights

Efficiency of water use is of particular relevance to rural water management insofar as irrigation tends to be wasteful and to come, as a result, under increasing pressure from competing sectors to become more efficient and release the water needed elsewhere in the economy and society. Arguably, saving in irrigation water consumption at farm level is encouraged if the user can dispose of the water he saves, for on-farm or off-farm use. A policy objective of encouraging on-farm water saving can be constrained by legal provisions directing that less-than-full use of the water one is entitled to entails loss of right for the unused — i.e., saved — portion of water. Other constraints stem from tying irrigation water to use on a particular piece of land, to the exclusion of other uses on-farm and off-farm, and to the exclusion also of use to irrigate a different piece of land belonging to the same irrigator. Uses of saved water off-farm, whether to irrigate another holding of the saver's or somebody else's holding, or for non-irrigation use, are thus barred. All these impediments to the mobility of saved water may discourage an irrigator from being consumption-minded and from investing to consume less.

The issue of using saved water on some other piece of land than the one being irrigated, and for a non-irrigation use, interfaces with the more general issue of the special bondage which tends to bind at law irrigation water to irrigated land. This bondage — referred to in legal parlance as "appurtenancy" — is particularly strong in the case of groundwater, and under conditions of generalized water scarcity. It results in water not being transferable separately from the land, and is aimed at preventing speculation in water rights. The same bondage is also evidenced in the tendency of permit systems of water rights to tie irrigation permits and the rights under them to use on a particular piece of land in pursuit basically of government-driven, as opposed to user-driven and market-driven, water allocation goals. Transferability of irrigation water rights to other kinds of uses or for the irrigation of other lands is thus effectively hindered. This general trend notwithstanding, water rights markets are known to exist, particularly in the Western United States and along the Indus River in Pakistan. Pure market-driven transfer systems, however, are rare. What tend to prevail are rather mixed systems of government-controlled markets.

Protection of water resources from pollution

The rural dweller is, at the same time, a victim of pollution of water resources due to sources external to the rural environment and an agent of pollution of domestic origin and of pollution having its origin from the runoff of land under irrigation and from irrigation return flows. The latter, in particular, has become a source of growing concern as a result of the increasing use of pesticides and fertilizers for the production of food and fibres. Legal responses to pollution from "point" sources — of which the rural dweller is mostly a victim — and from "non-point" sources — of which he is mostly the agent — are dealt with differently in the legislation. "Point-source" pollution control and abatement hinge on waste discharge licencing mechanisms, while control of "non-point source" pollution tends to centre on land use controls aimed at directing land use away from farming altogether, or at directing the manner of cultivating land towards non-polluting or less-polluting practices. To these particular ends, mixes of regulatory restrictions and voluntary programmes have been adopted in the legislation of the countries which have spearheaded approaches to this problem. Perhaps the single most complex legal issue which arises in this particular connection is, to what extent the legitimate property rights of cultivators can be restricted as to how much of one's own land can be put under cultivation and by what means or practices it can be cultivated. Restrictions may result from administrative *diktat* and be compulsory, or may be agreed upon by the affected cultivator(s) through negotiation with government and be voluntary. In either case, the corollary to the issue of compulsory or voluntary restrictions to the cultivator's legitimate property rights is the issue of compensation for the sacrifices imposed on, or accepted by, him, and the means of compensation, i.e., in cash or in kind, such as by replacing land made idle with cultivable land elsewhere.

Wastewater use

Wastewater has come to be regarded as an increasingly promising unconventional source of supplementary supplies, particularly as it augments the availability of water for irrigation, thus releasing high-quality water for higher-valued uses. The increasing recourse to wastewater to supplement dwindling freshwater supplies raises legal issues in connection with the health risks involved, and with decreased return flows for further use downstream. In addition, the pollution hazard of the sludges resulting from treatment processes needs to be properly addressed.

Paying for water and cost recovery of public expenditures in rural water projects

Paying for water at source, and the recovery from project beneficiaries of capital and/or operating expenditures incurred by Public Treasuries in connection with projects for the development and management of water resources serving the rural populations — notably, irrigation and rural water supply networks — have been a source of concern to governments, worldwide, whose financial capability to cope with the sub-sector's demands has run thin. The essentially policy issue of water pricing and cost recovery has legal and institutional ramifications insofar as payment for water and cost recovery are often hindered by impediments of a legal and institutional nature. A fairly frequent legal impediment to payment for water, and to cost recovery of operation and maintenance expenditures of irrigation and rural water supply projects, is the exemption of farmers from liability to levies and charges for the water they draw and the service they receive. Another is the unavailability or inadequacy of authority to levy, collect and enforce charges and arrears of payment. A frequent institutional impediment stems from the lack of mechanisms to ensure that revenues generated by the service beneficiaries are channelled back to the service providers and do not end up in the general cauldron of government revenues. A perhaps less frequent but no less powerful legal obstacle stems from water being legally regarded as a free commodity, that which is at odds with the notion of having to pay for it.

Responsibility of users of rural water supply and irrigation systems

In response to the growing inability of Public Treasuries to stem the drain of financial resources needed to develop, operate and maintain government-funded rural water supply and irrigation systems, the option of divesting the government of responsibility for the operation and manitenance of existing and new systems, in favour of users, is attracting much attention. A policy move in this direction raises a number of legal and institutional issues. Divestiture may entail transfer of the physical assets — i.e., the irrigation infrastructure — or it may stop short of it, with the government retaining ownership of the assets, while their "use" — i.e., operation and manintenance — is transferred to a third party. If the transfer involves the use — as opposed to ownership — of the irrigation infrastructure, the government — in legal parlance, the "transferor" — may want to negotiate the terms and conditions governing the use of the governmental property involved. The necessary flexibility can be achieved through the instrumentality of, for instance, a concession or permit between the government and the users - in legal parlance, the "transferee". Finally, the transferee of irrigation systems tends to be the water users constituted as a group. Such users' groups need to have legal status, generally in the form of users' associations, with authority to levy and collect charges from their membership, to borrow money and with standing to sue and be sued. In large irrigation systems, more complex legal configurations of users' groups are evolving with users' associations providing operation and maintenance of secondary networks and below, and with a separate corporate entity set up by users' associations operating the primary irrigation network, to the inclusion or exclusion of the system headworks, on behalf of the parent associations. A two-tiered transfer of the irrigation infrastructure can thus take shape, with both tiers having to be provided with authority to raise and collect charges, respectively, from their member users or from their client users' associations, to ensure the long-term financial viability of these arrangements.

Access to land and security of land tenure

These issues are of significance in the broader context of land reform and land redistribution programmes inspired by social justice goals, and they are of special relevance to the rural context. Access to land and security of land tenure generally entail replacing precarious forms of tenure such as tenancy and sharecropping of agricultural land, including in particular land under irrigation, with full ownership rights. In addition, security of land tenure has emerged forcefully in connection with irrigation development of land hitherto cultivated by traditional means, where traditional cultivators have been displaced by newcomers claiming fresh title to the developed land. Legislation supporting irrigation development, particularly for the benefit of the commercial agricultural sector as opposed to subsistence agriculture, tends to introduce modern, commercially-oriented instruments of land tenure, notably, written title, which ignore established customary practices. Whence the potential for conflict between customary occupants and statutory claimants of title, or between statutory occupants and claimants of customary titles. The issue — being a mixed one of policy and law — in this respect appears to be how to reconcile modern land titling systems and processes with customary rights of occupancy.

Effectiveness of the government water rights administration

The overall effectiveness of a legal system for the management of water resources and, in particular, the system's ability to ensure that water of a suitable quality is accessible to all users in need, that it is used efficiently, and that it is protected from pollution depends in large measure on a performing government water rights administration. While the actual configuration of the government water rights administration will vary with the circumstances — constitutional, geo-physical, developmental and others — of each country, there are certain parameters of general validity which can be of use in country-specific situations. A government water rights administration is akin to a central bank and functions along similar lines. Like a central bank, it must be in a position to control withdrawals made from the total mass of available water resources by issuing and revoking water withdrawal permits. Like a central bank, it must also know at all times the quantity of resources "in circulation" through outstanding permits, and the quantity left for withdrawal. Like a central bank, there must be a central unit within the structure of government with authority to grant, revoke and alter permits, and to keep relevant records. Such authority can, depending on the constitutional circumstances, be shared vertically by different levels of government, with proper channels of communication and with regulatory and financial mechanisms to ensure the adherence of lower levels of government to national policy. Just as a central bank's scope of authority must cover the entire money supply mass, so must the scope of authority of the government water administration extend to all the water resources available in a given country — from surface to underground and, depending on the circumstances, to wastewater.

The issue — being a mixed one of policy and institutional relevance — which emerges in this regard appears to consist in a majority of cases in how to reconcile the inherent unity of the natural resource and of the manifold management functions relevant to it, with the reality of governmental bureaucracies patterned along use-specific lines (i.e., with separate administrations responsible for irrigation, water supply, energy, transportation), or along functional lines (with separate administrations responsible for water resources allocation and water pollution control, respectively), or even along different kinds of water resources (as with separate administrations being in charge of surface and underground water management, respectively).

CONCLUSIONS: ACTION SUGGESTED

The review and reformation of policy calls for attention to, among others, legal issues, and the need for and extent of change in the legislation should be assessed to ensure the necessary legal support to policy implementation. While this meeting is not the proper forum to prescribe in detail the kind of legislation required to address the issues illustrated above and to remove legal obstacles to effective management of water resources in the rural context, action in the legal domain could be patterned along the following lines:

- legislation must be in place to regulate the use of water resources by different users in the rural context and outside. Conflicts among rural water users and between rural and non-rural users need to be minimized through a government-administered process of allocating available water resources to rural and other users. Primary, framework-type legislation should lay down principles, rights, powers and obligations for the entire water sector, while the details of implementation in the rural context can be left to subordinate-type legislation;

- legislation must be in place to protect water resources from pollution from "point" and "non-point" sources so as to minimize conflict among users of the resource as a source of supply and as a vehicle of wastewater disposal;

- legal obstacles to efficient water use need to be removed;

- the use of wastewater as a supplementary source of supply needs to be regulated by paying attention to the entire wastewater cycle, from the generation of raw sewage to the disposal of the sludge resulting from treatment;

- legal impediments to water charging and cost recovery need to be identified and removed, and legal mechanisms conducive to greater users' involvement in operating and maintaining rural water development projects need to be outlined, consistent with a policy of restraining water demand and reducing the role of government in water resources development and management;

- in the transition from traditional to modern agriculture in general, and in connection with irrigation development in particular, it is necessary to devise legal mechanisms aimed at evolving customary rights of tenure towards modern tradeable titles, thus bringing about in a phased manner a generalized system of land tenure based on written title;

- an effective water rights administration must be in place with proper terms of reference and qualified staffing to administer the water resources management legislation in effect for the entire water sector in general, and for the rural environment in particular.

Role of water supply and sanitation in integrated rural water management: policy analysis

POLICY FRAMEWORK

The end of the 1981-1990 International Drinking Water Supply and Sanitation Decade (IDWSSD) inspired an array of meetings, consultations and conferences which have evolved into a broad policy framework under which the water supply and sanitation (WS&S) sub-sector operates today. The most relevant of these policy statements (in chronological order) are:

- "The New Delhi Statement" emerging from The Global Consultation on Safe Water and Sanitation for the 1990s (New Delhi, September 1990)
- "The Declaration of Puerto Rico" emerging from Regional Conference on Water Supply and Sanitation (Puerto Rico, September 1990)
- "World Declaration and Plan of Action" emerging from The World Summit for Children (New York, September 1990)
- "The Dublin Statement" emerging from The International Conference on Water and the Environment (Dublin, January 1992)
- "Agenda 21" emerging from The United Nations Conference on the Environment and Development (Rio de Janeiro, June 1992)

In terms of **scope**, some statements are "broader" than the WS&S sub-sector (Agenda 21, World Summit for Children, and Dublin), others, are "specific" to relevant parts of the WS&S sub-sector i.e. Delft, Copenhagen and Montreal. The latter were issue-specific workshops which produced statements preceding Dublin and highlighted the need to focus upon **capacity building, the economic value of water**, and **the role of NGOs** respectively. All these concepts were carried over to larger conferences and broader policy statements.

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TABLE 1
Policy issues raised at different WS&S sector-related meetings during the 1990-1992 period

1. New Delhi; 2. Puerto Rico; 3. World Summit for Children; 4. Dublin; 5. UNCED/Agenda 21.	1	2	3	4	5
Alleviation of poverty/disease	*	*		*	
Protection against natural disasters		*		*	
Water conservation & reuse		*		*	*
Sustainable urban development				*	*
Agricultural production and rural water supply				*	*
Protecting aquatic ecosystems	*	*		*	
Resolving water conflicts				*	
The enabling environment	*			*	
The knowledge base				*	
Capacity building	*	*		*	
Political priority to WS&S		*			
Improved intra-sectoral coordination		*			
Increased private sector involvement		*			
Financial sustainability	*	*			
Balance between water & sanitation		*			
Community/women empowerment	*	*			
Upgrading of the WS&S sector public image		*			
Establishing of information management systems					
IMR and U5MR reduction by 1/3 by year 2000			*		
MMR reduction by 1/2 by year 2000			*		
Reduction of malnutrition of children by 1/2			*		
Universal access to water and sanitation			*		
Universal access to basic education			*		
Reduction of adult literacy rate by 1/2			*		
Improved protection of CEDC			*		
Integrated development/management of water resources					*
Fresh water resource assessment					*
Impacts on climate change					*

IMR = infant mortality reduction; U5MR = under five mortality reduction; MMR = maternal mortality reduction

Regarding their **content** or essence, these policies are mostly complementary. It can be argued, however that some conflict exists. The World Summit for Children outcome is for example clearly "goal-oriented" with very specific social development goals proposed for achievement by the year 2000. This approach is a strategy in itself, designed to rally policy makers and government leaders towards achievement of tangible social development results. The Dublin Statement and Agenda 21, on the other hand, inherently require a "building block" approach whereby different sub-sectors and sectors must necessarily forge innovative legal, institutional, financial and operational approaches to make optimal use of all available resources for the achievement of medium to long term development (process) objectives.

It is relevant to note that **protecting of aquatic systems/environment, alleviation of poverty and disease, and capacity building** are the policy issues most frequently featured.

The achievement of specific and frequently ambitious social development or WS&S sector goals could potentially be detrimental to long term service sustainability if careful planning, design and implementation of programmes is not undertaken. This also implies due consideration to capacity building, environmental and financial aspects, given the tendency to pursue aggressively a **service delivery approach** under such a policy framework. Alternatively, too much stress upon the **demand for services approach or pricing mechanisms** could very well delay the provision or facilitation of services to some of the poorest and most isolated pockets of unserved populations because these may not be in a position to voice their demands or compete for the limited investment capital available to facilitate the provision of basic services.

IMPLEMENTATION STRATEGIES: FROM POLICIES TO ACTION

It is obvious that when translating into action the WS&S policies or concepts generated in the 1990-92 period (Table 1), a balance must be sought which takes into account all the individual parts of the existing "policy puzzle" and adapts these to the conditions existing *in situ*.

While looking at the water resource management and the environment in its totality (in line with the Agenda 21 concepts), through the selection of environmentally-friendly technologies for its WS&S interventions, UNICEF policy emphasizes the pursuing of the specific goals established by the World Summit for Children. These goals have also in fact been accepted by WHO, through the WHO/UNICEF Joint Committee on Health Policies — JCHP.

Two main approaches exist for the "translation of policies into action" the **project** and the **programme** approaches. The former normally implies a short term intervention with resources allocated for the attainment of specific objectives. The programme approach is usually broader in scope and also frequently longer in its implementation time-frame, although the achievement of specific objectives is also envisaged, these may be intermediary, with a broader strategic goal being adopted for the medium to long term. Currently a debate is going on among United Nations agencies (through the Joint Consultative Group on Policy — JCGP) as to which is the most effective approach. It seems that the pendulum is swinging towards the **programme approach**, which has been pursued by several UN agencies including UNICEF.

One of the advantages of the programme approach is that it lends itself better to capacity building initiatives, at community, government and private sector levels. Capacity building has gained importance as a strategy to enhance sustainability and reduce external dependence, and it can have a far reaching effect, far beyond the WS&S sub-sector.

THE UNICEF PROGRAMME APPROACH

UNICEF-assisted programmes at country level normally operate on a five-year cycle, and are subsequently followed up by additional five-year programmes. Consequently a long-term commitment is established to support the survival and development of children and women, their households, communities and nations.

UNICEF-assisted programmes are multi-disciplinary in nature, covering the health, education, nutrition, and WS&S sectors with cross-sectoral interventions supporting sectoral initiatives, including communication, social mobilization and women's development.

Situation Analysis

The "programme cycle" is preceded by a situation analysis focused on the status of children and women. It focuses on the structural, underlying and immediate causes of child/female morbidity and mortality, and therefore describes the political, economic, social, institutional elements to be considered when formulating programmes designed to remove obstacles to child/female survival and development.

The data required to prepare a situation analysis are updated continuously so that when the time comes to generate them this can be achieved in a relatively short span of time.

Government officials and other development partners (NGOs, multi-laterals and bilaterals) are frequently called in to participate in the development of situation analysis as well as other phases of the "programming cycle".

Strategy Development

Once the situation analysis is finalized, discussions take place to determine how to remove the obstacles identified at different levels (immediate, underlying and structural) through effective interventions. At this stage, strategies are selected to address basic needs of children and women both from survival and development perspectives.

WS&S "strategy" is usually called upon to reduce:

- child morbidity caused by diarrhoea;
- incidence of dracunculiasis and schistosomiasis;
- burden of women and the female child particularly in collecting domestic water supply;
- rural to urban migration caused by drought.

WS&S interventions are largely regarded as potentially capable of supporting/improving:

- school attendance;
- infant care and nutritional status;
- empowerment of women;
- household income.

Plan of Operations

Once the strategies for interventions are identified, a five-year plan of operations is formulated with resource allocations defined for education, health, nutrition, WS&S, communication, social mobilization and other interventions. The five-year plan of operation is dissected annually into detailed plans of action with activities and budget lines.

ROLE OF WS&S IN INTEGRATED RURAL DEVELOPMENT

In the past, water supply interventions have very frequently been justified on the basis of health. While increase in the quantity of water consumed by households has been recognized as a pre-condition to improved personal and domestic hygiene, experience in the 1980s has taught us that without the "hygiene education" and "excreta disposal" components of WS&S, health impact is severely constrained. Equally important is the synergistic linkage of WS&S interventions with nutrition and education. Improvement in nutritional status of children as well as women is very closely linked to improved access to safe (and nearby) water supply and sanitation. Less time spent by children, particularly girls, in collecting domestic water provides them the opportunity to attend school.

Domestic water supply and improved sanitation in rural areas is a fundamental aspect of the rural development scenario. Low cost and environmentally-friendly technologies including handpump-equipped boreholes — which inherently extract minute quantities of groundwater, spring development, gravity systems, rainwater harvesting, and an array of on-site excreta disposal technologies have been extensively used worldwide over the last 15 to 20 years. Such technologies minimize the amount of water extracted from the hydrological cycle and at the same time limit the amount of waste-water returned to it. Experiences have however proved that when the broader aspects of rural water resources management are integrated with WS&S interventions — including more efficient water use by the agricultural sector, sustainability for all involved can be enhanced.

Effective groundwater replenishment, be it through reduction of surface runoff by means of stop-dams, and afforestation of areas with steep gradients; or construction of sub-surface dams in river beds, can increase and sustain groundwater abstraction for both domestic industrial and agricultural requirements in rural areas, particularly if these are susceptible to periodic droughts. Despite isolated good examples, these approaches have been under-utilized worldwide and should therefore be promoted much more aggressively in the future, particularly where manpower is idle and cheap, in which case short term socio-economic aid programmes could forge a sustainable environmental and human development in the medium to long term.

Since the late 1960s, UNICEF has been supporting rural WS&S interventions, with uninterrupted assistance in most countries where such support is initiated. Bangladesh and India are classic examples where such support has, over the last 20 years, substantially contributed to the increase in water supply service coverage, with a resulting improvement in the quality of life of millions of rural dwellers.

TABLE 2
Activities undertaken within the scope of UNICEF-assisted WS&S interventions

Capacity building	Public sector: hydraulic fracturing (India, Uganda) geophysics (Nigeria, India) hydrogeologic map production (Mozambique) drilling (Benin, Nigeria, Angola, Uganda, Sudan, Ethiopia, India, Bangladesh) gravity flow systems (Nepal, Burundi, Bolivia, Nigeria) spring protection (Rwanda, Burundi) latrine construction (Nigeria, Burundi) hygiene education (Guinea Bissau, Nigeria, Uganda, Egypt, Bangladesh)
	Private sector: handpump manufacture (India, Bangladesh, Guatemala, Pakistan, Mozambique, Nigeria) PVC casing for borehole construction (Nigeria) PVC/HDP riser pipes for handpump installation (Nigeria) latrines construction (Bangladesh)
WS&S sub-sector Monitoring	Brazil, Bolivia, Togo, Benin, Nigeria, Egypt, Burundi, Jamaica ....
Solar cookers	Chile
Reforestation	Benin, India
Solid waste management	Brazil
Micro-irrigation	Nigeria, Benin, Uganda, Oman
Waste-water recycling/aquaculture	Bangladesh

In fact, UNICEF assistance in the WS&S sub-sector currently amounts to approximately US$90 million/year allocated to almost 100 countries, which added to the resources of governments, NGOs and beneficiaries themselves, provides improved services for about 16 million people/year with water supply and 2 million people/year with sanitation.

Given the limited UNICEF resources allocated to the WS&S sub-sector, a basic strategic approach utilized is the marketing/advocating of successful small/medium scale experiences to be replicated on a national scale. This implies operating at the implementation end of the development process while simultaneously documenting such experiences and influencing the formulation of policies and strategies at the national level.

Besides provision of improved access to water supply and adequate sanitation, UNICEF assistance is also provided in the implementation and/or promotion of several other activities listed in Table 2.

The WS&S sub-sector has a unique role to play in "integrated water management", given its close contact with communities through the process of participatory planning and joint project implementation, which are becoming a standard mechanism to ensure the sustainability of WS&S infrastructures. Participatory planning enables the views of communities to be registered, and can become a relevant mechanism to address other water needs, as well as mechanisms to protect available water resources.

UNICEF's RESPONSE TO AGENDA 21

Ongoing Environment-focused Activities

Besides the ongoing multi-faceted activities undertaken by the WS&S sub-sector within UNICEF, other initiatives to complement these include:

- ensuring household food security and promoting the knowledge of food preparation techniques to reduce malnutrition;
- delivery of primary health care services;
- enhancing basic life skills as part of "education for life" initiatives;
- promotion of activities to empower women.

Future Environment-focused Thrust

According to the 1992 Human Development Report of UNDP, 80 percent of the poor in Latin America, 60 percent of the poor in Asia, and 50 percent of the poor in Africa live on marginal lands characterized by low productivity and high susceptibility to environmental degradation.

Among the poor, women are usually the most vulnerable, being under increasing stress as they are forced to spend more time in food production, processing and preparation under precarious conditions; in collecting water from ever more distant traditional sources; and in gathering fuelwood from depleting forests, farther away from their households. Simultaneously children become increasingly more susceptible to disease and malnutrition as they are left to fend for themselves in resource-scarce conditions.

UNICEF will seek to facilitate more explicitly, through modest seed funds, the initiation of community-based and managed activities under the umbrella of "primary environmental care". Such activities will contribute to the development of an approach whereby the most vulnerable, especially the very poor, women and children, can meet their basic needs while ensuring the protection and optimal utilization of the natural resources within their communities.

Activities will include among other inititiatives the production, use, and promotion of fuel-efficient stoves/solar cookers, school gardening of vegetables and fruit trees, small-scale reforestation for protection of springs and catchments, micro-irrigation with porous clay pots, solid waste management, and environmental awareness creation.

FUTURE PERSPECTIVES

Integrated Rural Water Management could be enhanced through improved multilateral agency coordination in the field. If UN agencies achieve coordination of their activities more effectively, they may pull together their government partners, improve intra-sectoral coordination, and thereby unify the water resources sector, which seems to be the starting point for integrated and effective use of water resources, and sustainable as well as equitable development.

UN agency coordination could be initiated by more intensive information exchange at headquarters level, followed by the identification of a few concrete countries/areas where cooperation seems feasible. Joint actions should be carefully documented and widely publicized so as to foster their emulation on a larger scale.

The ultimate qualitative measure of UN agency coordination would be the pooling of resources for joint implementation of activities.

An assessment should be made of current UN agency cooperation in the water resource management field, with the number of projects and degree of cooperation used as quantifiable parameters. The latter could be divided into "information sharing", "joint action" and "resource sharing/pooling".

Judging from the relevance given to **protecting of aquatic systems/environment, alleviation of poverty and disease, and capacity building** by different policy statements during the 1990-92 period, it seems that these should be the priority areas for joint UN agency action.

Global water information system: a contribution to integrated rural water management

WHY SET UP A GLOBAL INFORMATION SYSTEM?

With the increase in awareness on global issues, large scale data bases on natural resources are becoming more and more necessary. A general conclusion of most conventions and meetings focusing on natural resources management in general, and water resources management in particular, is the lack of reliable information about these resources at a global scale and the use which is made of them. Recommendations generally follow for information to be collected and processed for the purpose of more rational planning and management of the world's natural resources.

In the case of water resources, many data bases were created in response to such recommendations, with no in-depth investigation about the value, quality and benefit to be derived from the information being collected.

The UN system is currently not in a position to provide satisfactory basic information on water resources and water use, for planning and implementing programmes for sustainable development. A broad in-house consultation at FAO highlighted the fact that a real need exists to collect and process data on water resources, use and demand, both at national and global levels. At national level, the information should help countries to design appropriate policies and strategies for the development and sustainable management of their water resources. At international level, it should help to study trends in global water resources development and associated environmental effects, with special emphasis on agriculture, which represents 70% of world water use. Water scarcity, water quality and water resources potential should also be adequately documented. It should be possible to forecast, project and develop strategies and to study phenomena such as the impact of global climate change on water resources. Eventually, it should also be possible to define the basis for international agreements related to the allocation of shared water resources.

DISCUSSION PAPER 4

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The mandate of FAO includes the promotion of sustainable agriculture and rural development through the rational use and conservation of natural resources, most notably land and water. Such objectives cannot be achieved without a good knowledge of the resources and their use. Although some attempts have been made to collect and analyze information on water resources quantity and quality, demand and use at global level, at present there exists no comprehensive global data base on water, in support of sustainable land and water management.

The need for information on water resources, their current use, demands and trends, is twofold. In a water balance approach, volumes used and requested are compared to water resources in order to assess the degree of scarcity of the resource and the degree of satisfaction of the demand. These data are also needed to help planning the sharing of limited water resources in an integrated way.

Yet, management of water resources is not related only to the water balance. Data on water quality, pollution, waterlogging, irrigation efficiency, agricultural production, economic and social aspects of irrigation and drainage programmes are also necessary for a better understanding of the production system and to develop appropriate policies and strategies in agricultural and rural development.

EXISTING WATER DATA BASES

At the present time, there is no global surface water resources data base related to a geographical information system, and global information on groundwater is even scarcer and more difficult to access on a geographical basis.

Most of the work related to global assessment of water resources was carried out in the 1970s, during the International Hydrological Decade. It consisted of quantifying the different elements of the water balance at the scale of the continents. This work led to the publication of world water atlases. Breakdown by countries, mostly on an areal basis, made it possible to obtain 'lumped' figures at national level. Most publications and studies using global figures still refer to the values found in those calculations.

Numerous institutions collect, store and process runoff or groundwater data, be they national, regional or basin institutions. At a global scale, the most important institution dealing with hydrological data is the Global Runoff Data Centre in Koblenz (Germany). In collaboration with WMO, this centre is in the process of collecting runoff data from the most important rivers of the world. An activity in the field of water resources assessment, which is directly related to this Centre, is the work initiated by the World Climate Programme of WMO, aimed at producing a global water runoff data system. The approach has some similarities with the one developed in this paper, although the objectives are quite different. It is also worth mentioning the Hydrological Operational Multipurpose Subprogramme (HOMS), a WMO contribution in the field of technology transfer.

In the field of groundwater resources, UN/DESD (Department of Economic and Social Development), carried out many water assessment projects in recent times, mostly in Africa. They have developed software designed for data storage and analysis and connected them with geographic information systems. Again, for Sub-Saharan Africa, it is worth mentioning the UNDP/WB Sub-Saharan Africa Hydrological Assessment Project, which is aimed at assisting countries to establish an inventory of existing data and services, and a programme to improve national data collection capacity.

Unesco has focused on the creation of non-numerical data bases in the framework of the International Hydrological Programme (IHP). It promotes the creation of national water information centres in developing countries and assists them in setting up national data bases. It has also helped develop and distribute a software (IDAMS — Internationally-developed Data Analysis and Management System)) which allows the analysis of numerical data and can interface with numerical data bases.

For several years, now, the World Resources Institute has been collecting data on natural resources and the environment. Water resources data are collected mainly on the basis of existing literature.

In FAO, a number of data sets are available on natural resources, agriculture, forestry and fisheries. These can be used in connection with the establishment of a water resources data base. AMDASS (Agro-Meteorological Data SystemS), the FAO agroclimatic data bases can be used for the computation of rainfall and evapotranspiration. Also of considerable value is the methodology of the FAO study of irrigation potentials in Africa, which is based on data stored in a GIS. The digitized FAO/Unesco soil map of the world and the Unesco geological map are also available, as well as the maps used in the study of potential population-supporting capacity of the world.

QUESTIONS PRIOR TO IMPLEMENTING A GLOBAL WATER DATA BASE

Objectives of the data base

The scope of the data base and the identification of potential users will determine not only the structure of the data base and its content but also its geographical extent, the scale and the degree of detail required. Management of the data base, its updating frequency and the accessing modes are also closely related to the ultimate purpose of the programme.

Concepts and definitions

The second step towards the establishment of an effective data base is related to concepts and definitions and to the choice of the most appropriate indicators. The best example of ambiguity in water-related information systems is the lack of consensus about key concepts. Although reference is often made to the need for data on water resources, there is so far no unique and globally accepted definition of such concepts. This situation makes it very difficult to determine the type of data to be collected and the indicators to be used.

Concepts related to water resources

Many conceptual problems arise when dealing with water resources data bases. The definition of resource must first be agreed on. Assumptions must be made about the computation of different elements of the water balance: soil moisture, surface water, ground water, and about the fluxes: rainfall, evapotranspiration, runoff, infiltration. Furthermore, the global aspect of the exercise requires careful attention to the validity of the assumptions, to ensure that they are valid at a global level.

The complexity of the water balance, the interactions between its different elements (surface water, ground water, soil moisture), and the dynamics of the water cycle, are technical aspects which must be carefully taken into account. Geographical representation of the resource is another difficulty. Defining the resource by unit area needs further assumptions which require careful attention.

Most important in building the data base is the choice of time and space scales. They will determine not only the degree of precision one can expect from the data base, but also its complexity and its cost. Because this choice is directly related to the use one can expect from the data base, it will be closely connected to the objectives of the programme.

If water resources are to be computed for the purpose of assessing potential rainfed agriculture, precipitation will be the most important data to collect. If, on the other hand, the scope of the data collection process is to compute water availability for irrigated agriculture, domestic use and industries, focus should be put on surface and groundwater resources. Most of the time, the volumes at stake are so different that both purposes can hardly be handled within a unique water balance approach.

Several other important aspects must be taken into account while establishing the data base: physical considerations such as inter-basin transfers, international rivers, spatial and temporal variability, as well as socio-economic considerations. The way they are incorporated in the composition of the data base will determine its relevance to the sustainable development and management of water resources.

Water resources assessment

The degree of precision of the data base is closely related to the availability of data. Data on surface water resources consist of records from gauging stations on rivers and lakes, dams and reservoirs. In most countries of the developing world, these data are scarce, of relatively low quality or unavailable. When they are available, they represent only a few locations on the entire hydrological network of a country. Probably, the most easily accessible runoff data will relate to major rivers, yet for the purpose of agricultural development, small - or medium-size rivers may be as much of interest as the large rivers.

Various attempts have been made to collect, process and store runoff data into data bases on a global scale. In all cases, these operations have encountered major difficulties. One reason for this is that many governments consider water data as strategic information and are not inclined to release them.

Data on groundwater are still more difficult to collect. Existing data bases generally consist of well inventories and are hard to transform into quantitative resources indicators. The data cover only a very small percentage of existing aquifers.

Such problems are common in hydrology and water resources assessment. Unlike soil, geology and vegetation cover, which can relatively easily be defined on a geographical basis and with the help of remote sensing techniques, water resource data, by the dynamic nature of water and the relatively small number of data available, are relatively difficult to assess. Models, by simulating the hydrological cycle, can provide information on the global system. If properly designed and applied they can be used to assess resources in areas for which data are not available. Their scope must be to make the best possible use of available information (hydrological data, physiographical characteristics of the basins, land cover).

The constitution of a global geo-referenced water resources data base will be possible only with the help of some suitably standardized models to help in extrapolating runoff and ground water data in space and time, and to present them in a form which is compatible with a geographic information system. The basic approach would be a combination of models and observed data, leading to the best possible estimate of water resources.

Water resources, demand and use

A clear distinction must be made between two equally important problems. The first concerns the relationship between resources and demand, and is based on a water balance approach. Most of the information required can be expressed in terms of volumes or fluxes. A second field of investigation is more directly related to agricultural water use. Data on irrigated and drained areas, their extent, environmental aspects, energy, economics, crops, farmers' organizations are needed at a global scale to help assess trends, to improve forecasting on environmental impacts and to design global policies for rural water management. Both subjects are complementary and would benefit each other, but they can be dealt with in separate sub-programmes. A critical difference between them lies in the geographic representation of data. The first problem, based on the water cycle, must be treated on a catchment basis, while data requested in the second case are likely to be available only on the basis of administrative units.

Rural water use or global water use?

Although the prime interest inside FAO is for rural water, no assessment of water resources demand and use can be limited to agricultural water. It must encompass all sectors so as to ensure an integrated approach to the water balance problem.

THE PROPOSED PROGRAMME FOR A GLOBAL WATER INFORMATION SYSTEM

Expected outputs

The overall objective of the programme is to develop an efficient methodology for the assessment of water resources, water use and water demand at a global scale, to collect and analyse data and to establish an information system on water, which will be readily available to all users. The final output of the programme will be **a geo-referenced water use and water resources data base for sustainable agriculture and rural development**. The major components of the programme are described below:

A global geo-referenced information system on water management and use

This first component is intended to supply general information on water resources development and management, with emphasis on agriculture (mainly irrigation). It should be presented as an inventory of land developed for irrigation, of irrigation potential, irrigation techniques, water quality constraints, and of water used seasonally or annually. It would complement the existing FAO agricultural statistics publications. It would be based mainly on surveys carried out in different countries and in sub-regions of those countries.

PILOT STUDY ON SUB-COUNTRY WATER STATISTICS
A CASE STUDY FOR CHINA

Within the pilot phase for the development of a geo-referenced information system on water management and use, a desk study was conducted to test the methodology and the quantity and quality of information available. This involved an extensive questionnaire with sections on general statistics, water balance, irrigation, wetlands and floods, water supply in related sub-sectors. The total number of questions was 221, half being related to irrigation.

The choice of the geographical units for data is left to the user, but it is suggested to use the first level sub-country administrative unit although for water balance purpose the best geographical unit would be the river basin. The questionnaire is in the form of a matrix so that data can be entered for each geographical unit.

Information can be divided into two categories: numerical or coded. Coded information uses multiple choices to help in future data processing and analysis. There is provision for assessing data reliability and for reference to bibliographic origins.

The questionnaire is to be tested in several countries and with different modalities. National consultants might be requested to fill the questionnaire or the work can be done by an institution dealing with water resources management. The case study on China was conducted as a desk study, in order to assess the amount of information available at FAO and to test the questionnaire.

Information was collected from a list of 23 publications. It was decided to disregard data prior to 1987, except when they were not subject to rapid changes (water resources, land area, etc.). A significant amount of information was available at sub-national level, mostly on data related to infrastructure, manpower and physical geography. Twenty-four relevant indicators were compiled for which values could be found in every Province. At national level, 123 pertinent indicators were collected, and it was possible to calculate key ratios and to present basic statistics on water use by sector or by source, water balance, trends in irrigation development, information on irrigation equipment, drainage, crop production, energy, and environmental factors such as salinization or flood hazards.

The test revealed some shortcomings of the method, and changes will be made to improve the procedure. Some information which was not required in the questionnaire was worth collecting. Certain categories of information were available only at national level, with others available in every province. This will be taken into account when building the data collection software, to avoid large, empty matrices.

The case study on China showed that it was possible to collect recent data of high quality. Cross-checking between different references usually showed a good concordance. However, there was a lack of recent water resources data. Water resources throughout the world have been assessed on the basis of hydrological balance models in the 1970s, during the International Hydrological Decade, and this information is still used today. There is a need to update the information, not so much with respect to the water balance, but rather to improve data computation and spatial resolution now possible through recent development in computer capabilities and the use of geographical information systems.

The exercise highlighted the problem of relating the geographical computation of water resources and water use. Most water resources data were available on the basis of river basins, while information on water use was almost entirely by administrative divisions. There is a clear need for a mechanism to compare water resources and water needs on a common geographical basis if the degree of water stress is to be assessed at sub-national level.

Data from individual countries would be available in two different formats. Firstly, they would be incorporated into the general data base for further global or regional thematic analyses. Secondly, they would be published as country fact sheets, giving the most relevant indicators, which would be prepared and made available to users. Target users would be institutions dealing with policy and planning, development agencies and research institutions working on global scale environmental issues. Within FAO, the data base would contribute to the forecasting of agricultural production and agro-economics at global level. The statistics would provide a way for a country to compare its situation with others objectively, in terms of water development and management problems, constraints, potential and achievements.

Development of a hydrological and environmental simulation capability for water resources assessment

This component is aimed at providing a tool for the planning of water resources development and management in a framework of agriculture and rural development. It is intended to be used in connection with global natural resources assessment and development programmes, and at national and regional levels in connection with existing land use planning systems.

Development of a standard information system on rural water management for use at national and sub-national level

To complete the programme, it is also planned to develop software to store, process and analyse data on water for rural development. It could be used as a standard model to be progressively installed in countries. Training of staff in relevant government institutions, and the transfer of technology would help the countries in setting up and using statistics on water management for rural development, and it would help standardize data collection procedures and global data processing and analysis. This sub-programme is not discussed here.

Implementation

The programme is divided according to the first two components described above, each of them being further divided into three phases. Basically, for each component the preparatory phase is intended to work out a detailed programme of activities and to define the appropriate methodology. The first phase is devoted to establishing and validating the methodology through a pilot project covering only a few countries, while the second phase consists of generalizing it on a global scale.

Global geo-referenced information system on water management and use

The preparatory phase consists of designing a framework for water statistics at country level. The data base is made up of carefully selected indicators of water management and use. A questionnaire has been prepared on computer spreadsheet and pilot inquiries in selected countries are now being carried out to check the validity of the method. National consultants will answer the questionnaire, with the assistance of FAO Representations in the countries.

The data base can be built gradually, starting with a relatively small number of basic indicators and countries. Progressively, it can be completed by the addition of new parameters, by focusing on specific questions and eventually covering all developing countries. To be effective and useful, it must be regularly updated. Trends in water management are of major importance for forecasting and can be achieved only through regular updating of information. A periodicity of 5 years for updating on individual countries was selected.

Special care will be taken to ensure integration of the programme among similar efforts in the field of information for agriculture and rural development, both within FAO and with other UN organizations and international institutions.

Development of a simulation capacity for water resources assessment

The second part of the programme will consist of developing a simulation capability for water resources assessment. It will be based on a water balance approach and conducted on a catchment basis. It will be connected to the other existing natural resources and climate data bases available in FAO. The best use of FAO facilities in GIS and remote sensing will be ensured.

During the preparatory phase, availability of GIS on natural resources and topography will be identified for various scales. At the same time, the availability of water resources data for several conditions of climate and physiography will be determined. During the first phase, a water balance model will be selected from among existing models, and adaptations will be developed if necessary. The choice of model will be made on the basis of its capacity to be used in a large range of natural situations, and its ability to provide relevant information on water resources for agriculture. The model will then be calibrated over a selected number of watersheds in this pilot phase, and the data base will be completed. This tool will be used during the last phase of the programme, not only to assess water resources on a global basis but also to test the impact on water resources of forecast climatic change.

It is possible that the experience gained in the USAID-funded project "Monitoring, Forecasting and Simulation (MFS) of the River Nile in Egypt" will be used in the programme. In the USAID programme, a 'distributed' watershed model has been developed which integrates areal components, and for each of these includes ground characteristics, satellite remote sensing information, rainfall-runoff modelling and channel routing. In its current application, the model is in the process of calibration and validation to forecast reservoir inflows for water resources/irrigation management. The comprehensive nature and the advanced user-interface of the model make it a tool of choice for other applications. Because it is distributed and geographically referenced, it can integrate any geo-referenced information and simulate hydrological processes at any place, subject to the availability of cartographic material and processing capacity.

Inter-Agency Cooperation

Cooperation with other agencies will be sought in the implementation of the programme, to ensure optimal allocation of resources, to avoid duplication of efforts and to optimise the quality and comprehensiveness of data to be collected and processed. During the pilot phase (1993), the programme will be financed under the regular programme of FAO. In the 1994/95 biennium, it is expected that FAO funds will be adequate to collect data from about 20 to 30 countries. However, mobilization of resources to carry out the programme at a global scale would require collaboration from all concerned UN organizations and bilateral donor agencies.

It is hoped that inter-agency cooperation will be strengthened as a result of this Consultation and will pave the way for successful implementation of the programme.

Policies, strategies and planning for integrated rural water management — a case study of Jhabua District in India

OBJECTIVES

This paper presents a case study of a district in India where environmental degradation has been addressed through measures of integrated water resources management in the period 1986-1992. The case study underscores the inextricable link between poverty and environmental degradation and therefore highlights action that can be taken to reduce both, in a synergistic manner. Sustainable livelihood depends on a sustainable environment in this district as in many other parts of the world where people still depend primarily on natural resources for meeting their basic needs. By implication, this case study reveals an opportunity that exists to convert such an environmental crisis into an opportunity to address issues relating to the basic needs of the people in these areas. It is an opportunity that policy planners could seize, at national and international levels, to convert their policy pronouncements on sustainable development into operational programmes.

JHABUA, BASIC FACTS

Jhabua, situated between the latitudes of 21.30 and 23.55° North and the longitude of 73.30 and 75.01°, is one of the 45 districts in the state of Madhya Pradesh in India. It has a land area of 6792 km^2 and a population of nearly 1.1 million people. The people belong mostly (83%) to the Bhil tribe, one among the indigenous people of India, who are relatively backward in terms of their economic status. Ninety percent of the people are engaged in agriculture while about 10% still depend on the diminishing forest resources for their sustenance.

The Economy

With 90% of the population engaged in agriculture and with 90% of the agriculture being rainfed, the economy is characterized by its almost total dependence on water in the form of rainfall. The economy was once more forest-based and with the decline in forest cover, supplementary income generation from forests to support its rainfed agriculture has become impossible. This results in large-scale seasonal migration out of the district for six months

CASE STUDY 1
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TABLE 1
Major crops grown in Jhabua District

Major Crops	Area (in thousands of ha)	Percentage of total cropped area
Maize	80.8	20.3
Urad (black gram)	66.0	17.6
Paddy	25.7	7.8
Jowar	32.1	7.4
Groundnut	15.3	4.08
Cotton	12.9	3.44
Bajra	10.4	2.77
Wheat	8.7	2.32
Miscellaneous crops are cultivated in the remaining 34.3% of the area		

of the year. The vulnerability of the district to droughts that deprive its people of even their single rainfed crop, and its degraded natural resource base have meant impoverishment of a majority of the people. With a livestock population of over 921 000, the dependence of the economy on bio-mass and consequently on water resources is further aggravated.

Agriculture

The gross cultivated area is 368 557 hectares, 39 037 of which are irrigated. The area cultivated per person amounts to only 0.46 ha which is much lower than the national average. There are 120 041 holdings as per the agricultural census. Table 1 lists major crops along with sown areas as percentage of total cropped area.

Hydrogeology

The main physiographic units of the district are (i) a hilly terrain, (ii) a plateau area and (iii) undulating plains. The hilly terrain and the plateau area comprise the Deccan "trap lava" flows of Cretaceous to Eocene age. Hydro-geological mapping of the district exhibits Cretaceous-Eocene, Upper Cretaceous and Archean Systems. The Deccan "trap lava" area is noted for its wide variation in water levels.

The district receives an average rainfall of 840 millimetres annually in normal years. In a drought year, this could be as low as 440 mm, as in 1985, with most of this rain received only in the two months of July and August.

Physical Quality of Life

Jhabua, as a result of its poor economic status has a very low status in terms of social development indicators. Only 14% of the population is literate, with female literacy being as low as 8.55%. Infant mortality is very high at 144 per thousand births.

PRE-INTERVENTION SCENARIO

Folk stories of the people of Jhabua present them as a people who went to war with the Lord of the Clouds who is still punishing them by sending them little or no rain! This is indicative of their situation. The history of Jhabua has been the history of a people living from one drought to the next. The district used to be affected by a drought once every three to four years. While droughts represented the dramatic high points of their situation, the unpleasant fact about Jhabua was that as far as the people were concerned the normal years were not much better. In fact drought years at least brought in state intervention in terms of drought relief works. The record of intervention by India in drought situations has been well documented and does not require further repetition here (Sen 1981; Dreze and Sen 1989).

The problem of the people of Jhabua had less to do with periodic failures in rainfall and more with the erosion of their resource base. Their agricultural resource base was very fragile, with a thin soil cover in many parts of the district. Except for some areas with black cotton soil, the rest had inferior skeletal soils. Most of the rainfall was lost as runoff and there was hardly any moisture retention. The people depended mostly on one rainfed crop and the productivity thereof was usually low, so a substantial portion of the district's population migrated for six months of the year to work in other areas. Jhabua as a district was characterized by this periodic migration in the absence of a viable, sustainable resource base.

Past interventions by the state to address this problem have been, apart from crisis handling during droughts, through the Drought Prone Areas Programme (DPAP). The DPAP, conceived in 1973, sought to promote enhanced land and water resources management of those areas identified to have poor or degraded land and water resources. Areas like Jhabua, which had low rainfall and less than 15% of its net sown area under irrigation, were covered under the DPAP. Under this programme, additional resources for land and water development on a micro-watershed basis were made available. Unfortunately the DPAP was conceptually flawed in not incorporating a strategy to address the immediate problem of poverty of the people. In operational terms, it became severely limited due to shortage of resources. It sought to address the problems of the resource base without offering anything in the short term for the people living off these ecologically ravaged areas and still fighting a battle of survival, scraping a living off their small and marginal land holdings. It could therefore neither insulate people from droughts nor provide them livelihood security, which required large-scale generation of employment.

"Absence of water" was the key to the problems of this district. The district in a normal year received about 840 mm of rainfall, not too insignificant in terms of drought-prone areas. Most of this was lost as runoff, given the topography of this district of barren hard rock hills with steep gradients. However there was also considerable potential for impounding this run-off and increasing the surface storage in the district. Labour was in abundant supply as people would normally be idle or migrate for work. All that was needed was to use this surplus labour to create water storage through a systematic plan for integrated water resource management. **Such a strategy could address the demands of both the people and their resource-base**. What was needed was **a plan to use people to harvest water**.

THE INTERVENTION SCENARIO

This opportunity came about in 1985, while the district reeled under the century's worst drought, and the state government was forced to mount a massive drought relief operation through the years of 1985 and 1986. Coincidentally, a plan for water management along with technical expertise was provided by the Technology Mission on Drinking Water and Related

Water Management launched by the Government of India. The Mission chose Jhabua as one of its pilot districts for experimenting a new strategy of integrated water resources management to address the backward linkage of drinking water with environmental management for sustainability, and its forward linkage with improved health. The financial resources made available by the state to address drought through the creation of employment on public works, and the technical support for integrated water resource management, made possible a major effort for harnessing the water resources in the district.

The worsening drought conditions in the district in the summer months of 1985 were further aggravated with the failure of monsoons in July-August of that year, with the district recording only 420 mm, its lowest annual rainfall since year 1911. The poverty of the tribal people was dramatically expressed through a series of attacks by them on village markets (called **haats**, and mostly run by non-tribal people). The State, alarmed by these first-ever food riots in this district, launched a massive relief operation giving "carte blanche" to the District Collector to open as many relief works as required. The district administration in India is fairly well trained in managing relief operations and most of the time has a ready list of public works that could be taken up in such times. **The tragedy over the years has been that this list used to be dominated by road works that had no positive impact on drought-proofing. This also resulted in drought relief investments being generally perceived as ineffectual and wasteful.**

Three specific factors helped the district administration in Jhabua make water-harvesting central in the drought relief agenda:

The first was that drought relief works in Jhabua (as a district that periodically received drought relief investments) had become notorious for being wasteful in undertaking non-productive works and **this opinion could be utilized to push for a change in approach towards taking up water-harvesting works.**

The second was the need to articulate a policy statement made by the then Prime Minister Mr. Rajiv Gandhi, who visited the drought-affected district on 12 July 1986, that **"drought relief works taken up during the year should contribute to long term drought-proofing"**. This could also be used by the district administration to push the new agenda.

The third was a mere chance factor — the district had surplus staff of the Irrigation Department on a World Bank-assisted project on which they were deployed, in anticipation of project clearance. These experts were looking for work.

The factors mentioned indicate that creating a positive agenda for drought relief works is dependent on several variables — a fact underplayed in those scathing reviews of drought relief works. A relevant point to mention here is that most productive activities need water for their undertaking, and water being in short supply during drought situations becomes a limiting factor. Consequently, good ideas are frequently shelved. In Jhabua, for example, the administration ran into problems to find adequate water to mulch the black cotton soil to be used in bonding earthen dams. The preference for non-drought-proofing works like road construction is partly justified by water scarcity, the primary objective in such cases being the short term creation of employment.

The objective in 1986 was to generate employment opportunities for about one hundred thousand people, to be gradually scaled up to engaging 150 000 people by the peak summer months of April and June. The district administration identified works based on geographic spread, as people could not be forced to walk long distances for work. It was decided that:

> **two-thirds of all works opened should relate to water management, wherever possible to be followed by afforestation work (preparatory work like trenches and pits for afforestation) and road works would receive the lowest priority.**

All surveyed irrigation works were to be commenced and a large number of micro-minor irrigation tanks (primarily water-harvesting structures with small-scale irrigation) were taken up to ensure geographic spread of these public works. The Irrigation Department supported by the Agriculture Department, whose soil conservation wing had expertise to make small earthen tanks/farm ponds, were together able to start the construction of over 330 irrigation and water-harvesting tanks and 150 stop dams in the district, and by the peak months were able to engage over 100 000 of the 151 000 people involved in relief works that year.

The drought which continued into 1986 turned out to be a blessing, in that even the bigger works that were taken up in 1985 and were only partially completed, could be continued and completed.

As mentioned, the Technology Mission on Drinking Water and Related Water Management launched by the Government of India identified 55 districts of the country to experiment on integrated water management. Though the Mission was focused on drinking water which used only a small portion of the total available water resources, it recognized the need to focus attention also on water management, to ensure sustainability in domestic water supply. Jhabua was one of the 55 districts so identified and the Mission was intended to:

- ensure availability of drinking water in the context of drought, by integrated water resource management, and;
- eradicate guinea worm (dracunculiasis) within the time frame of 1986-1990.

It had therefore a focus on both quantity, in terms of availability, and quality in terms of potability. The Mission strategy entailed a transfer of technologies from the laboratories to the field, inter-sectoral action and people's mobilization for achieving its objectives. The Mission neatly dove-tailed into the ongoing effort in Jhabua aimed at developing water resources through large scale public works, in doing so it brought with it the technical expertise of national scientific organizations like the Central Ground Water Board, the Space Applications Research Centre and other affiliated agencies of the Council for Scientific and Industrial Research. These developed a district-level plan for integrated water management, and provided support in tasks like source-finding using satellite imagery.

The technology input pooled by the Mission ideally complemented the mobilization of men and money that was taking place in this district. It resulted in the implementation of over 2000 handpump-equipped boreholes in the district with about 250 of them utilizing the high-tech options worked out by the source-finding agencies of the Mission. By the end of 1986 Jhabua, with 1323 villages, had gained access to 6100 handpumps covering over 98% of its phalias or hamlets (the tribes of this district had a scattered habitation pattern with each village divided into four or more hamlets or **phalias**). Most of these water points were successful **and some failed ones of the past were rejuvenated as a result of the large scale augmenting of groundwater resources that took place through recharge from surface**

storage of the tanks and stop dams. The positive impact of these surface storages on the water table was underscored when this district reported the highest percentage of successful tube wells in an independent evaluation done for UNICEF India by Organizations Research Group (ORG) in 1987.

An opportunity for a parallel effort in the forward linkage of safe drinking water with health and productivity was provided in the guinea-worm eradication component of the Mission. The strategy adopted was to bridge the critical gap in software through social mobilization and health education. The incidence of guinea-worm was declining in the district through the creation of a large network of safe water sources (and ironically, a forced weaning away from traditional sources, as these were drying up). Guinea-worm at the beginning of the intervention phase was prevalent in 74 of the 1323 villages in the district. An analysis of the problem revealed the following:

- Guinea worm infections continued to exist, despite investments in safe water sources, since people continued to use unsafe sources in the absence of an awareness of adverse health implications.

- The human settlement pattern, referred to earlier as scattered, meant that people had to walk some distance to fetch safe water from the nearest handpump.

- The interface between implementing agencies of the water and health sectors was weak. In fact water-related health was an issue that "fell between chairs" in a turf-conscious bureaucracy.

- An interesting finding was that the creation of a special guinea-worm eradication unit within the health institutional structure at the district level had, inadvertently, a negative effect. This was caused by the health institutional machinery abdicating its functions to the special unit at district level, which in turn was constrained from mobilizing down-the-line functionaries. (Is there a lesson in this for policy planners who create special units to focus priority attention on a problem, in that it may result in losing the capacity to mobilize the larger group?)

The guinea worm problem was simple to solve. **The distance from the user to the nearest handpump had to be bridged through health education on the causes of dracunculiasis and the need to use safe water.** The water carrier in this district was the woman in the household and she had to be targeted for this awareness. Inter-sectoral coordination between implementing agencies within the bureaucracy had to be effected. People's action had to be enlisted to make the campaign successful. The following strategy was adopted to address the problem:

- A planned coverage of additional water points (handpump-equipped boreholes) in the 74 affected villages, and conversion of all step wells (walk-down wells that contributed to the spread of dracunculiasis) into sanitary wells.

- Formation of inter-sectoral action committees, at District and Block levels, of officials of general development administration, health and water supply to ensure inter-sectoral action for health education.

- Training (two-days at District level and four days at Block level) for all functionaries, to create a sense of joint effort and institutionalize inter-sectoral action.

- Formation of Front-Line Action Committees in each of the 74 affected villages. Each committee consisted of 10 members of which five were women, the village "panch" who was the local elected representative at village level, the school teacher, the village health worker and any other grassroots-level functionary posted in the village. It was therefore a mixed group of both grassroots functionaries and village volunteers.

- These committees were trained over a periods of 4 days at the block level. This was intended to make them campaign owners at the village level, instil leadership, give them an awareness of the disease and what could be done to eradicate it. Most of all it stressed the "can-do" element. These committees were given the task of organizing two-day village-level women's meetings to let others in the village know about the disease and its cure.

- A team of tribal volunteers was enlisted as a street-theatre group to develop plays and songs on the issue, using traditional media. The formats were familiar to the people as they drew on their traditional repertoire. This group was to function as social animators and would visit all the affected villages and participate in the village-level meetings. In addition, since it was a tribal practice to collect at the village haat (market) once every week, the haat being as much a social institution as an economic one, the group would perform in the haats. This was intended for "ambience-elevation" on the issue.

The campaign lasted for 8 months, which saw a significant increase in awareness on the issue. The guinea-worm search of 1990 reported complete eradication of this disease from the district.

These two interventions, one for water management and the other for eradication of a water-borne disease are linked only in that they both relate to water availability in the district. While the guinea-worm eradication strategy successfully utilized people's action, the water management efforts were run by the state with people used only as wage labour. The potential for people's action that could be enlisted for water management as well, and which was not fully utilized in Jhabua, is the focus of the post-intervention phase.

POST-INTERVENTION SCENARIO

At the outset it needs to be made clear that what is meant by "post-intervention" here is only the latter phase of the interventions that began in 1985, as these interventions, albeit in different forms, are continuing.

What is Jhabua like today, in 1993? It has certainly become a "positive" case of governmental intervention and is projected as **a district that has arrested its decline and begun its slow climb up towards reconstruction of its resource base.**

The over 450 tanks and 600 stop dams constructed in the period 1985-1992 have resulted in increased irrigation through lift, as people owning land in the command have come forward, with the support of the state government to form lift-irrigation cooperatives. This has resulted in many of these areas becoming multiple-cropped as against the earlier single rainfed crop, and has resulted in less migration out of the district. People are demanding more such works. The technical support base for undertaking these works has been upgraded. The development agenda continues to be focused on increasing water availability. Table 2 shows an increase in area under irrigation through this effort in the district.

TABLE 2
Evolution of irrigated agriculture in Jhabua 1985-92

Year	Area under irrigation (hectares)
1985-1986	21 382
1986-1987	24 696
1987-1988	27 814
1988-1989	31 348
1989-1990	34 672
1990-1991	36 921
1991-1992	39 037

The percentage of area under irrigation has doubled in this period of 1985-1992 and to that extent drought-proofing has been effected. People have begun taking two or more crops in a year and their income levels have increased.

Hydrogeological studies have helped in the proper location of low cost water-harvesting structures and check-dams. The Central Ground Water Board of the Government of India has published the results of some experimental studies in the district to establish the positive impact these water-harvesting structures have had on artificial recharge on a hard rock terrain. Jhabua, to a limited extent, has provided a model for the conjunctive use of surface and groundwater.

Guinea-worm has now been totally eradicated, and the social communication plan for guinea-worm eradication has presented a model that could be used for interventions for the elimination of water-borne diseases in general.

The major weakness in the Jhabua experience has been that even now **people's action** for environmental reconstruction is far from realized. What is happening is a state-driven programme still hooked luckily on the water agenda as it has been widely publicized as having succeeded. The crisis management in drought in 1985 and 1986 necessitated state intervention. But now the time has come to involve people directly in the improvement of their water and land resources, with the bureaucracy playing only a supportive role for technical assistance. Similarly the social mobilization strategy and inter-sectoral action evidenced in the guinea-worm eradication campaign need to be carried over into other areas.

LESSONS: CONSTRAINTS AND OPPORTUNITIES

The case study on Jhabua also reveals the tenuous nature of success. Many things happened as much on account of several contributing variables like political support, a tiring out of old models, focused attention through a national programme, availability of trained personnel etc. These become important in that integrated water management needs an enabling context. The fact that this agenda has still to be "discovered" even in drought districts is a comment on the system.

Political Support is not a Constraint

The first major lesson that is offered by Jhabua is that political support for state intervention in water resources management can be mobilized and is therefore not a constraint. In fact it even presents itself as an opportunity. The populism inherent in the interventions for drought relief is seen here to have helped catalyze a programme for integrated water management.

The political system is seen to be responsive to the issues of livelihood security more than resource rehabilitation and this could be utilized for an agenda that can combine livelihood security with resource rehabilitation. This is an opportunity which planners of environmental management ought to seize in order to come up with a labour-intensive water resources management plan.

Bureaucratic Organization is a Major Constraint

The major organizational constraint is a horizontally divided bureaucracy that still works as part of a command apparatus. Both in effecting water management and in the guinea worm eradication campaign the need to integrate the bureaucracy horizontally became a major requirement. Inter-sectoral action is critical, as issues relating to water management are necessarily cross-cutting.

This can be done to some extent by breaking down the hierarchy through pooled task groups. The consequent "destabilization" of turf can become a useful management strategy to break the existing work culture and to create a sense of collective effort. All this needs a coordinator of such action who has to become the conductor of orchestrated inter-sectoral interventions. Coordination of water management programmes seems to require authority structures where the jurisdiction is inter-sectoral. In the Jhabua case, the District Collector could coordinate the different agencies for water management and health education, since the Collector's jurisdiction was inter-sectoral. Institutional restructuring appears to be a very critical area for attention if objectives of integrated water management are to be realized.

In Jhabua inter-sectoral action, generated in the period of the crisis-handling in the drought years of 1985 and 1986, waned in subsequent years in the absence of institutional restructuring.

People's Plan for Integrated Water Management

The case study on Jhabua reveals that direct action by the community in environmental management is far from being realized. Even the best efforts made by governments fall short, in the absence of people getting directly involved. In Jhabua, the water-harvesting structures are seen as governmental property and even the minor repairs of these structures have to be attended to by the government. This is not on account of any apathy on the part of the people but because they are unsure whether they have the right to "tamper" with a structure created by the government. Steady erosion of rights over common property resources has contributed to creating this feeling which today limits collective action by the community.

Potential for Mobilization

Areas that witness the environmental crisis do have a radicalizing potential that can help mobilization (Hirschman 1983) and collective action. This would need to be triggered off through effective communication. The methods to be employed for such mass mobilization form an area needing urgent attention of planners, if objectives of integrated water management are to be realized. It would be contingent on institutional restructuring in a manner that maximizes decentralization and local action. Designing communication strategies for integrated water management that are context-specific, calls for pooling of effort by governments, NGOs, people's representatives, people's organizations and media professionals.

The Jhabua experience revealed that "to be perceived as having succeeded even partially", has been a motivating factor for the implementing bureaucracy. Successful cases could be used as communication "seed-labs" to enable replication. There is an absolute need to focus on software and social marketing issues to create the context for collective action.

A Turn-around is Possible Through an Agenda Combining Poverty Reduction and Eco-restoration

The final lesson of Jhabua is of hope that many similar areas that witness large scale environmental (and human) degradation today are capable of being turned around and put on a road to environmental recovery and sustainable human development. This requires a plan for integrated water management, supported by financial resources for large scale employment generation. Water-harvesting is a labour-intensive activity and offers an ideal investment opportunity for programmes that seek to address the twin objectives of poverty reduction and environmental rehabilitation. Financial support for this can be visualized to be tapering down in the medium term with increasing agricultural incomes.

To what extent is a case study on Jhabua a pointer? A drought-prone district identifying its basic development agenda around integrated water resource management is only doing something it ought to have done much earlier. The real pointer is towards a portfolio of investment for development planners and development institutions that seek to address environmental rehabilitation.

The Jhabua experience proves that effective utilization of public funds in drought-prone areas can rapidly bring about sustainable development which, in the medium to long term, benefits both government and the affected people. In the context of India, large-scale investment in integrated water resources management can have positive productivity implications. It can stabilize and improve agricultural production and integrated water resource management in drought-prone areas, and therefore help overcome the old trade-off argument of growth versus equity.

Such an agenda can succeed best when combined livelihood security, and a labour-intensive water management effectively address issues of poverty, while gradually rebuilding the natural and human resource bases. It also offers the as yet untapped resource, except in some NGO efforts, of using surplus human energy for environmental reconstruction. Collective energy is now on hold while water resources are as yet underdeveloped. Through appropriate organizational structures, this collective energy of people in water-deficit areas could be used for integrated water resources management. Jhabua represents a change in this direction.

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Integrated water resources and rural development in Indonesia

Rural development is the development of people and their institutions, resources and technology in rural regions. Since in rural areas agriculture is a dominant activity, then rural development is frequently interpreted as agricultural development. For developing countries such as Indonesia, that interpretation is still quite relevant because, even though gross domestic product of agriculture has already declined to 19%, 49% of the labour force is still engaged in the agricultural sector. Furthermore, rice, the staple food for most Indonesians, demands irrigation, and this activity consumes the major share of water in rural areas.

Water resources development in terms of irrigation in Indonesia is as old as rice cultivation practices (Pasandaran *et al.* 1992). Experience of food shortage in the first 20 years of development of Indonesia under the "New Order" government had reinforced the development of irrigation in order to support the rice self-sufficiency policy objective for the nation. The result was the achievement of rice self-sufficiency in 1984, after Indonesia had been the largest rice-importing country for a long time. Now, the irrigated area in Indonesia is more than 5 million hectares.

Agricultural sector growth during the last 20 years was about 5%. With this significant growth rate, rural poverty has decreased from 40% in 1976 to 14.3% in 1990, according to the Central Bureau of Statistics, 1991. This situation provided the precondition for the growth of other sectors, which is shown by their greatly increased share in the gross domestic product of Indonesia.

The continuing process of structural transformation of the Indonesian economy will increase and further complicate the patterns of demand for water. This increase in demand may come from sectors such as industrial, municipal, rural and power supply. Furthermore, due to imperfections in the management of water, some water resources have been experiencing a decline in quantity and quality, for example, salt water intrusion, groundwater contamination, surface water pollution, deterioration of watersheds.

CASE STUDY 2A

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TABLE 1

Projected water use in Indonesia in year 2000 (Source: Directorate General of Water Resources, MPW)

Region	Agricultural		Non Agricultural		Total (10^9 m^3)	Population (thousand)	Water use per caput (m^3/caput)
	Vol. (10^9 m^3)	%	Vol. (10^9 m^3)	%			
Java and Madura	55.57	62.11	33.90	37.89	89.47	122.115	0.73
Sumatera	21.33	65.67	11.14	34.30	32.48	24.013	1.35
Kalimantan	4.88	85.31	0.83	14.51	5.72	11.487	0.50
Sulawesi	6.49	47.41	7.19	52.52	13.69	14.443	0.95
Bali	1.41	88.12	0.19	11.87	1.60	3.032	0.53
Nusa Tenggara Barat	1.73	93.01	0.13	6.99	1.86	3.956	0.47
Nusa Tenggara Timur	1.61	92.53	0.12	6.89	1.74	3.734	0.47
Timor Timur	0.23	92.00	0.02	8.00	0.25	0.938	0.27
Maluku	0.97	93.27	0.07	6.73	1.04	2.279	0.46
Irian Jaya	0.75	81.52	0.17	18.48	0.92	2.194	0.42
Indonesia	94.97	63.77	53.76	36.10	148.92	188.191	0.79

THE CONTEXTS OF WATER RESOURCES DEVELOPMENT IN INDONESIA

Geographical-Ecological Context

Indonesia is composed of more than 16 000 islands. The geographic make-up implies that each island, according to surface water behaviour, should be considered as an independent unit of water allocation and management. It further implies that rather than undertaking all decision-making at the central level, resource mobilization, communication, and conflict resolution can be delegated to the lower level units, which are essentially island-based organizations.

While most of the western part of Indonesia has benefitted from water resources development, the drier areas in the eastern part of Indonesia, where the scope of water resources development is limited, have received an unequal share of investment. As a result, the incomes in areas without water resources development are significantly below those found in the more intensely developed areas in the western part of Indonesia. Another important characteristic related to the island-based water resources development is the concentration of development. Over the past two decades the concentration of development has been greater in Java due to greater population density, water resources endowment and rice production capacity in this island. Gradually, however, the development focus has been shifted to outer islands. Demand pressure for water is greater in Java than in the outer islands (Table 1).

The population density in Java is about 800 people/km^2, one of the highest in the world. The population has increased by the rate of 1% per annum in rural areas and 3.5% per annum in urban areas. This has led to sharp competition for land and water among competing uses.

The outer islands, however, are sparsely populated. Most of the areas in the outer islands are covered either with tropical rain forests, which are among the most important in the world, or are degraded and fragile deforested land. The forest resource has been rapidly reduced, estimates of annual depletion ranging from 600 000 to over 1 million ha.

Due to the increase in both industrial development and human population, water availability and quality are becoming major constraints on Java. Rainfall in this island is relatively abundant but heavily concentrated during the wet seasons (6 to 8 months). This concentrated rainfall, combined with increasingly deforested catchments and relatively short rivers, produces frequent flash floods, fast runoff and sharp variations in flow.

Technological Context

Within a given geographical-ecological setting, water resource systems are designed and constructed with certain specifications and capabilities. The nature and capabilities of such systems are themselves part of the context of water resources management.

The major source of water is river flows. As mentioned above, most of the river flows are highly fluctuating, which requires the managers to be able to respond to the changes in water availability. The acquisition and control structures generally used are diversion weirs, although pumps are sometimes used to abstract water from rivers. Reservoirs are also needed to reduce the variability in water supply. In Indonesia, large reservoirs have been constructed for multiple purposes in Java, and some in the outer islands. For non-irrigation purposes, the technologies have been used to meet relatively fixed design criteria for water allocation. In irrigation systems the technologies used can generally be differentiated between agency-managed technology and user-managed technology. In the first, the technologies used are closely related to design criteria for water allocation to meet the requirement of the predetermined cropping systems. In the latter, depending on the objectives, design criteria may be developed to meet the need for equitable water allocation. Related to these objectives, the regulation structures needed to control water supply are relatively simple, so that each of the users has access to water control. In the first case, water control is generally managed by an agency bureaucracy.

Economic Context

One of the issues related to water resources development is economic efficiency. This is different from water use efficiency as often used by engineers, by which they mean the ratio of water used to the total amount of water supplied. The higher this ratio the more efficient the use of water. Economic efficiency is related to the allocation of resources in ways that maximize their contribution to human well-being, within the constraints imposed by the existing distribution of wealth and income (Small and Carruthers 1991).

Because of the ecological nature of the water resource system in Indonesia, many of the systems operate with low water use efficiencies, and most likely with low economic efficiencies too.

A peculiar feature of water, that has important practical implications for financing policies, is the difficulty of measuring the flow. This is particularly true for many Indonesian irrigation systems, where water flows change not only seasonally but daily. Consequently, the task of water allocation among sub-units within an irrigation system becomes difficult. In many irrigation systems serving large number of small farmers, water prices do not exist because of the difficulties in measuring flows and because, historically, irrigation water has been considered free. In recent years the attempt to introduce an irrigation service fee has been undertaken by the government. Traditionally, however, farmers are often requested to pay for the service rendered by a water users' association or by local irrigation managers. In these irrigation systems, it is very likely that farmers get their irrigation water at a much lower price than they would be willing to pay.

The demand for water, except for domestic use, is in many cases a derived demand, as water is considered an intermediate product to generate agricultural or industrial outputs. Changes in prices of commodities, or the introduction of new crop varieties with greater yield responsiveness to water will shift the demand curve for water. In the Indonesian economy, and also in other developing countries, the long-run price of agricultural products tends to decline and the terms of trade are in favour of non-agricultural sectors. Hence, as there has been an increasing trend to convert irrigated land to other purposes, there has also been increasing demand pressure for water from non-agricultural sectors.

Most of the investments in water resources development, particularly the large-scale projects, were financed by public initiatives. Small-scale investment projects however were also undertaken by private investment, either individually or collectively as in the case of small communal irrigation systems. About 20 to 25% of the area of irrigation systems in Indonesia is served by these small-scale communal systems.

Historical Context

The history of water resources development in Indonesia accompanies the history of irrigation development and management. Even though the development of community irrigation systems might extend over more than two thousand years, modern irrigation systems introduced by colonial rulers were not developed until the middle of the 19th century; most likely this was related to irrigation technology for the lowland areas.

An assessment of principles of irrigation management was made in the early 20th century, particularly to support the management of irrigation systems constructed through public investment programmes. The focus of the assessment activities was on the principles of water allocation and on the delivery of water to the target point within an irrigation system. Two principles of water allocation were identified. The first was founded on the premise that government should control water allocation based on the predetermined crop schedule, and the second on equity in water allocation.

One of the discoveries in the requirements of irrigation systems was "The Pemali Curve" which has been used up to the present time to denote the relationship between the delivery requirement and the size of irrigation systems. It was found that the greater the size of irrigation system, the smaller the delivery requirement per hectare.

In a later stage of development, which incorporated improvements of technologies to deliver and regulate irrigation water, it was realized that different crops demanded different quantities of water. This led to the need to allocate water in accordance with the relative demands of crops. The concept of "Pasten" was introduced in response to this differential demand, with water allocation in accordance with the relative water demand of various crops. This water allocation concept, based on crop water requirement, however, is not determined by a price mechanism, and therefore is economically efficient only if water is not scarce.

The first water resource development project which incorporated multi-sectoral water allocation was Jatiluhur project in West Java. This project which was proposed by Blommestein in 1948, is the largest in Indonesia. It allocates water for irrigation, hydropower and domestic water supply to Jakarta. One other multipurpose project worth mention is the Brantas project in East Java. There has been a growing need for development of multipurpose water resources projects, because of their large multiplier effect in regional development. This type of project, however, requires a huge amount of investment and has a long gestation period.

Political-Legal Context

The most visible aspects of the political-legal environment are the policies of the government. During the colonial time, for example, the government policies for water resources development were focused on poverty alleviation and promoting export commodities such as sugarcane. Over the past two decades the goal of water resources development has been primarily to promote irrigation in order to support food self-sufficiency.

In recent years, in addition to the efforts to maintain food self-sufficiency, water allocation has been designed to promote diversification of commodities through agriculture, industries, and energy generation. Regulation of water resources, which is used as a basis for water allocation and management is by Law No. 11, 1974. This law replaces the previous general water law of 1936, which was designed to provide the basis for water allocation, particularly for agricultural commodities.

The law contains four main items that have important implications for water resources allocation and management.

- Water and water sources to be used for the greatest benefit of society.
- Water and water sources are controlled by the state. Regulation, planning, and licensing of water resources are under the jurisdiction of the government.
- Government jurisdiction on water resources can be delegated to the local governments and other legal entities.
- Planning and coordination are done by the government agency.

Law No. 11 provides for the centralized role of government in water resources development and management, even though it also provides a legal basis for the government to decentralize the activities on water resources to local governments and other legal entities. Government regulation No. 22, 1982, is used to regulate water resources management based on river regime units. As a follow up of this government regulation, 90 River Regime Units (RRU) have been identified; 63 of them are managed by provincial governments, 15 RRU are managed by central government and two RRU, namely Jatiluhur and Brantas are managed by state-owned corporations.

The management of groundwater resources, however, is not necessarily based on RRU, as often stated by the Ministry of Mining and Energy which has a mandate to regulate these water sources through Ministerial Regulation No. 3, 1983. It is the utilization of resources from groundwater that probably has to be managed in conjunction with surface water in RRU, together with the management of rivers, swamps, irrigation, etc.

The most recent development that has to be taken into account is the promulgation of Law No. 12, 1992, on crop cultivation systems, a sector which consumes the largest portion of water in Indonesia. This law provides the freedom to the farmers to plant crops of their own choice, which presumably induces crop diversification in irrigated areas. Consequently all these political-legal factors have to be considered in dealing with present and future water resources development in Indonesia.

WATER RESOURCES POLICY IN INDONESIA

Repelita I

Food production was the top priority of Repelita I (the first National Five-Year Plan). The most potentially productive area for food production was the intensively-cultivated, irrigated paddy fields of densely-populated areas of Java and adjoining Lampung (historical transmigration areas, populated by descendants of Javanese paddy rice farmers). At that time, most irrigation infrastructure had deteriorated due to lack of maintenance in the "Old-Order" government.

However, in addition to the deterioration of the irrigation facility, the upper reaches of watersheds had also deteriorated, due to erosion. This caused both direct flooding and sedimentation in rivers and canals, which in turn reduced the capacity of rivers and canals to irrigate during the dry season and to carry off rainfall in the wet season. The effect was drought during the dry season and the flooding of both agricultural land and human settlements during the rainy season.

The Government established five programmes in the Irrigation Sub-sector of the Agriculture and Irrigation Sector. These five programmes were: (i) land and water conservation, (ii) river improvement and safety, (iii) irrigation upgrading, (iv) irrigation extension, (v) irrigation development.

Construction of new irrigation works and the upgrading or rehabilitation of existing works for primary and secondary canals and associated structures, was the responsibility of the Government. The Central Government Directorate General of Water Resources Development (DGWRD) was responsible for large schemes, while small schemes of less than 500 ha were the responsibility of the regional governments. Tertiary canals and quaternary canals (distribution ditches actually located within the rice paddy field) were the responsibility of the farmers, as also was operation and maintenance of any works for which construction (or rehabilitation) had been completed by the government.

Repelita II

Agriculture was still the top sectoral priority, but in a wider understanding including not only food production, but also industrial raw materials and exportable products. The main issue for attention in Repelita II was that of employment. All sectoral activities were related to their employment-generating potential.

Two major policy changes were made between Repelita I and Repelita II. First, the term "irrigation" was replaced with "water resources" in accordance with the Enabling Law on Water Resources, which had just been passed in 1974. Second, the concept of "ecosystem" was introduced into Indonesian development planning and, specifically, into water resources policy. Based on the Enabling Law, which defined the river basin as the basic unit of water resources, the ecosystem concept was interpreted as referring to the river basin. This understanding still holds at present.

Of the five programmes in Repelita I, land and water conservation was moved to the Forestry Department, leaving four water resources programmes in Repelita II: (i) irrigation upgrading, (ii) new irrigation, (iii) rivers and swamps - which aggregated the "other irrigation" project of Repelita I, (iv) research, survey and planning.

New irrigation projects were focused on two main areas: upgrading simple systems of less than 2000 ha in densely-populated areas, and providing irrigation to transmigration areas.

Repelita III

Irrigation was relegated to the status of infrastructure for agriculture. Priority was given to irrigation activities which would directly support production and farmer incomes, such as simple (small) systems, the construction of tertiary and quaternary canals and the creation of paddy field, farm-level water management (which had begun during Repelita II), and pumped irrigation. The irrigation sub-sector had three programmes, (i) upgrading irrigation, (ii) new irrigation, (iii) swamps.

Repelitas IV and V

During the latest Repelitas, the direction of water resources policy has not changed greatly, but has consolidated its move in the directions already established since Repelita III. Operation and maintenance of existing irrigation systems, including farmer water-associations, is being given increased attention, as part of a general move to encourage broader public participation in development efforts.

Emphasis in the irrigation sector continues to move toward small-scale, cheap and immediately profitable irrigation works rather than large-scale, new efforts in virgin territory.

Environmental issues and the ecosystem approach are being implemented more seriously, particularly as the results of uncontrolled industrial pollution become increasingly evident in urban and industrial areas.

River basin planning is becoming more oriented toward watershed hydrology and management, rather than emphasizing irrigation and flood control. The problem of critical lands has reached crisis proportions in some areas of Java and the restoration of watershed rechargeability is an important priority.

Repelita V emphasizes the integration of water resources planning with other sectors, such as changes in cropping patterns and schedules to conserve water, change from paddy rice to high-value plantation crops which require less water, and increased reliance on water-user associations to improve maintenance of physical structures and efficiency in water use.

The changes were primarily in response to the increasing demands for water against a relatively constant supply.

THE GROWTH OF THE AGRICULTURAL SECTOR IN INDONESIA

Area Harvested and Production

Irrigation development primarily affected the expansion of the rice area harvested, and consequently affected rice-complementary commodity production. As indicated in Table 2, total irrigated service area in Indonesia increased from 3.4 million in 1969 to 5.4 million in 1987. As a result, the production of rice increased from 18 million metric tons in 1969 to 40 million tons in 1987 (Table 3). Simple computation showed that 10% increase in the irrigation service area increased gross rice production by 16%. Of course, this is an over-estimate, but the point is that the establishment of irrigation infrastructure has provided a precondition for the application of high-yielding rice varieties, fertilizer and other technological components. Besides area and yield as sources of growth, irrigation development was also an important determinant of cropping intensity increase.

Food Security and Poverty Alleviation

Increasing rice production by more than double has created the capacity of Indonesia to provide sufficient food for the people. This is shown by the increase in rice consumption from 110.4 kg/caput/year in 1980 to 116.6 kg/caput/year in 1987. The overall result of the increase in rice production is reflected by national high food security, and the reduction of absolute poverty in rural areas from 40% in 1976 to 14.3% in 1990.

Major Constraints and Trends

There are three inter-related water issues which will be of increasing importance in the future. These are: the efficiency of water use, competition for limited supplies of water for non-agricultural use, and water quality.

Competition for land is acute in Java because: (a) the population density is so high; (b) rice yields on sawah land are much higher than elsewhere in Indonesia, reflecting better soils, a long history of irrigation investment, and the development of intensive farming methods; and (c) demands for land for urban and manufacturing development and infrastructure are much greater on Java than elsewhere in Indonesia. Demand for non-agricultural land is particularly strong on the northern coastal strip of the island, the location of some of Indonesia's most productive paddy land.

There are no firm estimates of the extent of the annual transfer of paddy land to other uses, although the reality of urban and manufacturing expansion into paddy areas is immediately apparent in urban vicinities. There is a wide range of estimates of rates of transfer, from the implausibly low to the alarmist high. Future transfers could be greater, under a more efficient and deregulated land market. In addition, there are possible shifts of land within agriculture, away from paddy towards horticultural crops, for example.

TABLE 2
Potential irrigated service area in Public Works Systems, by type of system, Indonesia, 1969-87
(Source: Ministry of Public Works, DGWRD)

Year	Total Irrigated Service Area			Technical Irrigated Service Area			Semi-technical Irrigated Service Area			Simple Irrigated Service Area		
	Java	Off-Java	Indo.	Java	Off-Java	Indo.	Java	Off-Java	Indo.	Java	Off-Java	Indo.
	'000 ha											
1969	2506	882	3388	1172	298	1470	973	301	1274	361	283	644
1970	2513	923	3436	1240	309	1549	918	330	1248	355	284	639
1971	2506	982	3488	1291	281	1572	664	342	1003	554	359	913
1972	2513	1004	3517	1380	295	1675	583	352	935	550	357	907
1973	2518	1028	3546	1446	309	1755	524	359	883	548	360	908
1974	2522	1135	3657	1518	233	1751	430	447	877	574	455	1029
1975	2521	1236	3757	1522	269	1786	431	504	935	568	468	1036
1976	2555	1289	3844	1557	313	1870	467	473	940	531	503	1034
1977	2557	1385	3942	1563	318	1881	435	516	951	559	551	1110
1978	2581	1437	4018	1575	340	1915	459	530	989	547	567	1114
1979	2592	1470	4063	1604	357	1961	441	587	1028	548	526	1074
1980	2608	1500	4107	1642	365	2007	427	639	1066	539	496	1035
1981	2623	1529	4152	1680	373	2053	414	690	1104	529	466	995
1982	2637	1558	4195	1717	381	2099	401	741	1142	519	436	956
1983	2656	1586	4241	1752	393	2145	390	790	1180	514	403	916
1984	2735	1670	4405	1807	424	2231	338	811	1149	590	435	1025
1985	2696	1717	4413	1808	429	2237	363	839	1202	525	449	974
1986	2698	1924	4622	1861	544	2405	305	864	1169	532	516	1048
1987	2970	2388	5358	2069	691	2760	314	1032	1346	587	665	1252

While the constraints on land expansion on Java are primarily physical, the constraints on land expansion off-Java are mainly economic, social, and environmental. Almost 7 million ha of new land off-Java has been identified by the Ministry of Public works as suitable for irrigation development. Of this, almost 3 million ha are suitable at "low cost". In addition, there is about 400,000 ha of land off-Java which is within irrigation schemes but which is not yet irrigated.

Off-Java, therefore, the issue is not the physical availability of new land, but the costs of rehabilitation and of bringing new land under irrigation. These costs have increased sharply over the twenty years of the first four Repelitas.

While the pricing of irrigation water on a volumetric basis represents a first-best solution to economizing in water use at the farm level, such pricing requires controllable and measurable water supplies at the farm. Given the small size of Java's farms and the fragmentation of plots, such a system is probably not feasible for the foreseeable future. Improving O&M, is an essential step.

The evidence to date suggests that agricultural activities are not a significant threat to water quality. After the banning of certain pesticides, studies have shown no significant pollution due to agricultural chemicals. Similarly, crop production is not so far adversely affected by the impact of polluted water supplies. This is not to say that water pollution is not a problem in Indonesia. It is a problem, particularly in some areas of Java, where water pollution by human and industrial waste is at acute levels. Also, the rural population is subject to health risk on account of unsafe drinking water supplies.

TABLE 3

Irrigated and wetland area, dryland area, and total area, yield, and production of paddy in Indonesia, 1969-87

Year	Irrigated & Wetland Area			Dryland Area			Area			Yield			Production		
	Java	Off-Java	Total	Java	Off-Java	Total	Java	Off-Java	Total	Java	Off-Java	Total	Java	Off-Java	Total
	'000 ha			'000 ha			'000 ha			mt/ha			'000 mt		
1969	3933	2611	6544	345	1124	1469	4278	3735	8014	2.57	1.88	2.25	11003	7010	18013
1970	3947	2732	6679	341	1115	1456	4288	3847	8135	2.70	2.01	2.38	11580	7744	19324
1971	4037	2856	6893	365	1066	1431	4402	3922	8324	2.81	1.99	2.42	12389	7793	20182
1972	3992	2610	6602	326	970	1296	4318	3580	7898	2.76	2.09	2.45	11896	7490	19386
1973	4226	2838	7064	331	1009	1340	4557	3847	8404	2.86	2.20	2.56	13016	8465	21481
1974	4434	2906	7340	285	884	1169	4719	3790	8509	2.94	2.27	2.64	13853	8611	22464
1975	4379	2955	7334	265	896	1161	4644	3851	8495	2.95	2.24	2.63	13701	8630	22331
1976	4203	3026	7229	249	890	1139	4452	3916	8369	3.15	2.37	2.78	14031	9270	23301
1977	4115	3087	7202	245	913	1158	4360	4000	8360	3.00	2.57	2.79	13080	10267	23347
1978	4447	3251	7698	284	947	1231	4731	4198	8929	3.29	2.43	2.89	15551	10221	25772
1979	4393	3282	7675	217	912	1129	4610	4194	8804	3.40	2.53	2.99	15655	10627	26283
1980	4503	3316	7824	253	933	1186	4756	4249	9005	3.86	2.66	3.29	18358	11294	29652
1981	4763	3428	8191	266	924	1190	5029	4352	9382	4.07	2.83	3.49	20478	12296	32774
1982	4488	3385	7873	247	868	1115	4735	4253	8988	4.39	3.00	3.74	20806	12778	33584
1983	4479	3508	7987	291	885	1176	4770	4393	9162	4.53	3.12	3.85	21595	13707	35303
1984	4852	3695	8547	350	867	1217	5202	4562	9764	4.55	3.17	3.91	23666	14471	38136
1985	4965	3704	8669	307	855	1162	5272	4559	9832	4.59	3.25	3.97	24217	14808	39025
1986[a]	4986	3827	8813	345	831	1176	5331	4658	9989	4.59	3.50	4.08	24459	16297	40756
1987[a]	4971	3866	8837	214	871	1085	5185	4737	9922	4.73	3.24	4.04	24544	15535	40079

[a] Irrigated and wetland area and dryland area are preliminary estimates in 1986 and 1987.

Source: Central Bureau of Statistics.

There are two water quality problems for agricultural production. First, fisheries and aquaculture are particularly susceptible to water pollution, especially on the industrializing north coast of Java. One solution to this problem may be to divert canal water to aquaculture (rather than the use of return flows), as is the practice in some areas. Another may be to further develop fishing and aquaculture activities off-Java. Coastal zone management is becoming a critical need. A second, and potentially more serious problem in the long-term, is the spread of agro-processing and other manufacturing activities to rural areas, particularly on Java. Such activities are an essential part of development, are very significant sources of higher incomes for farming families, and should be encouraged rather than hindered. However, they can also generate pollutants, particularly those discharged into the water supply in rural areas. The solution to these problems lies not in regulating the growth of the activities themselves, but in the regulatory and fiscal policies to control such effluent. However, these are issues which go well beyond the agricultural sector.

INTEGRATION: ONE MORE STEP AHEAD

The above discussion suggests that water resources development is an essential part of economic development, which is transmitted through agricultural development. The immediate result is shown by an increase in food supply, food security and poverty alleviation in rural areas.

In the next 25 years, however, agricultural policy must be reoriented, firstly, from the present production-centered approach to an approach emphasizing farmer incomes, and secondly from a commodity approach to a functional agribusiness approach (Kasryno and Suryana 1992; World Bank 1992). In this context, a diversification strategy, namely a resource allocation based upon price signals, will become a major policy instrument. In addition, an agribusiness approach calls for more intra- and inter-sectoral linkages in management, both horizontally and vertically. It implies that a diversification strategy will induce the growth of the rural economic web of primary, secondary and tertiary industries in the rural areas.

Since all activities require water, then changes in the level and composition of rural industries will change the magnitude and composition of demands for water. In the field of agricultural production, the opportunities to cultivate varieties of crops are determined or conditioned by the irrigation structure. The more flexible the structure, the greater the opportunities for farmers to diversify their production.

A run-of-the-river system is appropriate only for rice cultivation. It is inflexible for the production of other agricultural commodities (Sugianto et al., 1989). This is one of the most important technological issues in future irrigation development in Indonesia, based on the following reasons:

- There is a persistent attitude that water resources development equates to irrigation development.
- The installation of new irrigation systems will involve large funding, including salvage costs of the existing systems.

- Most Indonesian farmers are small-scale subsistence farmers, and the question of who will pay for the investment becomes an issue.

- Technical knowledge of new irrigation systems is still rare in planning, design, and operation.

- The declining trend in terms of trade of agricultural products, and therefore whether new investment is worthwhile, is also an issue.

- Conflict among economic sectors on land allocation and use, and who will assure that new irrigation will not be replaced by other uses, particularly in Java.

The above issues cannot be solved solely by irrigation engineers. It is obvious that future irrigation development calls for broader approaches involving many disciplines and institutions.

Growing population and economic activities in rural areas will have tremendous impact on water resources. Given the variability of water availability seasonally and spatially, water resources management and development will involve simultaneously sectoral, spatial and institutional dimensions. The output characteristics of water resources development and management should include quantity, quality, time, and space. In this context, irrigation is only a part of water resources development.

Experience shows that a sectoral approach is necessary but not sufficient to reach sustainable development. In water resources, it is clear that a purely sectoral approach will create more harm than benefits in the future. Therefore, a more integrated approach is called for. In this connection, there have been three recent seminars held by BAPPENAS, the National Planning Agency, in 1991 and 1992, which have produced statements and conclusions as follows:

- Water resources problems are not homogeneous across regions, and therefore a system of regional weighting is needed.

- Existing data are not sufficient for estimating water resource capabilities and trends (changes) over time.

- Changes are needed in society's basic attitudes toward water, particularly the tendency to view water as a free good.

- Future water demand will arise from sectors other than agriculture (paddy rice), which will require a reorientation in the approach to water resources development.

The second seminar was a continuation of the first, and was held on 28-29 July 1992, in BAPPENAS, to discuss, specifically, the reorientation referred to in the last point above. This seminar produced the following conclusions:

- Policy makers now need a broader perspective than in the past, because the problems are different from 20 years ago.

- An integrated approach to development is needed, based on a river basin/island unit of management.

- Investment criteria should be based on the specific problems to be solved, including such factors as economic efficiency, justice, fairness, equality and sustainability.

- Human resources development requires attention.

- Institutions and organizations need to be improved.

The third seminar in the series was held in October 1992, and the following were the main issues:

Institutions:

- The need to reinforce the river basin as the unit of planning and management, the possibility of establishing a National Water Resources Council.

Allocation and management:

- The need for a new approach in water resources allocation and management.

- The need to reinforce the river basin as the unit of planning and management.

- Price and cost should be used as instruments of water allocation and management.

Policy and strategy:

- Reorientation of policy toward the macro-fiscal aspects, poverty alleviation and regional development.

- Harnessing of the price system and the possibility of cost sharing.

Human resources and the transfer of technology

- Increasing the capabilities of human resources through education, training and other mechanisms.

- Technology generation and transfer.

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Water resources development in Indonesia: problems and strategies

As with other developing countries, Indonesia is still characterized by a high rate of population growth. In 1990, the Indonesian population was 179.2 million. With an annual growth of 1.96%, it is expected that the population will be 209 million in the year 2000, and 280 million by 2020. This creates a very high water demand for domestic use, for industries, and irrigation.

A high rate of urbanization in some Indonesian cities, especially those on Java island, is causing a reduction in the area of irrigated ricefields, and other agricultural land, due to the use of land for urban and industrial development. In 1990, total urban population was 55 million, or about 31% of the total population. It is expected that urban population will rise to 80 million (37.6%) in year 2000, and 141 million (50.4%) by 2020. While some previously irrigated areas have changed to urban lands, their replacement by new irrigation schemes and ricefields is unfortunately less than half of the area lost to urbanization.

Water scarcity has been experienced in some areas, especially metropolitan areas with a very high water demand and limited fresh water sources. Surface water pollution, such as occurs in Jakarta and Surabaya, further complicates the problem of water demand. Consequently, water must be transferred from remote areas, which in some cases are already providing irrigation supplies. This calls for a re-evaluation of water allocation among different users. Scarcity has changed the perception of water from a social to an economic good, and in some areas scarcity problems are related both to its quantity and its quality.

WATER RESOURCES PROBLEMS

Water resources in Indonesia are distributed unevenly in terms of time and space, and the potential of water resources varies from one island to another. Annual rainfall ranges from 500 to 4000 mm. Even where rainfall is relatively high, seasonal variation complicates water resources management. In some areas, the available water cannot meet the demand, due to

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the limited amount and poor quality. The critical condition of the upper catchments of some rivers has increased the erosion rate, which threatens the continued use of hydraulic structures such as dams and reservoirs, irrigation networks, and flood-control structures that have been built at high cost. In the meantime, rivers, and especially those which flow through cities, have been polluted due to the weakness of environmental management. This surface water degradation has negative impacts on the freshwater supplies needed by cities and industries.

THE NEED FOR INTEGRATED PROGRAMMES

The above water resources problems call for an integrated and comprehensive development, with coordination among different sectors. The constraints of water resources in terms of time, space, quantity and quality must be considered in regional development, which requires coordination and integration among the sectors involved in a specific river basin.

By Government Regulation 22, 1982, water resources development in Indonesia is based on the river basin unit. Within this concept, river basins can be divided into rural and urban areas, as well as upstream and downstream areas. This classification is intended to identify the specific water problems in each defined area. In upstream rural areas for example, erosion control is the main concern, to maintain the continuity of supply from reservoirs. The rural downstream areas usually enjoy irrigation water, but are sometimes threatened by flood hazards. On the other hand, urban areas usually need a considerable water supply to support their functions as centres of economic activities, both for agriculture and for other uses.

WATER RESOURCES DEVELOPMENT STRATEGIES

The complexity of the future problems in development, with relatively limited water resources, raises the need to aim for sustainable water resources development. To achieve this objective, the following government strategies are outlined:

- Water resources development will be reoriented to **management aspects** more than to **development aspects** of the facilities. In this respect, water management will include multipurpose water use and the conjunctive use of surface and groundwater resources.

- With the increased complexity in water development, water resources planning will be done in a **comprehensive and integrated** manner. The integration of water resources development should be oriented to support regional economic development through river basin units.

- To attract funds for overall economic development, the role of private agencies in water resources development, especially to supply the domestic and industrial sectors, will be increased, in order to reduce the financial burden of the government.

- The application of advanced technology must be utilized, to support more efficient and effective water management. In agricultural development, for example, sprinkler and drip irrigation systems will be considered for cash crops.

- Human resources development will have high priority in the strategy for water resources development and management. Expertise and skills must be promoted to improve both irrigation management and water resources management as a whole.

Technical Session II

Research and development

Irrigation technologies for water use efficiency and environmental protection

COOPERATIVE ACTION FOR SUSTAINABLE DEVELOPMENT

There is a general consensus that conservation and effective water resource use are necessary for sustainable irrigated agriculture. The Dublin Statement, formulated at the International Conference on Water and the Environment (ICWE), 1992, calls for united and cooperative action at the local, national, and international levels to address waste, pollution and the threat of drought and floods:

> "Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment. Since water sustains life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems. Effective management links land and water uses across the whole of a catchment area or groundwater aquifer."

This international concern stems from the rising demand for food for growing populations, increasing competition for scarce water resources from urban and industrial sectors, and decreasing agricultural productivity from inefficient irrigation practices and insufficient drainage, among other factors.

Two broad strategies are evident in countries' responses to the problem of achieving a sustainable demand-supply balance while maintaining an acceptable standard of water quality:

- promoting water conservation through improved demand management, reuse and increased efficiency; and
- enhancing water quality through salinity and pollution control and treatment.

The competing claims for water from municipal and industrial users pose a challenge to agricultural users, who account for nearly 80 percent of water use. An appreciation of the need for **water conservation in agriculture** has emerged and pressures on the sector to

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improve water resource use are mounting. Planners are increasingly paying attention to water conservation, since current systems of water delivery are already overextended and development of new sources of irrigation water is constrained by high capital costs. Promoting water conservation involves implementing demand management measures and technological and managerial improvements in water delivery systems.

The **enhancement of water quality** ensures that water of sufficiently good quality is used for agricultural purposes so that salinity and sodicity do not unfavourably affect soil and freshwater in the long run; that treated drainage and sewage water is fit for agricultural use and human contact; and that chemical contamination of water resulting from the use of herbicides and pesticide is controlled. The strategies of water conservation and quality improvement are linked, because action with regard to quality also augments available water supply, as in the case of drainage water reuse in agriculture. Similarly, inefficient water use lowers productivity of water and leads to salinity build-up, adversely affecting land and water quality.

The design and implementation of these strategies will require action on many fronts, including:

- re-examination of water resource allocation decisions across multiple uses;
- policy reforms following the valuation of water and review of opportunity costs;
- incentives to improve water use efficiency;
- adoption of technologies for water saving and water quality improvements;
- institutional and management reforms to provide incentives for water conservation and productivity gains.

There are international and national efforts to promote such actions in the various water-related sectors. In the international arena, programmes sponsored and implemented by a number of UN organizations, including the UNDP, FAO, Unesco, WMO, and WHO as well as by professional associations, like the ICID, the IWRA, the International Association on Water Pollution Research and Control, and the International Water Supply Association, have extensively mobilized awareness and interest of water resource professionals in questions of productivity and water quality within their respective sectors. In addition, many developing countries have begun to reassess systematically their water resource management strategies. Within the irrigation sector, the most recent ambitious effort to address some of the important emerging concerns of productivity and quality was the establishment in 1984 of the International Irrigation Management Institute (IIMI), focusing on institutional and managerial aspects of improving the performance of irrigation systems.

THE ROLE OF IPTRID

In an effort to complement the work of key national and international agencies and to promote technology research in irrigation and drainage, the International Programme for Technology Research in Irrigation and Drainage (IPTRID), co-sponsored by the UNDP, the World Bank, and the ICID, was established in 1991. The broad objective of the three-year programme is to promote technology R&D in irrigation and drainage by providing a forum for collaboration among developing countries, donors, and national and international research institutions for developing and implementing research projects. IPTRID's efforts are focused on three broad R&D themes: **modernization** of irrigation and drainage systems; ensuring **sustainability** of land and water use; and improving technologies for **maintenance**.

- The **modernization** theme addresses technological issues brought about and required by the universal trend in the shift from supply to service-oriented irrigation (Box 1). This includes technologies for reliable water delivery service to farmers, currently plagued by rigid and unreliable water supply systems. Activities associated with the theme will also contribute to the water conservation strategy, referred to above, and to the prevention of deterioration in water quality.

- The **sustainability** theme encompasses concerns related to land and water use, such as waterlogging and salinity control, drainage water reuse and efficient disposal. Thus, work on this theme has a direct bearing on water quality issues.

- The **maintenance** theme refers to improving methods of maintaining irrigation and drainage systems in a physically, financially and environmentally sustainable manner. Improved weed control practices and sediment control, as well as the development of an adequate information system, are at the heart of the maintenance theme. Progress on this theme will contribute to both water conservation and enhancement of water quality.

The impact of technology R&D in irrigation and drainage on water conservation and water quality enhancement is not direct and immediate. Incentives are crucial for the generation of appropriate technology and farmer adoption. Similarly, local institutional capacity and attributes of system managers are significant aspects for consideration in choice of technology. Hence, there is a need for complementarity of IPTRID's efforts with other national and international agencies and for strong linkages, in particular with IIMI.

BOX 1 MODERNIZATION THROUGH THE IMPLEMENTATION OF THE SERVICE CONCEPT

Traditional upstream-controlled irrigation systems are designed and operated with the aim to spread a certain, limited amount of water over the command area. Modern systems, however, follow the service concept where water is provided for the convenience of the user, implying more efficient use of water resources at all operational levels of an irrigation system. The service concept is guided by two basic principles. First is the belief that individual farmers should have as much flexibility in the water delivery as is economically and technically possible, since they are more capable than a central water authority to anticipate the correct amount and timing of irrigation, which is affected by differences in soil texture, soil depth, crop types, planting dates, plant varieties and irrigation system constraints. Moreover, since it is the farmer who must ultimately carry the financial burden and risk of growing crops, it should be the farmer who controls the use of irrigation water. The second notion is that it is much easier for a small, single purpose organization to set its objectives, mobilize resources, control the behaviour of its members, and agree with its client on the desired level of services than for a central organization. The implementation of this concept implies a completely different approach to design and operation. The service concept divides an irrigation system into several operational levels. Each of the operational levels provides an agreed upon level of service to the lower level and in turn, each lower level compensates the next upper level for the services received, thus creating an autonomous system. (Burt and Wolter 1992)

COUNTRY EXPERT MISSIONS

IPTRID responds to country requests for assistance on research related to the three themes mentioned above. Between late 1990 and 1992, at the request of participating governments or other host institutions, IPTRID organized four expert-team missions to five countries. Together, these countries account for about 40 percent of irrigated agriculture in the developing world and span four important agricultural regions in the world. The countries and the theme focus of the missions are shown in Table 1.

The expert missions assisted in the formulation of technology research priorities, based on a review of operational problems in irrigation and drainage, sector and user needs, and ongoing research efforts in each of the countries visited. Taken together, the priorities identified in the missions give an indication of some important areas for technology R&D relevant to water conservation and water quality concerns in the countries currently in partnership with IPTRID. These priorities are determined by a panel of national and international experts and do not constitute an exhaustive inventory of all research topics that would address similar concerns in the countries. Needless to say, these R&D priorities cannot be generalized as applicable to global needs and, hence, attempts to extrapolate their significance have to be treated with caution. Nevertheless, the priorities identified do offer a glimpse of significant gaps in some of the most important irrigating countries.

TABLE 1
IPTRID country missions and theme focus

Country/ Themes	Modern-ization	Sustain-ability	Maintenance
Egypt		M	P
Pakistan		M	P
Mexico	M	M	M
Morocco		M	P
China	M	M	P

M Major Focus; P Partial Focus

PRIORITIES IN TECHNOLOGY R&D

The R&D priorities identified by the IPTRID expert missions have been consolidated by selecting the priority R&D areas mentioned in at least two of the country reports. Table 2 shows the consolidated list of technology R&D priorities for the five countries, and their relevance to the strategies of water conservation and water quality improvement is indicated (IPTRID 1991a; 1991b; 1992a; 1992b).

System Assessment

This priority area focuses on the need for careful systems diagnosis before planning R&D interventions, since critical problems could vary from system to system. For instance, system problems could arise from poor water control in the main and secondary canal systems or due to the mismatch between the main system and on-farm techniques in use within a given irrigation system. With regard to drainage, diagnosis would similarly assist in identifying areas for improvement, whether related to choice of techniques, materials or design criteria. The diagnostic phase is common to all further undertakings to improve irrigation and drainage systems, including efforts at policy reforms and management and institutional improvements. In this context, it is useful to note that there has been a renewed worldwide interest in assessing system performance, as exemplified by the extensive coverage found in the journal

TABLE 2
R&D priorities

	Priority areas	Water Conservation	Water Quality Improvement
1.	**System Assessment**		
	▸ Identification of performance gaps	•	•
	▸ Assessment of technology needs		
2.	**Conjunctive Use and Management**		
	▸ Aquifer management	•	o
	▸ Recharge techniques	•	o
3.	**System Design Improvements**		
	▸ Canal regulation improvements for more reliable water supply	•	
	▸ Review and formulation of design criteria for drainage (spacing, depth)	o	•
	▸ Alternative energy	o	
4.	**Materials Improvements**		
	▸ Materials research: gates; drainage envelope; lining	•	
5.	**Maintenance Improvement**		
	▸ Integrated Weed Control	•	o
	▸ Equipment Assessment	o	o
6.	**Reuse/Disposal Techniques**		
	▸ Blending of fresh and saline water	o	•
	▸ Effects of saline water on soil and fresh water	o	•
	▸ Health implications of reuse	o	•

• Strong influence o Weak influence

Irrigation and Drainage Systems (1991). Moreover, IIMI and IFPRI have been collaborating on a research programme in Performance Assessment.

In assessing performance it is helpful to use the **service concept** (Box 1) focusing on the interfaces between the different subsystems in an irrigation scheme. Questions to be addressed in such an analysis are:

- What is the level of service required?
- What is the level of service actually provided?
- What is the capacity of the system to improve the service?
- What is the capacity of the client to pay for better service?

With regard to **process**, irrigation managers and project planners in developing countries are looking for **practical and operationally useful guidelines** for performance assessment. This is an important caution to be kept in mind when undertaking research in this area. Some relevant questions are:

- Are quick but reliable assessments feasible?
- Can irrigation project or planning staff be trained to undertake these assessments?
- How can water users be included in the assessment exercise?

While useful and reliable data may not be available in all projects, setting up extensive procedures for measurement and monitoring may not be feasible in the short run. Thus, proxy measures that could be used in the assessment need to be investigated. Stakeholders involved in the irrigation system, irrigation related agencies, irrigation managers and water users, have to participate in the performance assessment exercise if it is to incorporate all relevant objectives and if it is to be followed up with commitment for action on the findings. The assessment would indicate the gaps in technology that need to be addressed in order to achieve the required level of service in the irrigation drainage system.

Conjunctive Use and Management

This topic was somewhat of a surprise in the IPTRID expert mission's findings. The missions did not include water resource planners and yet it was clear, as in the case of China and Pakistan, that conjunctive use of surface and groundwater was critical to improving efficiency of water distribution and use. Indeed, the experience in Pakistan of using tubewells to provide vertical drainage and irrigation water supports the case for conjunctive planning and management of water resources. The extensive use of tubewells through SCARP, the Salinity Control and Rehabilitation Project, had positive results in the freshwater areas and arrested further degradation in the saline areas. However, the lack of drainage and the extensive use of tubewells may have led to problems of secondary salinization, particularly in the downstream areas. Using a more expansive view of conjunctive use and management that includes rainwater, soil moisture, surface and groundwater, an integrated water resources management approach has proved to be a successful experiment in China (Box 2).

The need for integrated planning has been propagated earlier and it has been practised in parts of the developing world. Yet it has not been systematically included in the process of water resources planning. In accepting this priority area for R&D, particularly in view of the implications for water conservation, IPTRID's emphasis would be on technologies of aquifer monitoring and recharge, including modelling. The promotion of effective R&D in this priority area would require linkages between technology specialists and those involved in basin or watershed planning and management.

System Design Improvements

When IPTRID presented its global theme of Modernization, system design improvements loomed large in its agenda. The lack of capacity of the irrigation system to provide reliable water supply had been extensively discussed. It was felt that in many countries it would be important to plan for system modernization to meet new objectives and demands of agricultural production, particularly diversification, instead of conventional rehabilitation to restore an irrigation system to its original state. Thus, the priority area of canal regulation improvements identified in the missions did not come as a surprise. The experience of IPTRID only confirms an earlier thought that modernization of irrigation systems was contingent upon agricultural objectives and water availability; seasonal demand for reliable water supply; and institutional and farmer capacities. In other words, modernization must be understood within the framework of efficient, equitable and reliable water delivery services.

BOX 2 **MANAGING THE 'FOUR WATERS'**

From 1949 to 1980, the irrigated area in China increased by 32.7 million ha and currently constitutes 46.7 million ha. Due to problems of scarce water resources and the limited possibility of expansion, the rate of growth has fallen substantially. In response, Chinese engineers and agronomists have developed an innovative method of water management, known as the concept of the 'four waters', which refers to a comprehensive control and supervision of groundwater, surface water, soil moisture and rainfall for agricultural production. The objective of this approach is to produce two crops per year over the most extensive area possible with limited use of surface water. The basic innovation of the 'four waters concept' is the dynamic control of the aquifer. Whereas traditional horizontal drainage keeps the groundwater table below a certain level to avoid waterlogging and secondary salinization, dynamic groundwater management, in addition to controlling the water table, uses the aquifer as storage. The dynamic groundwater management keeps the level of the aquifer within a specified range, which is defined by hydrological and agricultural requirements, and takes into account the constraints posed by salinity hazards and the need for efficient energy use. The 'four waters concept' has been tested extensively in the Nanpi experimental station in Hebei Province and in a pilot project of 23 600 ha. The results have been positive. The implementation of this water management approach showed that large areas of saline-alkaline land could be reclaimed, and land which was previously unsuitable for irrigation, due to groundwater salinity, has been cultivated. Moreover, yields increased 77%, from 3735 kg/ha to 7800 kg/ha. Multi-annual hydrological simulation demonstrates that, with only 550 mm average annual rainfall, as much as 43% of the dry season irrigation requirements can be met without groundwater mining or external water imports. (Shen and Wolter 1992)

Opting for such a contingency approach does not imply taking a stand for or against "sophisticated" or specialized hardware. Rigid, *a priori* theoretical views on this matter have obstructed a practical, case by case analysis of water supply needs, technological solutions and the conditions for success of their adoption. In Mexico, where the move for modernization is the strongest among the IPTRID countries, the Comisión Nacional del Agua (CNA) and IPTRID are engaged in developing a framework for modernization in the irrigation districts taking into account these various considerations (Box 3).

BOX 3 **THE SERVICE CONCEPT IN MEXICO**

In Mexico the service concept is being incorporated into the framework for modernization currently being developed. The irrigation systems in Mexico typically consist of four levels of irrigation operation: 1) on-farm operation; 2) small canals controlled by water user organizations; 3) larger canals which deliver water to the modules that make up the irrigation districts; and 4) diversion dams, storage dam, and watershed, which are under the charge of CNA. The purpose of each of the three operation service levels (dam, large canals, modules) in the water delivery system is to provide the appropriate degree of service to the next lower level. In turn each lower receiving level (on-farm, module, district, dam) compensates the next upper level for the services received, thus creating an autonomous system. The execution of the service concept may be the most difficult step in the implementation of a modernization programme, since the concept must be clearly understood and accepted by personnel at all levels in an irrigation scheme in order for an irrigation project to achieve its maximum potential. (Burt and Wolter 1992)

Since canal regulation and water control are so vital to reliable water delivery, it is rather surprising that even greater attention was not paid to these issues in the expert missions. The focus on canal regulation in the recent India mission has changed this situation somewhat (IPTRID 1993). This is partly because the requests from Egypt, Pakistan and Morocco were for assistance in identifying priority projects in waterlogging and salinity control. The preoccupation with the expansion of irrigation systems in the developing world had led to a prolonged neglect of drainage. In particular, countries like Egypt and Pakistan have major problems with the encroachment of saline land, hence the interest in drainage. The expert missions interpreted the country request narrowly and did not address "upstream" concerns of water control. In the case of Pakistan, it has been noted that the focus of the expert mission on waterlogging and salinity control, without adequate reference to poor water control and canal regulation was a deficiency. It is now clear that while emphasizing one theme or another, the IPTRID expert missions will have to take an integrated view of the system. Otherwise a focus on drainage without attention to poor water control may cure the immediate problem without preventive action.

Two other problem areas related to system design improvements were highlighted in the IPTRID expert mission reports. With respect to drainage, the need to review old **design criteria** (watertable depth, spacing of pipes, etc.) currently in use was emphasized, especially in light of new knowledge on the subject and advancements in materials research. Many national and international organizations are engaged in investigations related to this topic and it is IPTRID's task to link irrigation managers and adaptive research in developing countries to such ongoing investigations (Smedema 1992; Ochs 1992). A second problem area was concerned with **alternative energy sources**. Both China and Mexico placed the use of solar- and wind-powered pumps as possibilities, especially in less accessible regions. Since in this case, the main gap in adoption of the new technology is the availability of affordable pumps using alternative energy sources, private manufacturers could be encouraged through a range of tax incentives to participate in developmental work on a selective basis.

Materials Improvements

The need for materials research is an ongoing concern in the irrigation sector. For instance, significant advances have been made in canal lining technology (e.g. geomembranes); in drainage envelopes (e.g. geotextiles); and the use of a range of PVC pipes in distribution systems. The IPTRID Egypt/Pakistan report refers to the possibilities of alternative material for envelopes. Similarly, the Mexico report points to corrosion of gates as a problem for the attention of adaptive research. Practical research on lining material was also strongly recommended in Mexico. In this connection though, the caution was raised that basic questions on the need for canal lining, quality of construction, cost, and alternatives such as low pressure pipelines for certain situations should be considered before lining decisions are taken.

The need for attention to materials research also directs us to the important issue of aging structures in many of the irrigation systems in the developing countries. The problem of aging structures is stressed in the China report. The specific activities highlighted in the report are: (1) preparation of a common standard for evaluating the degree of aging of the structures and the inventory by categories of the prevailing degradation problems; (2) adaptation and testing of available technologies in the local environment with particular reference to frost conditions; (3) preparation and publication of standard norms; (4) dissemination of the new technology.

Research on structures is already advanced, mainly in developed countries and in some developing country institutions as well. Accordingly, there is a need for linkages with centres of excellence, for information and technical intelligence for adaptive research efforts.

Maintenance Improvement

Neglect of maintenance has led to several rounds of rehabilitation in many countries. Many reasons have been suggested for the neglect: lack of operating budgets; relatively easier access to capital for rehabilitation; poorly skilled or motivated maintenance staff; and lack of accountability for maintenance related expenditures. IPTRID's missions have spotlighted an additional problem with maintenance. Even if the right **institutions** with the proper accountability were in place and **budgets** were strictly set aside for maintenance, **techniques of maintenance have to be appropriate**. For instance, IPTRID reports point to the need for review of techniques related to problems in an important area of maintenance, i.e., weed control. The control of weeds is applicable to both irrigation and drainage systems. In this context, none of the countries surveyed had in place an integrated mechanical, biological and chemical control programme for weed control. As noted in the IPTRID Mexico report (1991b):

> "Aquatic vegetation control is required in the canals, drains and reservoirs of Mexico to keep the conveyance of water within acceptable limits of the designed condition. Determination of what is acceptable will depend upon what maintenance can be afforded and carried out in the long term.... A combination of methods is required in order to be effective.... An integrated approach requires incorporating biology, engineering and hydraulics."

A related problem is the choice and use of the right type of machinery in maintenance. Use of inappropriate machinery has led to unfavourable environmental effects in the past. For instance, using draglines for weed removal has unfavourably affected the stability of canal slopes in some countries. It is clear to us that irrigation and drainage programmes need a **technology assessment component**, especially for maintenance. There is little basic research involved in the assessment activity. However, what is needed is systematic testing and selection of equipment. Field trips to observe farmers' experiences should form a part of the assessment. Equipment selection is an area where private sector involvement should be encouraged. Ultimately, suppliers are likely to be manufacturing firms who would have a stake in assessing the needs and adapting their products to suit user needs if there is market potential.

Integrated weed control and technology assessment highlight the need for **appropriate technologies** in irrigation and drainage, taking into account (1) strategic questions such as what techniques should be used for maintenance; (2) financial implications of the techniques used; (3) environmental effects due to application of certain methods. Brabben (1992) calls for a renewed approach to maintenance based on these considerations.

A review of the maintenance theme brought about by the expert missions indicates that very little systematic study has been conducted to determine the link between deterioration and performance of irrigation structures. For example, in the case of road maintenance in developing countries, the link between deterioration, performance and its subsequent cost was analysed. The results of the study indicate when intervention is necessary to prevent considerable deterioration of the road system. However, it is clear that irrigation systems are more complex, being composed of several operational levels (main, secondary, tertiary and on-farm), which makes it that much more necessary to determine patterns of deterioration and consequent effects on system performance. This is indeed an area for future research.

It is also clear that well substantiated country-based cases of improvements in techniques in maintenance programmes and their impacts on system performance and costs are not available. Such cases would be useful tools for mobilizing policy makers' interest in dealing with a neglected aspect of maintenance.

Reuse and Disposal of Drainage Water

The pressure on water resources has compelled rethinking on the possibilities of reuse of drainage water for agriculture. A number of methods are now available, for instance, cyclical use of freshwater and use of relatively low/moderate saline water at different stages of crop growth, blending of grades of saline water, and storage of saline water in evaporation ponds prior to reuse. Whereas treatment of urban waste water has had a long tradition of analysis, review and standard-setting, the treatment and reuse of drainage water in irrigation has received relatively less attention (Smedema 1992).

IPTRID reports have emphasized gaps in understanding and the need for investigations in reuse. In Pakistan, many activities associated with the SCARP projects produce large quantities of low salinity drainage effluent. In some cases the water is directly pumped into large irrigation canals and reused; in other cases, the effluent is pumped into surface drains and disposed off in rivers and reused by downstream farmers. In most of the SCARPs, the effluent is mixed with canal water at the watercourse head. In certain SCARPs, it is not possible to dispose of the effluent using the existing irrigation or drainage system and it is disposed of using evaporation ponds. The environmental impact of those ponds is not yet known and needs to be studied to detect any adverse effect on the environment. Suitable criteria for mixing/cycling of irrigation water of different qualities including sources such as tubewell water and drainage effluent should be developed (Box 4).

In general, however, issues of reuse are not receiving adequate attention for two reasons. The quantity of water added to the "pool" from reuse is said to be relatively small. While this may be the case globally, the amounts concerned can be quite significant locally. In Egypt, for instance, it is expected that drainage water will be a source of over 7 thousand million m^3 of water for agriculture in the year 2000, up from about 4.5 thousand million m^3 in 1990 (Abu Zeid and Rady 1992). To be able to assess the technical and financial viability of reuse projects is crucial for Egypt, where varying local soil conditions do not permit a universal solution. To be sure, there are strategic questions involved here. For example, to return to the Egypt case, it is argued that water saved along the Nile basin is really not water added to the stock of water available for irrigation. To add to the stock, it is said, one has to treat water in the salt tank in the delta. However, financial and environmental questions can be raised alongside: is it less expensive to treat the water before it becomes highly saline? What is the effect on soil and water of neglecting the salinity build-up along the Nile? Quite apart from basin-level salt balances and other strategic considerations, the need remains for attention to R&D in techniques of reuse in cyclical use, blending, and storage (Rhoades 1990). Reuse research also offers the possibility to build links with crop research (Shani

BOX 4 **REUSE OF DRAINAGE WATER FOR IRRIGATION IN EGYPT**

In the face of rapidly increasing demand for water resources, the Ministry of Public Works and Water Resources of Egypt supplements the available water supply through the reuse of lower quality drainage water for agriculture. However, reuse of drainage water may have adverse effects on the water quality of the hydraulic system, on the soil system, where salt and pollutants may accumulate affecting the soil profile and the crop yield, and the groundwater quality, which may be polluted and salinized affecting the soil conditions, crop yields, public health and the natural habitat. Although the Drainage Research Institute of the Ministry's Water Research Center has been conducting investigations to develop guidelines for water reuse planning and management, little study has been conducted at the field level to assess the effects of salinity on the environment, viz., soil, crop, and natural habitat. Moreover, there have been no field studies analysing the effect that irrigating with reused drainage water has on the soil profile. Thus, the Ministry, in conjunction with IPTRID, has developed a project proposal with the objective of studying the effects of drainage water reuse on soils, crops, public health and natural habitat in the Nile Delta. The study would also provide a baseline for planning, and early warning of possible problems in the future.

1992). In addition, there is need for attention to desalinization methods and to the health implications of reuse.

NETWORKING AND CAPACITY BUILDING

The R&D priorities described earlier constitute a set of key areas for **diagnosis and action related to adaptive technology research**. The bulk of investment in irrigation and drainage projects involving surface water is devoted to the main and secondary canal and field systems. Consequently, the performance of these systems is crucial for efficient use of investment resources. Moreover, reliable water delivery is a necessary condition for user satisfaction, effective cost recovery and water management. Improvements in system performance will therefore provide a basis for financial and physical sustainability. In time, these improvements will contribute to the goals of water conservation and water quality enhancement sought by the new emphasis on integrated water resource management.

In no case does the adoption of technologies involve a simple, straight forward transfer of equipment and techniques to a developing country. **Technological adaptation** is critical to success. IPTRID's thrust for adaptive R&D is, therefore, quite valid. The intensity of such R&D can vary, depending on whether the emphasis is on "research" or "development". For example, maintenance equipment assessment is an identified priority area. Clearly, this falls on the "development" end of the technology R&D continuum, since it is not new equipment and techniques that one is looking for but rather the fit of available equipment with a set of local soil and canal conditions. On the other hand, reuse of drainage water for agriculture is a topic that requires systematic investigation into short and long term effects of reuse on soil and water quality and thus can be classified in the "research" side of R&D. The process of technology generation and adaptation has many critical linkages, in particular, with national policy and user needs. In the case of Mexico, changes in design or in maintenance techniques must be suited to the country's strategy of transferring the management of irrigation districts to water users.

The necessity of these linkages indicates the importance of **networking** in the form of disciplinary and institutional collaboration between researchers and irrigation managers and practitioners, between countries and between R&D agencies working in the sector. Adaptive research requires researchers to be mindful of operational problems and their solutions, while practitioners have to be careful about analyzing the design and consequences of technological innovations being introduced. However, there are few incentives in the present institutions for researchers to be "operational" and for practitioners to be "research minded". It is our hope that the projects we support will lead to stronger linkages between the two groups. In Egypt, for instance, formal steering groups composed of representatives of research and programme implementing agencies are being planned. In Mexico, the draft Guidelines for Modernization, prepared by CNA/Instituto Mexicano de Tecnologia del Agua/IPTRID, are being reviewed by officials in the irrigation districts to ensure their operational relevance.

The nature of collaboration can vary from collaborative research to information exchange. For example, Egypt has had about 30 years of experience with horizontal pipe subsurface drainage but very little experience with tubewell drainage. Pakistan on the other hand has many years of experience and a large amount of research on tubewell drainage, but has only a short history on horizontal pipe drainage. A combination of skills and experience could help each other improve subsurface drainage technology. Clearly, collaboration and exchange of experience would be mutually beneficial to Egypt and Pakistan. Furthermore, in South China's Hubei Province, subsurface drainage in paddy land has been tested at an experiment station for four years with the following benefits: increased soil temperature by up to 1°C, increased crop yield by 60 to 300 kg/ha/crop, gained more workable days for field operations such as harvesting, and provided the opportunity to diversify cropping. The soils and conditions in this area are typical of a large area of South East Asia and much of this information could be transferred to and applied in other countries.

One step forward in the direction of information exchange among agencies in the field is the networking activity spearheaded by Hydraulics Research Wallingford together with the Centre National de Machinisme Agricole du Génie Rural des Eaux et des Forêts (CEMAGREF) and the International Institute for Land Reclamation and Improvement (ILRI), in conjunction with the International Commission on Irrigation and Drainage (ICID) and under the IPTRID umbrella. IPTRID has also established close ties with IIMI, at both the institutional and operational levels. In addition, the biannual publication of *GRID*, the IPTRID network magazine, is beginning to provide a forum of communication by informing readers about research and development in irrigation and drainage. It is hoped that this effort will encourage different means of exchanging information and experience among developing countries and between developing and developed countries. This is not easy since the process of formation and sustenance of networks faces considerable organizational and financial obstacles.

It is hoped that efforts at networking among agencies and resource institutions within a country and among countries will lead to an **enhanced capacity for improving the quality of research** and its relevance to problems faced in delivering and utilizing water for agriculture.

CONCLUSION

Developing countries could consider incorporating R&D priorities, such as those presented here, into ongoing or planned irrigation and drainage programmes and projects. Means of financing these R&D components have to be determined. Given the fact that global expenditure on R&D in developing countries is only about 0.5 percent of total investment in the sector and that R&D components receive low priority when budgetary constraints arise, a concerted effort will be required on the part of countries, international organization and donors (Safadi and Plusquellec 1991). In the future, the lack of attention and commitment to the development and implementation of R&D programmes will lead to system deterioration and threaten the sustainability of irrigation and drainage systems. It is hoped that interested parties will meet and discuss mechanisms for financing R&D in the sector within the perspectives of water conservation and water quality enhancement.

There have been several attempts to identify gaps in technology R&D in irrigation and drainage. Often, they have resulted in long lists of topics without a clear sense of priorities. In this paper, a set of priority R&D topics has been proposed, based on IPTRID's assessment of technology research needs in Egypt, Pakistan, Mexico, Morocco, and China. Currently, similar efforts of priority setting are underway in India and West Africa. Together, it is hoped that a sharper image and a more shared understanding of future possibilities will emerge from IPTRID's country assistance activities.

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Research and development needs for integrated rural water management

Research and development (R&D) are inter-linked activities; they go hand-in-hand. They are also dynamic in nature, in other words, they are continuous processes. Since new problems develop with time, and economic and social conditions change, it will be necessary to update existing technologies and develop new ones.

The world's water resources are facing an unprecedented crisis. This is reflected in the opening paragraph of the Dublin Statement (ICWE 1992) which reads: "Scarcity and misuse of freshwater pose serious and growing threats to sustainable development and protection of the environment. Human health and welfare, food security, industrial development and the ecosystems on which they depend, are all at risk, unless water and land resources are managed more effectively in the present decade and beyond than they have been in the past."

The need for R&D is indeed great for effective management of the water resources in the present decade and beyond. The need is even greater in the context of rural water management for the following technical reasons:

- The rural sector is the largest consumer of the world's freshwater resources, of which irrigation consumes more than 80% of the rural water share. At the same time, irrigation water use efficiency is low, and in many developing countries it could be as low as 40%. Even a mere 10% improvement in irrigation efficiency can contribute significantly to overcome water shortage problems faced by other users.

- Despite large amounts of water used in crop production in rural areas, a large proportion of rural communities do not have access to adequate and safe water for drinking and sanitation. Technological solutions are needed to promote concurrent development of water supply for irrigation, drinking and sanitation, and when appropriate, multiple use of water diverted for agricultural use.

- Agriculture could use relatively low quality water and thereby make free an equal amount of good quality water for other uses. The use of marginal quality waters such as saline waters (drainage water and groundwater) and treated municipal and industrial

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effluents could ease the water shortage situation in many arid and semi-arid countries. Research and development in this area is urgently needed.

R&D should not be viewed solely from the point of view of technological innovations. There are also economic, institutional and human resources related problems. In this context, the role of national institutions from developed and developing countries, as well as United Nations organizations and multi- and bilateral institutions, will need to be defined and coordinated.

This paper examines the R&D needs in rural water management in three sections. Section 1 focuses on technological aspects of R&D particularly those which interphase with agricultural and non-agricultural uses of water in the rural communities. Section 2 deals with institutional aspects and partnership and collaboration between national and international institutions to promote R&D. Section three highlights some issues for discussion.

SECTION 1: TECHNOLOGICAL ASPECTS

Research Needs for Improving Water Use Efficiency

Improving water use efficiency in agriculture is now universally acclaimed as a major issue in rural water management. While many factors contribute to the present low water use efficiency in agriculture, lack of affordable and appropriate technologies to assess, develop and manage water resources is certainly a key factor.

Water use efficiency is identified as a top priority action area by FAO's International Action Programme on Water and Sustainable Agricultural Development, IAP-WASAD (FAO 1990a).

Improving irrigation water use efficiency is implied in the strategy of the International Irrigation Management Institute. IIMI's mission is reported as "to strengthen national efforts to improve and sustain the performance of irrigation systems in developing countries through the development and dissemination of management innovations" (IIMI 1989). The fundamental strategy of IIMI is irrigation management, and technological research is not a priority area. IIMI has adopted seven themes to build its research programme, namely:

- Institutions for irrigation management;
- Management of water resources for irrigation;
- Management of financial resources for system sustainability;
- Management of irrigation facilities;
- Management of irrigation support services to farmers;
- Management of change in the institutions for irrigation;
- Management of irrigation organizations.

The objectives of the World Bank/UNDP International Program for Technology Research in Irrigation and Drainage are to formulate and implement research and development in irrigation and drainage to increase productivity through technological innovations (WB/UNDP 1990). The programme has identified three research thrust areas, namely:

- Modernizing irrigation and drainage systems;
- Ensuring sustainable land and water use; and
- Improving technology of maintenance.

It appears that within the 'international research system', inadequate attention is given to adaptive research on irrigation methods. While, in the USA and other developed countries, a number of new and advanced irrigation technologies such as Low Energy Precision Application (LEPA) and Surge Irrigation (Box 1) are being developed, the adaptation of such techniques is not adequately supported under international programmes.

BOX 1 **Emerging Irrigation Technologies: LEPA & Surge Irrigation**

The Low Energy Precision Application (LEPA) method of irrigation basically consists of a low pressure moving irrigation system, such as modified centre pivot system or linear-move system, where sprinkler heads are replaced by drop tubes which deliver water to the soil surface. The crop response to this system of irrigation is similar to stationary drip installation with closely spaced emitters. Saline water can be used without damage to foliage under this system. The system uses a pressure which could vary between 7 to 35 k Pa. It maximizes irrigation efficiency with low pressure nozzles near the ground, and the application efficiency could be as high as 90% (Fangmeier *et al.* 1990). It was reported that the average amount of water applied per hectare by Texan farmers dropped 28% between 1974 and 1978 because they adopted LEPA (Postel 1989).

Surge flow irrigation is defined as the intermittent application of water to furrows or borders creating a series of on and off periods of constant or variable time spans. Usually water is alternated (switched) between two irrigation sets until irrigation is completed. The switch is accomplished with a surge valve and an automatic controller. Surge flow greatly reduces the intake at the top of the field because the opportunity time is much less than under continuous flow method. It is reported that efficiency of irrigation could be improved to an average of 70% or more. In the USA, the effectiveness of surge irrigation as a water conservation measure is demonstrated by its rapid growth and acceptance by farmers (USDA 1986).

There is need to pay attention to this area of adaptive research, either by incorporating it into existing international irrigation research programmes or developing new programmes.

Adaptive Research on Irrigation Methods

On-farm irrigation methods exert considerable influence on the overall water use efficiency in irrigation schemes. Several technological advances in developed countries have been reported during the past two decades, but their adoption in developing countries has been slow. Apart from economic and social reasons, the technical adaptability of these methods under developing country conditions is not fully resolved. This calls for adaptive research in this area.

A number of modern irrigation techniques such as sprinklers, drips and a host of micro-irrigation techniques are shown to be more efficient than surface irrigation. However, these irrigation techniques cannot fully replace surface irrigation methods, particularly, in traditional rice growing areas in Asia where flood irrigation has been practised for centuries.

Technological innovations are thus needed to improve efficiency of a number of irrigation methods, not necessarily to replace one with the other. Some potential areas for applied research are:

- flood irrigation of rice through flood-depth control, better land preparation, alternate dry and wet regimes, seepage control and other practices;
- non-flooding rice irrigation such as border and sprinkler methods which could be introduced in non-traditional rice growing areas and where other conditions favour the application of such methods;
- adaptability of surge irrigation to farming conditions in developing countries;
- sprinkler and micro-irrigation methods with particular reference to cable-irrigation systems, centre pivots, LEPA, and sub-surface drips.

Domestic Use of Irrigation Water

Because priority has often been placed on economic development rather than the delivery of social services, water development has tended to favour irrigation schemes rather than community water supplies in rural areas. The health and social functions of domestic water supplies and sustainability of irrigation systems are intricately interwoven. As their immediate objectives are not the same, traditionally, they are planned as separate systems.

Recognizing the relationship between agricultural production and the well-being of farmers and rural populations, and mindful of the high financial costs of developing separate water resources, three questions arise: is it possible to design new or to modify old irrigation systems to satisfy both functions?; what problems are involved?; and what benefits might be realized?

Most research documenting the health aspects of irrigation systems has focused on the irrigation system as the cause of various health problems. Indeed, there is good reason for this focus. However, health benefits of irrigation development have not received the same attention.

The fact that people use irrigation canals as source of household water, whether or not the system has been intended to serve that purpose, has been established through observation and documented in the literature (Box 2). Given that the canal is an established source of household water supply, it would seem reasonable to invest on methods of conveyance and/or treatment that would improve the quality of water.

Because financial and human resources are limited in developing countries, provision of perfect water supply systems will be impossible. Thus the need for improved systems which can deliver the best service with the available resources has become evident. Dual-purpose irrigation systems may be one way to address critical water need, and may serve as another example of incremental improvements in service as the best use of financial resources.

Based on available literature, it is not possible to make any conclusive statement about the feasibility of designing irrigation systems to provide household water supplies. The range of professional opinion and organizational experience seems too varied and the literature too scarce to know accurately how effectively they can satisfy the water needs of people (Jones 1981).

Four main categories of issues which could determine the feasibility of a dual-purpose system emerge: (1) engineering considerations, (2) investment costs, (3) administrative and organizational arrangements, and (4) public health safety and environmental impacts.

Applied research and pilot testing in this area is urgently needed. A possible starting point for promoting dual-purpose irrigation systems is suggested below:

BOX 2 **Irrigation Water for Household Use**

Water withdrawn from canals, wells, or taps and carried to houses includes water for drinking, food washing and preparation, and some for washing dishes. There are many examples where all domestic water is directly withdrawn from a canal irrigation system. In some cases the canal near a municipality or village is allowed to flow through a pond to reduce the velocity and facilitate silt settlement.

In Nepal, mountain irrigation systems are channelled directly through villages when possible for a very convenient domestic water supply. A USAID small-scale, piped irrigation project in Guatemala is reported to have routinely installed a tap in each yard if the water source was from a covered spring.

The USAID Bhairhwa-Lumbini groundwater project in Nepal encouraged the use of irrigation tubewell water for drinking purposes and suggested that "gastro-intestinal disease resulting from polluted water used by villagers is the most common health problem that the potable water from tube wells will solve".

A number of projects in Sri Lanka, including the Gal-oya, have had a mandate since their inception in the 1940s to supply water for domestic purposes. The design paper of the Gal-oya project suggested that provision should be made for treated drinking water for 20 000 people, in addition to flood protection, irrigation and power generation.

A 3500 ha irrigation project in El-Salvador, is called the longest bathtub in the world. The canal through the centre of the valley is a natural place for people to congregate, wash their laundry, and bathe. In Central Java, where masonry, flow-measurement structures were constructed for research purposes in an unlined canal, they immediately became the most popular washing and bathing places. Canals in India and Pakistan are often lined near a village, and steps are constructed for easy access to the canal for washing and bathing (Yoder 1983).

1. Documentation of present experience;
2. Planning and design considerations for dual-purpose systems;
3. Treatment of irrigation water and health safeguards; and
4. Pilot projects to adapt existing technology.

Use of Marginal Quality Water

Limited supplies of fresh water are increasingly in demand for competing uses and create the need to use marginal quality water in agriculture. Although there is no universal definition of marginal quality water, for all practical purposes it can be defined as water that possesses certain characteristics which have the potential to cause problems when it is used for an intended purpose. For example, brackish water is a marginal quality water for agricultural use because of its high salinity hazard, and municipal wastewater is a marginal quality water because of the associated health hazards. From the view point of irrigation, the use of marginal quality waters will require careful planning, more complex management practices and stringent monitoring procedures than when good quality water is used (FAO 1992).

Saline Water Use

Saline water is a potential source of irrigation water. Two common sources of saline irrigation water are: groundwater from aquifers which are naturally saline or which became saline due to human activities, and drainage effluents from agricultural lands. Saline waters are used in irrigation all over the world, intentionally or unintentionally, with varying results (Box 3). There are some examples of successful use as well as total disaster.

Recognizing the importance of saline water in irrigation, FAO convened an Expert Consultation in this subject in 1989. The Consultation recommended the following actions which imply strong need for technological research (FAO 1990b).

1. Integrated management of water of different qualities at the level of farm, irrigation system and drainage basin, with the explicit goals of increasing agricultural productivity, achieving optimal efficiency of water use, preventing on-site and off-site degradation and pollution, and sustaining long-term production potential of land and water resources.

2. Use of high efficiency irrigation methods with minimal leaching fractions to reduce drainage volume; successive reuse of drainage water for progressively more tolerant species; reuse of otherwise unusable saline water by halophytes for wood or other products or amenities, in order to minimize further the drainage volume; and final disposal in sustainable ways, options including drainage to the sea, to rivers at high discharge or to evaporation ponds.

3. Monitoring programmes on soil and water quality, providing feedback as an integral part of the management of irrigation systems.

4. Further research to fill gaps in the present understanding and knowledge of the effects of irrigation-water induced salinity on soil-plant-water relationships, including cumulative effects on perennials.

BOX 3 **Use of Saline Water in Irrigation**

In the USA, extensive areas (about 81 000 ha) of alfalfa, grain sorghum, sugarbeet and wheat are irrigated (by gravity flood and furrow methods) in the Arkansas Valley of Colorado, with water salinity not less than 1 500 mg/l and up to 5 000 mg/l. In the Pecos valley of Texas, groundwater averaging about 2 500 mg/l of total dissolved salts, but ranging far higher, has been successfully used to irrigate cotton, small grains, grain sorghum and alfalfa, for three decades.

Cotton is successfully grown commercially in the Nahal Oz area of Israel with saline groundwater (EC of 5 dS/m and SAR of 26). The soil is treated annually with gypsum and National Carrier water (non-saline) is used (usually during the winter) to bring the soil to field capacity to a depth of 150 to 180 cm prior to planting.

In Egypt, 3 to 5 thousand million m^3 of saline drainage water are used for irrigating about 405 000 ha of land. About 75 percent of the drainage water discharged into the sea has a salinity of less than 3 000 mg/l. The policy of the Government of Egypt is to use drainage water directly for irrigation if its salinity is less than 700 mg/l; to mix it 1:1 with Nile water (180 to 250 mg/l) if the concentration is 700 to 1 500 mg/l; or 1:2 or 1:3 with Nile water if its concentration is 1 500 to 3 000 mg/l; and to avoid reuse if the salinity of the drainage water exceeds 3 000 mg/l.

The saline Medjerda river water of Tunisia (average annual EC of 3.0 dS/m) has been used to irrigate date palm, sorghum, barley, alfalfa, rye, grass and artichoke. The soils are calcarious (up to 35% $CaCO_3$) heavy clays which crack when dry.

Extensive use of saline groundwater from shallow aquifers (106 000 hectare-meters per year) is being undertaken in nine districts of Haryana State in India. In four of the districts, the brackish water is used directly for irrigation, while in the remaining five it is used after blending with fresh canal water, or by alternating between the two supplies (FAO 1990b).

5. Promoting development and use of mathematical and computer simulation models to assess the quality of water for irrigation and to predict long- and short-term effects of irrigation water quality on crop yields, soil properties and quality of the environment.

6. Establishment of pilot farms or pilot areas to test and assess proposed high efficiency irrigation methods and complementary soil and crop management practices using saline water, before large-scale implementation.

Reuse of Wastewater

Expansion of urban populations and increased coverage of domestic water supply and sewerage give rise to greater quantities of municipal wastewater. With the current emphasis on environmental health and water pollution issues, there is an increasing awareness of the need to dispose of these wastewaters safely and beneficially. Use of wastewater in agriculture could be an important consideration when its disposal is being planned in arid and semi-arid regions.

Properly planned use of municipal wastewater alleviates water pollution problems, conserves valuable water resources, and takes advantage of the nutrients contained in sewage to grow crops.

Many countries have included wastewater reuse as an important dimension of water resources planning. In the more arid areas of Australia and the USA, wastewater is used in agriculture, releasing high quality water supplies for potable use. Some countries, for example, the Hashemite Kingdom of Jordan and the Kingdom of Saudi Arabia, have a national policy to reuse all treated wastewater effluents and have already made considerable progress towards this end. In China, sewage use in agriculture has developed rapidly since 1958 and now over 1.3 million ha are irrigated with sewage effluent. It is generally accepted that wastewater use in agriculture is justified on agronomic and economic grounds, but care must be taken to minimize adverse health and environmental impacts. A number of issues still need to be clarified and appropriate technologies will have to be developed and tested to promote wide use of wastewater in agriculture.

An Expert Consultation on "Safe and Efficient Irrigation with Treated Sewage Water", (FAO 1991) identified the following research needs:

1. Simple, efficient and economical waste treatment methods including updating existing technologies, and developing new and innovative ones; emphasis should be given to low cost systems.

2. Modification of irrigation design, techniques and management to account for the specific characteristics of effluent irrigation water.

3. Methods to balance the nutrients and soil moisture for commonly grown crops, with particular reference to fertilizer applications and pollution that may result from irrigation with wastewater.

4. Evaluation of changes in physical and chemical properties of soils by wastewater and sludge applications.

5. Monitoring of changes induced in irrigation runoff, drainage and groundwater quality by wastewater use.

6. Development of rapid analytical methods for routine monitoring of effluent quality and crop conditions.

7. Development and testing of multi-sectoral decision-making tools to evaluate the feasibility of reuse of wastewater.

SECTION 2: INSTITUTIONAL AND COORDINATION ASPECTS

Institutional Problems and Prospects

One of the key components to meeting the challenges of water crisis is concentrated and coordinated effort of R&D on sustainable water resources management. Although many good international efforts have recently been initiated, R&D in Integrated Rural water Management (IRWM) are yet to be put into practice systematically by the international research and funding communities. In relation to the needs of developing countries, research in water development in the developed nations still produces solutions that are too complicated, involve too much technology and use too many sophisticated or expensive inputs. The result is that R&D solutions are not finding their way to meeting the problems in developing countries.

There is a tremendous imbalance between expenditures on R&D that take place in the "North" and those undertaken in the "South", where most of the world's irrigation and drainage takes place. Expenditure in R&D on irrigation and drainage in developing countries is estimated at approximately $80 million per year (World Bank/UNDP 1990) compared to global sums in excess of $2.6 thousand million spent in the early 1980's for agricultural research.

Most developing countries however are not well equipped for R&D activities in water resources and need to have their national institutions strengthened both in terms of budget and capabilities. There is also a need to solve the problem of lack of institutional capacity, and to widen the perspectives of those decision-makers that deal directly or indirectly with R&D in integrated rural water management. The tendency is to consider R&D only from the technological angle of the engineering and natural sciences. Policy-makers at the national and international levels are often in search of technological "cure-alls" to solve the many water-related problems. Obviously, integrated approaches will need to include the various perspectives of the social sciences as well.

Partnership in R&D

The partners who deal with R&D on water resources can be divided into three groups, namely: national institutions from developing countries; national institutions from developed countries; and international institutions, UN organizations and multilateral and bilateral donors.

At the national level there are primarily those institutions that are a part of government. While most developing countries have agricultural research institutes, not many of these conduct specialized research in topics related to water issues. These specialized institutions may be part of the Ministry of Agriculture, or Public Works, or associated to a State University. In rarer cases, there may be autonomous research bodies funded by government.

Generally, however, the national institutions that do exist are quite weak, operating with severely reduced human, financial or material resources. These institutions regularly experience a certain degree of "braindrain" of their qualified, yet poorly paid staff, whose conditions of employment are often difficult. In spite of operational hardships, these national research institutions constitute the primary partners who should be implicated in developing strategies for R&D in integrated rural water development.

Other more unconventional national partners to be implicated in this R&D are different non-governmental and grass-roots organizations. These groups often conduct informal research. Their experience constitutes a wealth of information dealing with the real problems as they are felt by the primary water users. NGOs are also well known for being involved in adaptive research and adjusting solutions to the local environment. This demonstrates a pragmatic yet sensitive way of dealing with water issues and problems.

At the international level, there are many different organizations that are specialized in various aspects of rural water management for developing countries. The UN system supports R&D in water resources management in developing countries through technical assistance programmes and special action programmes. A number of FAO's technical assistance programmes directly or indirectly support adaptive research in rural water management. The FAO's International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD) advocates applied research as an important support action for rural development. The World Bank/UNDP initiative IPTRID, mentioned earlier in the paper, is a good effort which deserves support from all relevant UN organizations. Within the multilateral development system, there are institutions belonging to the Consultative Group on International Agricultural Research (CGIAR). The International Irrigation Management Institute (IIMI), also discussed earlier in the paper, has been the most active of these in the field of water.

Several bilaterally-funded research institutions are also actively involved in this field. Three such institutes are l'Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM), the International Institute for Land Reclamation and Improvement (ILRI) and the International Development Research Centre (IDRC).

A number of research institutions and universities in developed countries are directly involved in overseas research projects through grants provided by bilateral donors. These institutions have established good collaborating partnerships with research institutions and universities in developing countries.

The many partners, both at national and international levels, who are involved in R&D on integrated rural water management reflect different perspectives and potentially substantial resources. If the R&D challenges of the future are to be met, a maximum amount of interaction and collaboration will need to take place among these various partners. Approaches to collaborative planning will have to recognize the comparative advantages that each of these partners has in its particular field of specialization. These advantages should be the basis for developing a coordinated strategy for the planning and funding of R&D activities.

Yet, one of the main constraints that has to be faced is the lack of financial resources that have been committed to R&D in rural water management. There must be an increased commitment on the part of the donors if substantial progress is to be made in the near future. The donors will also need to think about optimum ways of allocating R&D resources. Support should be distributed among the specialized national and international research institutions, the non-traditional research partners, and the specialized executing agencies that have established technical capabilities and networks to provide technical assistance. Unfortunately, research in water issues has yet to be placed on the priority list of many donors.

SECTION 3: ISSUES FOR DISCUSSION

The purpose of this paper is to stimulate discussion on how R&D in integrated rural water management could be promoted in developing countries. This is done by identifying some key issues, in terms of both technological and organizational aspects.

With regard to technological issues, it is not the purpose of this discussion paper to propose a full list of topics that need to be addressed. Only issues which are not adequately addressed under ongoing programmes are presented.

In the case of organizational and coordination aspects some general problems and prospects are highlighted.

Existing international research and development programmes, notably the World Bank/UNDP Programme on Technological Research on Irrigation Drainage, the IMMI's research programme on irrigation management and the UNDP/World Bank/WHO R&D programme on water supply and sanitation could possibly meet the needs. However these programmes are sector-oriented, and will require some form of coordination to promote integrated rural water management.

For the purpose of stimulating discussion, certain preliminary and general questions are raised.

- "What are the research gaps in rural water management technology and how can they be addressed?
- "Do we have R&D strategies for integrated water management in the rural areas?"
- "How will the strategies related to R&D be coordinated globally?"
- "Which body will ensure this coordination and the monitoring of progress in R&D?"
- "How will the responsibilities be divided among the different organizations to ensure the most effective achievements?"
- "Where will the funds come from to enhance and expand the R&D activities that desperately need to be undertaken?"
- "What mechanisms can be put in place to monitor the progress of R&D for integrated rural water management?"

Research and Development have both short-term and long-term perspectives. Both of these time-frames must be kept in mind when establishing R&D priorities and strategies. It may be difficult to justify investment when the benefits can only be expected in the long term. Problems that are current and produce short-term benefits normally receive investment priority. As the central objective of this R&D is the attainment of sustainable water resources to meet the needs of the present and future generations, a balanced strategy is needed to guide decision-makers.

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Reuse of community wastewater: health and environmental protection — research needs

WASTEWATER AS A RESOURCE

In the arid and semi-arid regions of the world, water has become a limiting factor for agricultural and industrial development. Governments are continuously searching for unexploited sources of water which can be economically and effectively used to supplement the scarce water resources available.

Many eastern Mediterranean countries for example, where rainfall is about only 100 millimetres per year rely on a few perennial rivers, wadis and groundwater reservoirs usually located in mountainous regions. Drinking water is usually supplied through expensive and difficult-to-operate desalination systems, and more than 50% of the food demand is supplied through importation from other regions. In these countries, wastewater represents a valuable resource which could be reclaimed and utilized for many beneficial uses such as irrigation, industrial processes, groundwater recharge, and eventually for human consumption.

A city like Muscat, in the Sultanate of Oman, with a population of 350 000, and an average *per caput* consumption of 250 litres per day and a return flow of 80% will produce some 70 000 cubic meters of wastewater per day or about 25 million cubic meters per year. At an application rate of 2 metres per year, this water could be enough to irrigate about 1250 hectares.

BENEFITS OF THE USE OF WASTEWATER FOR IRRIGATION

Wastewater recycling through agricultural schemes should be considered as a first priority for treatment and disposal of urban wastes. The traditional schemes for treatment and disposal of wastewater should be implemented only if local conditions or other technical, institutional or socio-cultural aspects do not present strong restrictions on reuse.

The major benefits which can be expected from well-operating reuse systems are as follows:

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TABLE 1
Increase of crop yields through wastewater irrigation (Mara and Cairncross 1989; Shende 1985)

Irrigation Water	Crop yields (tonnes per hectare per year)				
	Wheat (8)*	Mung beans (5)	Rice (7)	Potato (4)	Cotton (3)
Raw wastewater	3.34	0.90	2.97	23.11	2.56
Settled wastewater	3.45	0.87	2.94	20.78	2.30
Stabilization pond effluent	3.45	0.78	2.98	22.31	2.41
Fresh water + NPK	2.70	0.72	2.03	17.16	1.70

* Years of harvest used to calculate average yield

Economic Benefits

Studies made in several countries have shown that crop yields can increase if wastewater irrigation is undertaken under appropriate management. Table 1 provides data on long-term field experiments made in Nagpur, India, by the National Environmental Engineering Research Institute (NEERI), investigating the effect of wastewater irrigation on crops.

Effluent irrigation from conventional secondary treatment systems, with typical concentration of 15 mg/l of total nitrogen and 3 mg/l of total phosphorous at the usual irrigation rate of about 2 metres per year, will provide application rates of N and P of 300 and 60 kg/ha year, respectively. Such nutrient input can reduce or eliminate the need for commercial fertilizers. The addition of wastewater, aside from nutrients, will provide organic matter which will act as a soil conditioner, thus increasing the capacity of the soil to store water (WHO 1989).

The increase of productivity per unit area is not the only benefit since effluent irrigation can also provide an increase in agricultural production due to the growth in the irrigated area and the possibility of multiple planting seasons (Bartone 1986). Another major benefit, occurring particularly in many arid and semi-arid regions, is the conservation of limited water resources. This is done by utilizing wastewater instead of clean water resources which could be preserved for more stringent use as drinking water.

Environmental Benefits

Well planned and managed agricultural or aquacultural reuse systems can improve environmental conditions by reducing damage to hydraulic resources and by developing the surroundings of large cities.

The factors which may lead to improvement of the environment when wastewater is reused rather than disposed of in other ways are the following:

- Avoidance of discharge to surface waters, preventing occurrence of unpleasant unaesthetic situations, anaerobic conditions in rivers and eutrophication of lakes and reservoirs. The conservation of water resources will provide benefits for uses such as water supply and recreation.

- Saving groundwater resources in areas where over-utilization of these resources in agriculture is causing problems of water level depletion and salt intrusion.

- Possibility of soil conservation by humus build-up on agricultural land and the prevention of land erosion.

- Help to control dust storms and desertification in arid zones through irrigation and fertilization of tree belts. This practice would provide the additional benefit of controlling environmental degradation caused by the demand for fuelwood.

- Improvement of urban aesthetic conditions and recreational activities through irrigation and fertilization of green spaces such as gardens, parks and sports facilities.

On the other hand, there are some potential negative environmental effects that should be carefully considered in the planning and control of reuse systems.

- **Possibility of groundwater contamination.** The main problem is associated with nitrate contamination of groundwater which is utilized as a source of water supply. This may occur when a highly porous unsaturated layer above the aquifer allows for deeper percolation of nitrates from the wastewater. However, when a deep homogeneous unsaturated layer capable of retaining nitrate forms lies above the aquifer, there is little chance of contamination. The uptake of nitrogen by crops will reduce the possibility of nitrate contamination of the underground water table, depending on the rate of uptake by plants, and the rate of wastewater application to the crops.

- **Build-up of chemical contaminants in the soil.** Depending on the characteristics of the wastewater, long-term irrigation may lead to build up of toxic materials (heavy metals, refractory organics, specific ions such as boron, sodium and chloride) and salinity on the unsaturated layers of the agricultural soil. To avoid accumulation of toxic levels and taking up of toxicants by crops, it is advisable that irrigation be made only with wastewater of predominantly domestic origin. Adequate soil drainage is also of fundamental importance in order to minimize soil salinization.

- **Long-term irrigation schemes may create habitats for the development of disease vectors such as mosquitoes and snails.** To avoid this possibility, standard vector control techniques should be applied to avoid the transmission of vector-borne diseases.

Health-related Benefits

There is no doubt that in developing countries, well managed wastewater irrigation systems have a great potential for improving health, quality of life and social conditions by providing better nutrition through improved food supply and a better ecological balance between the city and its rural surroundings with rural jobs and settlement opportunities (Bartone 1986).

However, the negative health effects must be of concern to public health authorities and institutions in charge of reuse schemes: sewage farm workers; consumers of crops, meat and milk produced in wastewater irrigated fields and pastures; and nearby dwellers are the groups exposed to the risk of transmission of communicable diseases.

EFFLUENT QUALITY MICROBIAL GUIDELINES FOR AGRICULTURE

The very strict microbial standards developed over 50 years were based on **potential risks** associated with the mere presence of pathogens in wastewater, soil and crops rather than in the **actual risks** which are supported by epidemiological evidence.

In 1918, the California State Health Department set quality criteria for irrigation. Several revisions made over the years have turned this legislation into one of the most complete and restrictive in use today (California SDPH 1968). Unfortunately, many countries have adopted the same criteria with little or no adaptation to local possibilities and constraints.

In 1971, the WHO Meeting of Experts on the Reuse of Effluents (WHO 1973) recognized that the extremely strict California standards for reuse were not justified by the available epidemiological evidence, and recommended a microbial guideline for the unrestricted irrigation of vegetables eaten cooked of not more than 100 total coliforms per 100 ml. The meeting also felt that there was a need for wastewater irrigation guidelines to be given a sounder epidemiological basis, and recommended that this matter be fully investigated.

Since then, major efforts have been made by WHO; the World Bank; the United Nations Environment Programme; the United Nations Development Programme; the International Development Research Centre, Canada; the International Reference Centre for Wastes Disposal, Switzerland; the Food and Agriculture Organization of the United Nations; the US Environmental Protection Agency and many academic institutions throughout the world to provide a more rational epidemiological basis for wastewater irrigation guidelines. Extensive new epidemiological evidence has been accumulated, and earlier studies and reports have been evaluated. The findings of these studies have been carefully reviewed by leading public health experts, environmental scientists and epidemiologists at meetings in Engelberg (IRCWD 1985) and Adelboden (Mara and Cairncross 1989) in 1985 and 1987 respectively, and at numerous national and international meetings and consultations.

The consensus view of the epidemiologists and public health experts who have reviewed these data is that the actual risk associated with irrigation with treated wastewater is much lower than previously estimated, and that the early microbial standards and guidelines for effluent to be used for unrestricted irrigation of vegetables and salad crops normally consumed uncooked were unjustifiably restrictive, particularly in respect of bacterial pathogens. On the other hand, they considered it unjustified to disregard parasitic diseases which were, according to epidemiological evidence, the main risk for individual and public health associated with the use of insufficiently treated wastewater in agriculture. The epidemiological evidence has been extensively discussed in several reports and documents (Shuval *et al.* 1986; Blum and Feachem 1985).

On the basis of the new evidence, the Engelberg report recommended new guidelines containing less stringent values for faecal coliforms than those previously suggested. However, they were stricter than previous guidelines in respect of number of helminth eggs, which were recognized to be the main actual public health risk associated with wastewater irrigation in those areas where helminthic diseases were endemic. The Engelberg recommendations were subsequently reviewed and confirmed at the Adelboden meeting.

TABLE 2
Recommended[1] microbiological quality guidelines for wastewater use in agriculture[3]

Category	Reuse Conditions	Exposed Group	Intestinal Nematodes[2] (arithmetic mean no. of eggs/100 ml per litre)	Faecal Coliforms (Geometric mean no.)	Wastewater Treatment Expected to Achieve microbiological Quality
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks[4]	Workers Consumers Public	≤ 1	≤ 1000	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees[5]	Workers	≤ 1	not applicable	Retention in stabilization ponds for 8 to 10 days or equivalent helminth and faecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and public does not occur	None	Not applicable	Not applicable	Pre-treatment as required by irrigation technology, but no less than primary sedimentation

1 In specific cases, local epidemiological, socio-cultural and environmental factors should be taken into account, and these Guidelines modified accordingly.

2 *Ascaris*, *Trichuris* and hookworms.

3 During the irrigation period.

4 A more stringent guideline (≤ 200 faecal coliforms/100 ml) is appropriate for public lawns such as hotel lawns with which the public may have direct contact.

5 In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

In Geneva in 1987, the Scientific Group on Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture 1987 (WHO 1989), supported by this preparatory work and the epidemiological evidence currently available, established the basic criteria for health protection of the groups at risk in reuse systems and recommended the guidelines shown in Table 2. These are related to the category of crops, reuse conditions, exposed groups and appropriate treatment systems to achieve microbiological quality. The guideline values are supported by epidemiological evidence rather than being based on microbiological criteria as had been the practice in the past. This involves the concept of "real" or "attributable" risk which introduces, in the epidemiological chain, physical and social factors such as acquired immunity and the susceptible/immune population ratio, which affect the probability of developing disease as a result of exposure to reuse water. For the first time, a guideline value on intestinal nematodes has been recommended, supported by epidemiological evidence from studies made in Germany, India and Israel on the incidence of ascariasis in field workers and consumers of crops irrigated with wastewater. In fact, intestinal nematodes present the highest risks of wastewater-related disease transmission due to their long survival periods in the soil, long persistence in the environment, a low infective dose, practically no host immunity and the limited possibility of concurrent infection in the home.

Traditional approaches based on "potential risks" (qualitative presence of pathogens in wastewater, soil or crops, and no detection of disease caused by them) has led to the development of very restrictive standards in many countries, which have been difficult to implement and enforce. Conventional secondary or tertiary treatment systems (such as activated sludge, chemical aided sedimentation, rapid sand filtration and disinfection) originally designed for protection of receiving waters, are required to attain such standards (Hespanhol 1990). Besides the high costs and operational problems involved, these processes remove most of the humus-like organic matter and nutrients which, otherwise, would contribute to an increased yield of crops and, in many cases, would do away with the need for synthetic fertilizers.

TECHNICAL ASPECTS - MEASURES FOR HEALTH PROTECTION

Health protection in wastewater reuse schemes can be achieved through the application of four major measures: wastewater treatment, crop restriction, safe wastewater application methods, and human exposure control and personal hygiene.

Wastewater Treatment

Methods of wastewater treatment were first developed mainly in response to the concern for the adverse conditions caused by the discharge of wastewater in the environment. Early treatment objectives were concerned with (i) the removal of suspended and floatable material; (ii) the treatment of biodegradable organics; and (iii) the elimination of pathogenic organisms. In August 1973, the US Environmental Protection Agency published its definition of secondary treatment including three major effluent parameters; 5-day BOD, suspended solids and pH (US EPA 1973). A coliform standard included in the original version was deleted in July 1976 (Metcalf and Eddy 1979) probably due to the concern associated with chlorine and the effects of chlorine compounds on the aquatic environment and trihalomethane formation.

The same treatment criteria mainly for BOD removal are still being followed in several parts of the world when planning treatment schemes for wastewater reuse. Since new guidelines are now being provided, criteria for wastewater treatment should change accordingly in order to attain appropriate effluent quality. Table 3 summarizes the available information on the removal of excreted bacteria, pathogens and helminths, and indicates where the proposed guidelines for category A, irrigation Table 2 can be met (Feachem *et al.* 1983).

The following can be considered for treatment systems in terms of their appropriateness for wastewater treatment and utilization in irrigation schemes:

TABLE 3
Expected removal of excreted bacteria and helminths in various wastewater systems(Mara and Cairncross 1989)

Treatment process	Removal (log_{10} units) of			
	Bacteria	Helminths	Viruses	Cysts
Primary sedimentation Plain Chemically assisted[A]	 0 - 1 1 - 2	 0 - 2 1 - 3[G]	 0 - 1 0 - 1	 0 - 1 0 - 1
Activated sludge[B]	0 - 2	0 - 2	0 - 1	0 - 1
Biofiltration[B]	0 - 2	0 - 2	0 - 1	0 - 1
Aerated lagoon[C]	1 - 2	1 - 3[G]	1 - 2	0 - 1
Oxidation ditch[B]	1 - 2	0 - 2	1 - 2	0 - 1
Disinfection[D]	2 - 6[G]	0 - 1	0 - 4	0 - 3
Waste stabilization ponds[E]	1 - 6[G]	1 - 3[G]	1 - 4	1 - 4
Effluent storage reservoirs[F]	1 - 6[G]	1 - 3[G]	1 - 4	1 - 4

A Further research is needed to confirm performance
B Including secondary sedimentation
C Including settling pond
D Chlorination or ozonation
E Performance depends on number of ponds in series and other environmental factors
F Performance depends on retention time, which varies with demand
G With good design and proper aeration the recommended guidelines are achievable

- **Conventional primary and secondary treatment systems:** Raw wastewaters contain 10^7 - 10^9 faecal coliforms per 100 ml and it is clear from Tables 2 and 3 that conventional systems (plain sedimentation, biofiltration, aerated lagoons, activated sludge and oxidation ditches) cannot produce an effluent which complies with the new guidelines for bacterial quality ($\leq$ 1000 faecal coliforms per 100 ml).

  It must also be considered that conventional wastewater treatment systems are not generally effective for helminth removal. There is a need for research and development to improve helminth egg removal efficiency of conventional systems so as to meet the recommended microbiological guideline values.

- **Waste stabilization ponds** are the preferred method of wastewater treatment in warm climates whenever land is available at reasonable costs (Mara 1976; Arthur 1983). Ponds in series of anaerobic, facultative and maturation units with an average detention time of 10 to 50 days (depending on temperature) can be designed to produce effluents which meet the proposed guidelines for both bacterial and helminthic quality. More detailed information on stabilization pond systems can be found elsewhere (Bartone and Arlosoroff 1987; Mara *et al.* 1983; Mara and Silva 1986).

- **Disinfection**: Disinfection of wastewater, usually done through the application of chlorine has never been completely successful in practice due to the difficulty in maintaining a uniform and predictable level of disinfecting efficiency. Effluents from well-operated conventional treatment systems treated with 10-30 mg/l of chlorine and a contact time of 30-60 minutes will provide a good reduction of excreted bacteria but will have no capacity for removing helminths and protozoa (Feachem *et al.* 1983).

Due to the complexity of operation and maintenance, high costs and lack of consistency in disinfecting efficiency, the process should not be recommended for wastewater reuse in agriculture in developing countries. More reliable treatment systems such as stabilization ponds can provide effluents which meet the proposed guidelines without the need for disinfection.

- **Storage reservoirs**: Since demand for irrigation is usually concentrated in the dry season or in some particular periods of the year, wastewater can be stored in large reservoirs, thus providing further treatment, especially concerning bacteria and helminth reduction. Storage reservoirs have been used in Mexico and Israel (Shuval *et al.* 1986). There are at present insufficient field data on their performance to formulate a rational design process, but it is clear that pathogen removal will be strengthened by dividing them into compartments connected in series. The greater the number of compartments and the longer the minimum period of retention time, the more efficiently the pathogens will be removed. An appropriate design recommendation might be to provide a minimum hydraulic detention time of 10 days during the irrigation season, and to assume only a unit reduction of only 2 $\log_{10}$ in both faecal coliform and helminth eggs. Thus the effluent being discharged into the reservoir should contain no more than 100 helminths eggs per litre, and if it is to be used for unrestricted irrigation, not more than 100 000 faecal coliforms per 100 ml during the irrigation season (Mara and Cairncross 1989).

- **Tertiary treatment**: Tertiary treatment systems were originally developed to improve the quality of secondary treatment systems. Mechanisms designed to improve physicochemical quality (rapid sand filtration, denitrification, carbon absorption) have little or no effect on excreted bacterial removal, but some (such as filtration) may be effective in removing helminths. Further research is needed to provide reliable design data. These systems, however, are usually complicated and expensive, and their use in developing countries to produce suitable effluents for crop irrigation is not recommended (Mara and Cairncross 1989).

- **Sludge treatment**: The sludges originating from the settling units of some wastewater treatment systems show a high concentration of pathogens, including helminth eggs, which may remain viable for up to a year. No treatment is required however, if it is applied to land by subsurface injection or placed in trenches prior to the start of the growing season (Shende 1985). For other methods of land application, the following treatment methods may be considered in order to meet the recommended guidelines:

  - Storage from 6 to 12 months at ambient temperatures in a hot climate

  - Anaerobic digestion. Anaerobic digestion plants operating at temperatures lower than mesophilic temperatures show parasite egg removals from 90 to 95% but only 30 to 40% removal of ascaris (Gunnerson and Stuckey 1986).

    Batch thermophilic digestion at 50°C for 13 days will ensure the inactivation of all pathogens. Batch digestion is required to avoid pathogen short circuiting.

- Forced aeration co-composting. Co-composting of sludges with domestic solid waste or some other organic bulking agent such as wood chips for 30 days at 55° to 60°C and further maturation for 2-4 months at ambient temperature will produce a stable pathogen-free compost (Obeng and Wright 1987).

Crop Selection

As shown in Table 2, crops can be grouped in categories A, B, and C according to the exposed groups and the degree to which health protection measures are required.

To keep crops restricted to Category B, the following conditions should be feasible:

- where a law-abiding society or strong law enforcement exists;
- where a public body controls allocation of the wastes;
- where an irrigation project has strong central management;
- where there is adequate demand for the crops allowed under crop restriction and where they fetch a reasonable price;
- where there is little market pressure in favour of excluded crops. (category A)

Wastewater application methods

Application of irrigation water to land can be done in the following ways:

- by flooding or border irrigation, wetting almost all the land surface;
- by furrows, wetting only part of the ground surface;
- by sprinklers, in which the soil and crops are wetted in much the same way as by rainfall;
- by subsurface irrigation, in which the surface is wetted little, if any, but the subsoil is saturated; and
- by localized (trickle, drip or bubbler) irrigation, in which water is applied to each individual plant at an adjustable rate.

Irrigation methods providing little or no contact of the wastewater with edible parts of crops (such as subsurface or drip irrigation) involve higher cost and require a more advanced treatment of wastewater to avoid clogging of emitters. On the other hand, they would provide better health protection and higher water use efficiency (Table 4).

HUMAN EXPOSURE CONTROL

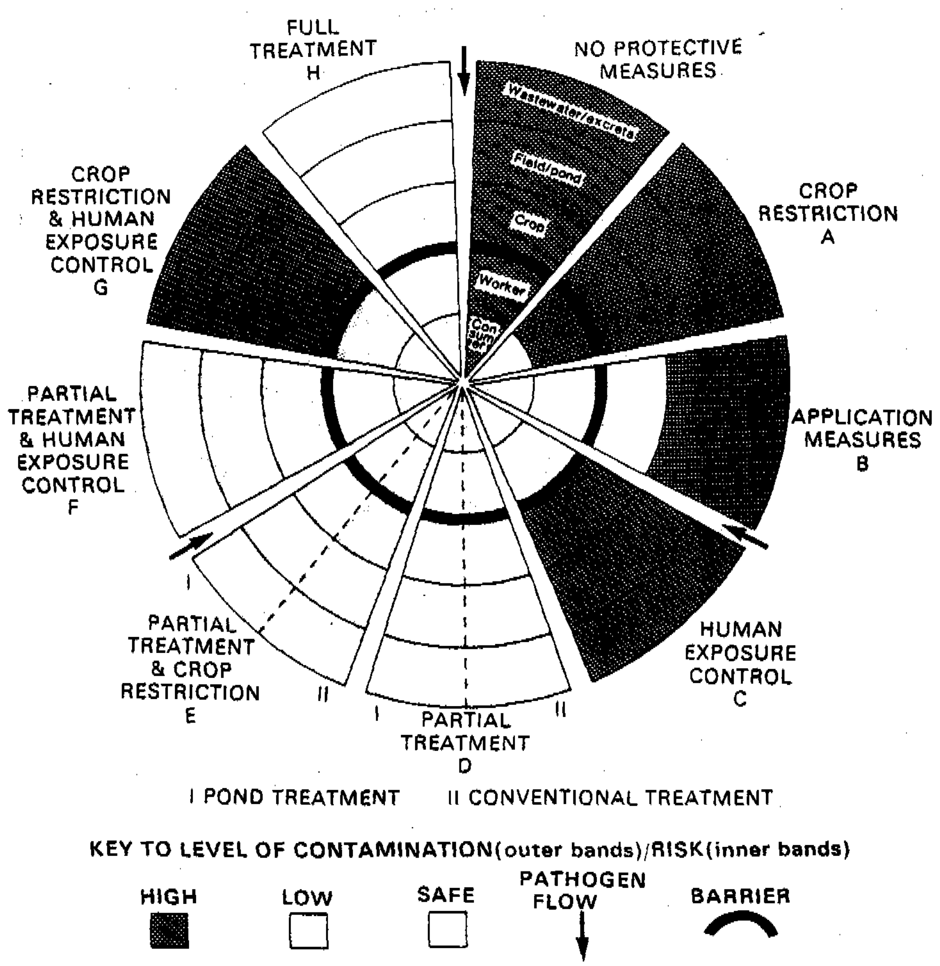
The groups of people that are more susceptible of being at risk from the reuse of wastewater in agriculture are the following:

- agricultural field workers and their families
- crop handlers
- consumers of crops, meat and milk originating from the wastewater irrigated fields
- those living near the affected fields.

TABLE 4
Factors affecting the choice of each irrigation method, and the special measures required when wastewater is used, particularly when it does not meet the proposed Guidelines (Mara and Cairncross 1989)

Irrigation method	Factors affecting choice	Special measures for wastewater
Border (flooding) irrigation	Lowest cost, exact levelling not required	Thorough protection for field workers, crop handlers and consumers
Furrow irrigation	Low cost, levelling may be needed	Protection for field workers, possibly for crop handlers and consumers
Sprinkler irrigation	Medium water use efficiency, levelling not required	Some Category B crops, especially tree fruit should not be grown. Minimum distance 50-100 m from houses and roads. Anaerobic wastes should not be used due to odour nuisance
Subsurface and localized irrigation	High cost, high water use efficiency, higher yields	Filtration to prevent emitters clogging

FIGURE 1
Generalized model to show the level of risk to human health associated with different combinations of control measures for the use of wastewater or excreta in agriculture or aquaculture



The methods for eliminating or minimizing exposure depend on the target groups and can be listed as:

- **Agricultural field workers and their families and crop handlers.** Higher potential risks mainly with respect to parasitic infections. Protection can be done through:
  - use of appropriate footwear to reduce hookworm infection
  - use of gloves (mainly for crop handlers)
  - health education
  - immunization against typhoid and hepatitis A
  - regular chemotherapy mainly for intense nematode infections in children and control of anaemia
  - provision of adequate medical facilities to treat diarrhoeal diseases

- **Consumers** — Protection can be done through:
  - cooking of vegetables and meat and by boiling milk
  - high standards of personal and food hygiene
  - health education campaigns
  - meat inspection (where there is risk of tapeworm infections)
  - ceasing the application of wastes at least two weeks before cattle are allowed to graze (where there are risks of *bovine cysticercosis*)
  - ceasing the irrigation of fruit trees two weeks before the fruits are picked
  - information on the location of the wastewater irrigation fields and posting warning notices along the edges of the fields

- **People living near the wastewater irrigated fields.** There is no epidemiological evidence that aerosols from sprinklers are a significant risk of pathogen contamination. However, in order to allow for a reasonable margin of safety and to minimize odour, a minimum distance of 50-100 m should be kept between houses and roads and sprinkler systems.

INTEGRATION OF THE VARIOUS MEASURES FOR HEALTH PROTECTION

To the planners and decision makers concerned with wastewater reuse, wastewater treatment appears as a more straightforward and "visible" measure for health protection, with crop restriction as a second approach. Both measures, however, are relatively difficult to implement fully: the first limited by costs and problems of operation and maintenance, and the second by lack of appropriate markets for specific products or by legal and/or institutional constraints.

It should be realized that the application of isolated measures, while not economical, may have only partial effects in terms of health protection. Crop restriction for instance, may protect the consumers of crops but does not provide protection to farm workers and their families, who will continue to be exposed to infections, particularly from eggs of parasites. Figure 1 shows, in a schematic and simplified way, three combinations that can protect the health of workers and consumers. The level at which three of the recommended protective measures (wastewater treatment, crop restriction and irrigation methods) are to be established should be determined through cost/benefit analysis.

ONGOING ACTIVITIES ON HEALTH AND ENVIRONMENTAL ASPECTS OF REUSE

Aiming at the promotion of the practice of reuse to improve the health status of developing countries through increased food production and to protect sources of water from wastewater pollution, WHO is developing a large programme whose priority actions are associated with:

- The development of guidelines and recommendations to support the countries in the implementation of safe and effective reuse schemes.

- The convening of seminars and workshops to disseminate guidelines as well as technical, institutional, economic and operational information on reuse to decision makers in Member States, particularly developing countries.

- The promotion of research and studies on health, technical and environmental subjects associated with the use of wastewater for agriculture and aquaculture.

As far as the development of guidelines is concerned, two documents are in the final phase of preparation:

Chemical Guidelines for the Safe Use of Domestic/Industrial Wastewater and Sludge in Agriculture

The Health Guidelines for the use of wastewater in Agriculture and Aquaculture, Report of a WHO Scientific Group, published by WHO in 1989, were not aimed at an in-depth discussion of chemical pollutants, but attention was called to the situation found in many developing countries where there are many small-scale industries not provided with their own wastewater treatment systems, and not located in isolated industrial zones. It was stressed that unsaturated zones lying above aquifers in irrigated fields will retain chemical pollutants, particularly heavy metals, with their concentration in the soil increasing with time, thus making possible after many years of irrigation, that "levels will be reached at which crops will take up such pollutants at concentrations toxic to man". The Scientific Group recommended that the situation should be monitored when the wastewater contains substantial quantities of industrial effluents.

The document also calls attention to groundwater contamination arising from the use of wastewater in irrigation and from applying sewage sludge to land. The main concern is nitrate accumulation in groundwater, which is a serious problem in many countries, especially where a shallow or highly porous unsaturated zone lies above the aquifers.

Guidelines for the chemical quality of irrigation water have been published by FAO (Ayers and Westcot, FAO 1985; Pescod, FAO 1992), including values related to salinity, rate of water infiltration into the soil and specific ion toxicity. The WHO guidelines concentrate on toxicological effects and are directed to assess the effects of land application of wastewater on the following groups at risk:

- consumers of crops produced on irrigated fields, and
- users of groundwater contaminated through land-application of wastes

The agents or pollutants of concern from a public health view-point considered in this document are the following: organic chemicals including pesticides, heavy metals such as cadmium and lead, nitrates and sodium. Nitrates and sodium, which are usually not considered as toxic substances, are included because of their haematological and long-term cardiovascular effects when present in water supplies at high levels.

It must be pointed out that about one hundred thousand chemicals are used routinely in manufacturing, industrial processing, commercial development, and domestic activities around the world. Even with the most stringent control on use of chemicals and on disposal of chemical-containing wastes, some of the spent chemicals would inadvertently find their way into the municipal wastewater. The collection system of publicly owned treatment works is, most likely, obliged to accept discharges containing potentially hazardous chemicals. It is however, difficult to anticipate which chemicals, in what concentrations, and at what time they appear in the wastewater stream. While the conventional biological wastewater treatment processes are effective in removing bacteria, suspended solids and biochemical oxygen demanding materials, their ability to attenuate potentially toxic chemical substances present in the incoming wastewater often cannot be predicted, as treatment processes are not designed to remove toxic substances.

Basic activities under development to accomplish the study are the following:

- Conduct comprehensive reviews of literature on toxic chemicals and their presence in wastewater and sludge produced in biological wastewater treatment plants. Through this endeavour, a list of candidate chemicals for regulatory consideration should be developed.

- Ranking the environmental exposure potential and environmental fate of candidate chemicals according to their physical/chemical properties. The information is used to develop the possible exposure scenarios for each chemical.

- Assess possible exposure from food and drinking water (groundwater) and risk of such exposure, rough estimates of dietary intakes of candidate chemicals are being made by using the "global diet" (from Food Balance Sheets, FAO, Rome) and the expected levels of contaminants in food; estimates of exposure from drinking water are also being made using the expected levels of contaminants in groundwater and volume of water consumed. The total estimated intake from food and drinking water should be compared to the toxicologically established Acceptable Daily Intake (ADI) or Provisional Tolerable Weekly Intake (PTWI), established by the FAO/WHO expert committees to determine whether or not consumers are at risk.

- Estimate the potential human health risk for each exposed group as a function of the expected concentration in wastewater and sludge.

The issues involved are being identified and an approach in setting chemical guidelines for the use of wastewater and sludge for irrigation will be recommended.

The Virus Concern in Wastewater Reuse Systems

The WHO Scientific Group which recommended the microbiological guidelines for reuse agreed, based on epidemiological evidence, that transmission of enteric virus diseases through wastewater reuse systems is not so important as transmission of bacterial and helminthic diseases (model of decreasing order of importance).

Endemic viruses diseases are the least effectively transmitted, because concurrent transmission in the home is generally so intense that most infants acquire permanent immunity in the first years of life, so there is little likelihood of excess disease occurring as the result of additional exposure from wastewater use.

However, since the publication of the document "Human viruses in water, wastewater and soil" (TRS 639) by WHO in 1979, a large amount of investigation has been made available allowing for a better understanding of health problems and environmental risks related to enteric viruses. Several approaches are now available to assess the risks associated with exposure to low numbers of enteric viruses in the environment.

This large amount of additional information constitutes an important asset to review the effects of viruses on wastewater reuse schemes, mainly with respect to the assessment of viral contaminants in industrialized countries where concurrent routes of infection are not significant, and high standards of hygiene are prevalent.

A document has been prepared addressing the health risks of virus contamination through the use of domestic wastewater, excreta and sludges from wastewater biological treatment plants. The document, which is to be revised by a group of internationally recognized experts, addresses the following aspects:

- Occurrence and survival of viruses in water, soil and crops
- Environmental risks from wastewater, excreta and sludge on: surface water, groundwater, sea water, soil and crops
- Removal of viruses by wastewater treatment processes
- Health risks to wastewater treatment plant workers, field workers, crop handlers, consumers and people living near irrigated/fertilized fields
- Health risks associated with groundwater pollution caused by irrigation/fertilization of crops with wastewater, sludge and excreta
- Techniques for detection
- Recommendations for monitoring
- Evaluation of the relevance of guideline values (viral concentration in wastewater, sludge and excreta) for restricted and unrestricted irrigation
- Health safeguards

- Recommendations for irrigation practices including operation and maintenance

- Research needed

RESEARCH NEEDS ON THE USE OF WASTEWATER

The Scientific Group Meeting on Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture held in WHO, Geneva, 1987, suggested that research into a number of subject areas needs to be continued and intensified. Research should be complemented by purposeful case studies on the upgrading of traditional practices as well as the implementation and operation of newly developed schemes for wastewater use. Efforts should be directed towards filling the gaps in knowledge and, where possible, towards monitoring and evaluating the effectiveness of the guidelines recommended.

Areas of priority for research and development are:

Wastewater Quality Assessment

Although methods for the detection of helminth eggs are in use today, they are not completely satisfactory, so that there is a need to develop and improve low-cost, reliable egg-detection methods which have a high degree of sensitivity. Further investigations are also required to facilitate the determination of egg viability in order to develop analytical methods which will be suitable for routine application.

Wastewater Treatment Technology

Research should be directed towards existing as well as new wastewater treatment technologies, and the following areas should receive special attention:

- waste stabilization pond technology, including developing and evaluating the performance of:
    - land-saving options (such as deep ponds); and
    - systems and designs aimed at minimizing evaporation losses

- treatment technologies other than waste stabilization ponds that achieve effective helminth egg removal; these may be:
    - for use in upgrading conventional treatment systems, such as biological-filter and activated-sludge plants (for example, by the addition of maturation ponds, which are entirely aerobic, or sand filtration); or
    - new techniques such as direct chemical treatment of sewage and horizontal- or vertical-flow roughing filters

- the effectiveness, cost and environmental impact of wastewater disinfection, with particular reference to helminth egg inactivation;

- bacterial removal in waste stabilization ponds under varying conditions (of climate, organic loading, etc.); and

- treatment to inactivate pathogens in sludges from ponds and other wastewater treatment plants, and in particular simple treatment processes for use on a small scale.

Wastewater Application Technology

In this field, research should be directed towards existing as well as new irrigation technologies which can provide the best health protection while at the same time conserving water. Techniques should be developed which allow the distribution of settled (i.e., minimally treated) sewage to a variety of crops without clogging delivery devices (especially in drip and trickle systems). This will facilitate the "safe" application of wastewater with minimal treatment.

Human Exposure Control

The effectiveness of methods for human exposure control, for both workers and consumers, should be evaluated under field conditions. There is a need to assess the performance of delivery systems (e.g. health care programmes for hygiene education and provision of protective clothing), compliance rates and the resultant health effects.

Socio-cultural Research and Integration of Measures

Research into public and users' attitudes to wastewater reuse is needed, both in areas where it is practised and in those where it may be introduced. This may be done using case study analyses. The social and cultural factors affecting the acceptability of and compliance with the health protection measures suggested (e.g. crop restriction) need to be evaluated in a variety of different cultural settings. Finally, research aimed at developing systematic methods of identifying the most cost-effective approach to health protection under any particular local conditions should be considered.

Epidemiological Research

The monitoring and evaluation of the recommended guidelines by carefully designed epidemiological studies is highly desirable.

Different at-risk groups, including the children of agricultural workers, should be examined. Studies of wastewater reuse in irrigation in a variety of settings, both where the microbiological quality guidelines are met and where they are not, should also be conducted. The most urgent need is to evaluate any improvement in the health of agricultural workers and their children in situations where the new helminth egg guideline is met. Studies are also required to fill gaps in existing knowledge, including studies of excess morbidity (where possible), of excess frequency of infection, of protozoal disease, and of the more virulent infections, such as typhoid fever, in relation to wastewater use.

Aquacultural Research

There is an urgent need to conduct research into the microbiological and epidemiological aspects of the use of wastewater in aquaculture, so that guidelines may be proposed in the future with greater confidence. The health effects on both aquacultural workers and consumers of fish should be evaluated in a variety of socio-cultural settings. Research is particularly needed in areas where the major trematode infections (e.g. clonorchiasis, schistosomiasis) do not occur and where bacterial infections are of greater concern. Research on the impact of excreta use in aquaculture is also required.

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Environmental management for disease vector control in rural water resources development projects

The term environmental management is frequently used these days, but means different things to different people. In its broadest sense it can refer to any action by man to modify the environment for an increased utilization of natural resources; agriculture is, as such, probably the oldest form of environmental management. In a more contemporary sense it is synonymous with cleaning up the environment, to remedy the adverse effects of rapid development which may threaten the natural resource base for this or future generations. When restricted to human health it means managing environmental determinants of health with the objective to achieve an optimal health status for a target population. And limiting its context even further, environmental management has become standard terminology in disease vector control as one of the methods to reduce populations of invertebrates (insects, snails) that play a crucial role in the transmission of human diseases. The other methods are chemical control (the use of insecticides) and biological control (the use of natural enemies). This paper considers environmental management mainly in its more limited sense.

When considering the interactions between environment, development and health, it is a good starting point to put attributes to "environment". The first distinction should be of components of the environment which we can or cannot influence. Of the influenceable components some may be an important determinant of human health, others may be of no consequence. In the first case, environmental change may entail human health hazards, and development may offer opportunities to improve health. Other components of the environment will be out of our influence, and adaptation of human behaviour will be the way to escape from human health risks resulting from their change.

A second important aspect of the environment concerns scale: from the micro-environment of our skin to global climatic conditions there is a range of possible health effects imaginable. Changes are seldom singular events, and the assessment of the effects of environmental change on human health is therefore a complicated process. In theory, ten interactions between environment, development and health are imaginable, as illustrated in Figure 1.

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FIGURE 1
Inter-relationships between environment, development and health (adapted from Bradley 1991)

ENVIRONMENT

⇑ ⇓ ⇑ ⇓

HEALTH ⇔ DEVELOPMENT

E ⇒ + ⇒ D	Irrigation in desert areas
E ⇒ - ⇒ D	Soil erosion
E ⇒ + ⇒ H	Improved domestic water supply
E ⇒ - ⇒ H	Irrigation-associated schistosomiasis
D ⇒ + ⇒ H	Reduction of poverty-related ill health
D ⇒ - ⇒ H	Loss of land by the poor (malnutrition)
H ⇒ + ⇒ D	Estate agriculture (e.g. tea plantations)
H ⇒ - ⇒ D	Abandonment of agriculture
D ⇒ + ⇒ E	Terracing of fields
D ⇒ - ⇒ E	Deforestation

In the less developed countries infections are the main causes of disease and death, and the poorer the country the more they predominate. The chief environmental factors influencing the nature and magnitude of infectious disease problems are those covered in the term "poverty" and the climate. Under these conditions, environmental determinants of health are diverse, but, especially in the case of the "classical" tropical diseases, they include water, human excreta, ambient temperature and humidity.

The original classification of water-related diseases by Feachem *et al.* (1980) continues to hold true and it is of relevance to repeat it here as it distinguishes by route of transmission and suggests potential interventions of an environmental management nature.

- **Water-borne diseases**, where the pathogen is transmitted by ingestion of contaminated water. Cholera and typhoid are often spread this way.
- **Water-washed diseases** involve faecal-oral contamination from one person to another, facilitated by the lack of adequate quantities of water for washing. Many diarrhoeal diseases as well as infections of the skin and eyes are transmitted in this way.
- **Water-based infections** occur where part of a pathogen's life cycle takes place in the aquatic environment. Schistosomes and other trematode worms with aquatic snails as their intermediate host are an example, as is the parasite causing guinea worm disease.
- **Water-related vector-borne diseases** are transmitted by bloodsucking insects that rely on an aquatic environment for the larval part of their life cycle.

The association between water resources development and human health has been the focus of fluctuating attention since the discovery at the end of the last century of the transmission mechanisms of infectious diseases. The role of water in the epidemiology of these diseases can be a direct one (when transmission occurs by drinking contaminated water) or an indirect one (when vectors of disease have a life cycle linked to the aquatic environment). The use of environmental management for vector control (previously referred to as source reduction) in the context of irrigation development and reservoir construction was popular during the first three decades of this century, but became completely marginalized for several decades following the second world war, in the wake of the initially spectacular successes of residual insecticides, often in combination with new drugs. Its re-discovery at the end of the 1970s, when chemical control began facing serious problems, and the prospect of accelerated irrigation development in the 1980s implied the urgent need to incorporate health safeguards into water resources development, has led to new ideas about vector control in the context of sustainable development. These have been described elsewhere (Bos 1992).

Basic facts about the vector-borne diseases are given in Table 1. At a global level the two most important diseases are malaria and schistosomiasis. They all affect mainly rural communities, with the exception of the arboviral disease dengue/dengue haemorrhagic fever, which is intimately linked to urban conditions, and lymphatic filariasis in those areas where it is transmitted by *Culex* vectors that breed in organically polluted water. In Africa, both diseases form a considerable obstacle to rural development, in particular the development of irrigated agriculture. In rural parts of Asia, vector-borne diseases reduce the production potential of farmer communities; in highly endemic areas, elevated levels of child mortality hamper the effectiveness of family planning programmes. The costs incurred by these diseases range from expenditures by health services and agricultural production losses to direct and opportunity costs to community members in terms of e.g. expenditure on drugs or time lost to accompany a sick family member to a health post. The work of Mills in Nepal (1992) illustrates the spectrum of cost aspects related to malaria and its control.

The 1980s have certainly witnessed a revival of the interest in environmental management, in particular as, on the one hand, vector-borne disease control faced increasing difficulties (insecticide resistance, drug-resistant malaria) and, on the other, the political climate turned progressively more favourable to environmental issues and the concept of sustainability emerged. Nevertheless, its application, whether as a health safeguard in water resources development, or as a component of on-going integrated vector control activities, has still not flourished to its full potential.

The application of environmental management suffers from a number of constraints which are listed below. Some of these are elaborated and an analysis is made how, in the context of achieving an integration of the development and management of rural water resources, they could be overcome and which technological developments would facilitate the process. The constraints, then, are:

- the lack of a policy framework to promote the use of environmental management in water resources development;
- if any, inadequate institutional arrangements to ensure the intersectoral cooperation necessary for the consideration of environmental management in the planning, design and implementation of water resources development;
- the use of conventional, economic indicators in project appraisal which favours remedial health measures rather than the early incorporation of health safeguards;
- a limited knowledge base for the application of innovative environmental management techniques;
- insufficient mobilization of communities in the operation and maintenance of water projects (be they irrigation or drinking water supply projects) with, linked, sub-optimal opportunities for community-based environmental management;

TABLE 1
Basic facts on major water-borne and water-associated vector-borne diseases (WHO 1990)

Disease	Prevalence/ Incidence	Distribution	Association with water	Intervention options/ constraints
Malaria	267×10^6/ 107×10^6 (estimates)	Throughout the tropics, limited by altitude; patchy over time and space	Vectors generally breed in clean water; depending on vector species to a greater or lesser extent linked to irrigation and dams	Case detection and drug treatment; various options for vector control/ spreading drug resistance, insecticide resistance, increasing importance of *P. falciparum* malaria
Schistosomiasis	200×10^6 (estimate)	North and tropical Africa; coastal South and Central America, Western Pacific (mainly China/ Philippines)	Snail intermediate hosts in natural water bodies, irrigation schemes and reservoirs	Effective drug treatment, mollusciciding, environmental management, water supply and sanitation, health education/drugs and molluscicides expensive, no single method suffices
Filariasis	88.5×10^6 (estimate)	South and SE Asia, Central and East Africa, Caribbean and coastal Central and South America, Pacific Islands	*Culex* vectors breed in organically polluted water; *Mansonia* vectors associated with aquatic weeds; *Anopheles* vectors in Africa associated with irrigation	Case detection and drug treatment; source reduction and other environmental management measures/ chronic, debilitating disease with low mortality, with low priority as a result
Arboviral diseases	varies by disease	Several diseases, main ones: Japanese encephalitis in S, SE and E Asia; yellow fever in rural Africa and pockets in S. America; dengue in urban centres of the tropics	JE vectors breed in irrigated rice fields, dengue vectors in small, peridomestic water collections	Vaccines available for JE and YF; source reduction and other environmental measures for dengue vector control/vaccine for JE expensive, delivery of vaccines expensive; vector behaviour evades residual insecticides
Guinea worm infection	Incidence in Africa 1×10^6 annually (estimate)	West and Central Africa; pockets in India and Pakistan	Strictly associated with contaminated drinking water (Cyclops intermediate host)	Provision of safe drinking water; filtration of water from suspected sources

- the location-specificity of effective environmental management measures (as opposed to the universal applicability of chemical control methods).

Solutions can be developed for the above constraints which in part depend on technical advance and for which, therefore, further research is required. The possible solutions are discussed first, followed by areas of technological research and development. Policy issues and institutional arrangements are considered as one area.

POLICY ISSUES AND INSTITUTIONAL ARRANGEMENTS

The decision-making processes that take place during the planning of water resources development are guided by policies of governments and, at the appraisal stage, policies of bilateral and multilateral donor agencies. Government policies are usually derived from a national development plan, and formulated for specific sectors. A literature review of the impact of development policies on health (Cooper Weil *et al.* 1990) shows the range of such policies and the scope of adverse health impacts they may incur. In 1989, the Panel of Experts on Environmental Management for Vector Control reviewed policies and programmes of governments and external support agencies in connection with environmental management in the context of development projects (Mather and Bos 1989). One of the key policy areas identified in this review was that concerning Environmental Impact Assessment (EIA).

Several of the less developed countries are in the process of formulating and testing policies and legislation for a formal assessment of the possible environmental impacts of development projects. The external support agencies, for their part, apply policies requiring such an assessment prior to the final appraisal of a proposed project.

The place of human health in environmental assessments remains a matter of debate. In the conventional approach, health is dealt with in a sectoral way. As a result of this compartmentalized approach, the assessment does not extend to a review of design options, what they mean in terms of environmental determinants of health, and how design modifications can be made that reduce adverse health effects. Instead, recommendations generally focus on remedial measures to cope with a deteriorated health situation by strengthening of health services (more dispensaries, increased case detection and drug treatment, intensified programmes of vector control etc.). This is in sharp contrast to what the World Commission on Environment and Development (WCED 1987) advocates ("prevention instead of after-the-fact-repair"), and ultimately places an additional burden on the health sector.

A pro-active approach should not only consider health from a negative angle. The word "impact" has, over the years, obtained a negative connotation and is now generally dropped from the assessment terminology. However, the assessment does not necessarily have to be a neutral event. Development can in fact benefit from a positive approach which tries to identify health opportunities in the context of a water resources project. This goes beyond the generally recognized benefits of such projects: a reduction in water-borne and water-based infections associated with projects for drinking water supply and sanitation or improved nutrition in the case of irrigation development. Integrated rural water management will contribute importantly to a synergism between the inherent health benefits of each type of development.

Finally, the ambiguous role of the health sector should not be left without mention. All too often, ministries of health maintain a strong focus on health services at the expense of health risk management. Health authorities may be less than willing to delegate health risk management to other, relevant sectors. Health professionals are insufficiently trained to participate in the inter-sectoral dialogue at project planning stages and to argue effectively at the time of project appraisal with external donors, so that, as a result, allocation of project funds to health-promotional activities does not occur to its full potential.

PROJECT APPRAISAL BASED ON ECONOMIC INDICATORS

The successful promotion of environmental management for vector control depends on persuading financing bodies (which may be donors, governments, irrigation authorities, NGOs, commercial banks and even individual farmers) of the desirability of expending resources on environmental management.

Two important aspects of this statement need elaboration. One is that human health cannot be adequately expressed in monetary terms. This implies that health considerations cannot be included in the cost-benefit analysis of a proposed project.

When it comes to the financial appraisal of water resources development projects, the Internal Rate of Return (IRR) will often be the over-riding criterion in the decision-making of financing agencies. Even leaving health aside, there has been considerable criticism on this approach. An ODA (UK Overseas Development Administration) supported study brought to light five major drawbacks of the use of the IRR as the main criterion, some of which also are of relevance for the health dimension of irrigation development (Tiffen 1987):

- a bias against sustainability (the discount on future costs and benefits reduces the economic importance of the project's life extending beyond 10-15 years to a negligible level) and against projects requiring high initial investment and low maintenance costs;
- an excessive stress on immediate realization of full benefits rather than a phased project implementation which would favour a gradual adoption by farmers of increasingly sophisticated irrigation management practices, and a stronger economic base for operation and maintenance;
- total reliance on the IRR, which gives a false sense of security concerning the project outcome and is a disincentive for continuous monitoring and re-adjustment;
- preference for rigid solutions with an optimal IRR, over sub-optimal solutions which offer a greater degree of flexibility during construction and operation;
- the ease with which cost-effectiveness is manipulated and the resulting unreliability of the IRR. The exclusion of a proper drainage component from irrigation projects is a well-known example (with often severe repercussions for the health status of the local population).

The second aspect is the relative disadvantage of environmental management methods for vector control as opposed to, for example, conventional insecticide spraying. Especially in the context of development projects, environmental management is often synonymous to additional engineering works which require considerable capital investment. Depending on the discount rate applied, the recurrent cost incurred by spraying operations may make the latter option seem more cost-effective. This argument will weigh particularly heavily when the funds for health safeguards are obtained as a loan; if they are obtained as a special grant under bilateral technical cooperation, a decision favouring preventive environmental interventions will be greatly facilitated.

The constraints imposed on the application of environmental management by the strict use of economic criteria can, in part, be overcome by development policy changes. These are, however, not likely to occur unless the methods of economic evaluation of health aspects are improved. The trend towards integrated rural water resources management offers an important opportunity to increase the profile of water-associated health issues: as policies have to be (re)formulated to arrange for the allocation of limited water resources to the various user groups, environmental and health considerations need to be incorporated in the establishment of priorities. The sum of positive and negative environmental and health impacts associated with specific water use should be reflected in water prices and tariffs for the user groups. Mechanisms should be designed that ensure a flow of financial resources, thus generated, for use by sectors adversely affected by specific water use.

INSUFFICIENT KNOWLEDGE BASE

The 30-year gap in the development of innovative environmental management methods and in research on their effectiveness under specific eco-epidemiological conditions is the legacy of a period of singular reliance on the application of residual insecticides for the control of disease vectors. Now, an effective interaction is needed between basic vector-ecological research (which should include new approaches in population genetics and modeling) on the one hand, and the development of innovative structural engineering and water management techniques. The Zimbabwe example given in the case studies document prepared by Snellen provides an example. In the context of integrated rural water management this means expanding studies on water saving and re-use technologies, with vector ecological and human health components.

Of particular concern from the human health viewpoint are small-scale water resources developments. They are usually not subject to scrutiny for environmental (or health) effects, yet their cumulative impact may exceed that of a single. medium size project. Traditional epidemiological stratification should be complemented by ecological typification, which will help determine the effectiveness of specific environmental interventions. This may prove difficult in complex ecological situations with more than one vector species, or a vector with some degree of elasticity in its breeding requirements, but even so, it may be possible to attribute relative risks to different components of the environment.

COMMUNITY INVOLVEMENT IN OPERATION AND MAINTENANCE

The application of environmental management measures is particularly well suited to be carried out with the involvement of the local community. On the one hand, it does not have major risks, such as is the case of applying residual insecticides, and it is often congruent with good agricultural practices. Indeed, some measures may have beneficial effects on agricultural production, and this can be used to motivate community members to cooperate in their application.

Environmental management should be placed in the broader context of Operation and Maintenance (O&M), an area which, by itself, is of particular interest in the context of integrated rural water management. Both in irrigation and in drinking water supply, O&M issues have received increasing attention because of their importance for sustainability. Integrated management of rural water resources provides an opportunity for irrigation managers and sanitary engineers alike to learn from each other's experience in this field and mutually adopt successful strategies.

With respect to irrigation O&M, suggestions have been made in the past on how a devolution of responsibilities to the farmer level, with proper incentives, could lead to increased community involvement in the O&M activities. Proper education, through the agricultural extension network rather than through the conventional health education channels, could ensure the incorporation of environmental management measures for vector control.

PRIORITY AREAS FOR TECHNOLOGICAL/METHODOLOGICAL RESEARCH AND DEVELOPMENT

In order to achieve successfully the above solutions to the constraints on the application of environmental management, research and development action is required in a number of technological/methodological areas listed below.

- **Health assessment techniques.** EIA methods have been the basis for the development of specific methods to assess the health risks involved in water resources development (Birley, 1991). The issue is therefore not how to develop the methodology, but rather how to make it more accessible for a non-specialist readership. Two possible approaches are **Expert Systems** and **Hypertext**. The former has lost a lot of its initial popularity because it implies decision making by the computer rather than by the person in charge of water resources planning. A **Hypertext** version of the PEEM guidelines for forecasting vector-borne disease implications of water resources development is now under development and will shortly be tested for its acceptability.

- **Monitoring and surveillance**. The decision to accept the conclusions and implement the recommendations of a health risk assessment should not be made without installing a proper system of monitoring and surveillance. Two new techniques should be further developed and tested for their health application: remote sensing and Geographic Information Systems.

  Initial trials of remote sensing to detect and target important vector breeding sites have been conducted in California and Mexico. These trials took place in relatively stable situations. The effectiveness of this technique in monitoring an on-going water resources development project needs to be tested, preferably in a simple, one-vector ecosystem where it causes drastic environmental change.

  The development of national GISs, particularly for natural resources management and the integrated management of river basins, and often using remotely sensed data, is accelerating. It is important to ensure that, in any national GIS initiative, inter-sectoral sharing of databases is promoted and that health data are selected that are plausibly associated with specific environmental parameters for further analysis. GIS work by WHO's Schistosomiasis Unit on the distribution of the disease on the Tanzanian island of Pemba have demonstrated the potential of this tool in targeting intervention activities.

- **Improved economic evaluation methods.** Existing economic evaluation methods do not do justice to the health implications of water resources development and do not favour the incorporation of environmental interventions as health safeguards. The principle that health is a basic human right is very true, but adds very little weight to the argument to include health considerations at the appraisal stage negotiations of a water resources development project. Further research is needed to develop the economic evaluation tools. In the meantime, cost-effectiveness analysis should be promoted as the method of choice in selecting from different vector control options in association with development projects.

- **Typification of ecosystems for stratification.** Risk attribution and selection of environmental management methods in small-scale water resources development (whether for irrigation, drinking water, water for livestock or other purposes) should be based on proper ecological typification and linked to epidemiological stratification. This requires in-depth longitudinal studies on vector ecology in well-defined ecosystems, followed by the testing of specific environmental management measures for their effectiveness.

  Micro-level GIS can be an important tool in the analysis to arrive at a typification.

  In rural areas with irrigated agriculture, collaboration with research groups studying methods of integrated pest management should aim at the development of a broad strategy of pest and vector management, with major farmer involvement.

- Innovative environmental management measures. In the past ten years, a lot of effort has gone into reviewing pre-world-war II literature to retrieve existing, but forgotten knowledge on source reduction and species sanitation. An example is the review of scientific literature originating from the former Dutch East Indies, from which three case studies are presented in the paper by Snellen.

  Newly developed measures will need testing for their effectiveness under different conditions, their cost-effectiveness in comparison with other vector and vector-borne disease control options and, most importantly, their acceptability to farmer communities. Sweeping statements need to be verified and fine-tuned to local conditions, such as "in irrigated rice production systems intermittent flooding and draining is an effective vector control method" (only true if there is enough water available and soils are sufficiently rich in nutrients not to suffer from the leeching effect of this intervention) or "canal lining solves the vector breeding problems caused by seepage" (where canal lining may not even be cost-effective in the long term, primarily for water saving purposes).

  The trend towards rehabilitation/modernization of exiting irrigation schemes offers yet another opportunity to develop and test environmental interventions under well described conditions where risk factors are well defined. New technology research initiatives in irrigation and drainage such as the UNDP/WB/ICID IPTRID should be given assistance in developing a programme component that focuses on the environmental and human health aspects of their activities.

OPPORTUNITIES FOR HEALTH PROMOTION IN INTEGRATED RURAL WATER MANAGEMENT

Finally, it is worth listing the opportunities for health promotion and protection that follow directly from the integration of rural water management. Some of these have already been alluded to above.

The joint planning of water resources development will overcome situations that have occurred in the past, where a water supply and sanitation component was omitted from irrigation development, resulting in human behaviour with a high risk for schistosomiasis transmission. This has been particularly true in many African irrigation schemes. Joint monitoring of water quantity and quality will allow an early warning system for groundwater pollution. In the past, contamination of groundwater has been a reason for people to shift to irrigation canals as their source of their drinking water, again with specific risks of schistosomiasis transmission.

Water pricing will be an incentive to prevent water losses through seepage (irrigation) or defective conveyance systems (water supply) and as a result vector breeding places will be reduced. Financial incentives can be used to involve farmer communities in operation and maintenance work more closely, and this can be expanded to include works of an environmental management nature to create more sanitary conditions.

The promotion of community-based fish culture will also be facilitated by the integration of rural water management. This will have a direct health benefit by improved nutrition. As experience from India has shown, given the necessary education, communities are capable of combining the cultivation of fish for consumption with that of larvivorous fish, which can then be used to restock vector breeding places. Under the correct ecological conditions this can be yet another contribution to the reduction of risks of vector-borne disease transmission.

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Monitoring of integrated rural water management programmes: water supply and sanitation

BACKGROUND TO MONITORING

Effective management of rural water development requires a continuous flow of high quality information, specific to the needs of the programmes concerned. Information of this type is provided by systems which monitor, or periodically assess, certain important parameters as a means of determining progress towards defined goals, managing current operational activities, and planning future actions.

Monitoring of programme activities is not uniformly practised in the rural water management sector. Some programmes, such as flood control, irrigation development, and the supporting technical areas of climatology and surface and groundwater hydrology, have a long tradition of extensive monitoring for management purposes. Other programmes, such as water supply, sanitation and vector control, have not used monitoring as a tool for sector management. The case of water supply and sanitation, however, provides an illustration of the growing importance that monitoring can play, over time, in rural water development.

The lack of information on the status of water supply and sanitation in developing countries first presented itself as an issue in the late 1950s. At that time, WHO was intensifying its efforts to support countries in their programmes to reduce diarrhoeal and other water-borne diseases through improvements in water supply and sanitation services. The lack of data was not only an impediment to planning but the inability to quantify the problem also reduced the impact of advocacy efforts and hence contributed to the relatively low priority given to the sector by national governments and external funding agencies.

Although monitoring of water supplies and sanitation expanded during the 1960s and 1970s, the application of monitoring information was limited because of a lack of awareness of its value on the part of many governments.

DISCUSSION PAPER 8

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A major impetus to monitoring was provided by the International Drinking Water Supply and Sanitation Decade (1981-1990), which was a major outcome of the United Nations Water Conference, held in Mar del Plata, Argentina, 1977. The Mar del Plata Plan of Action recommended that governments "develop national plans and programmes for community water supply and sanitation, and identify intermediate milestones within the context of the socio-economic development planning periods and objectives, giving priority attention to the segments of the population in greatest need". Resolution II of the Conference also recommended that "national development policies and plans should give priority to the supply of drinking water for the entire population and to the final disposal of waste water".

It was from these recommendations that routine monitoring of water supply and sanitation became established during the Decade. WHO, in association with other members of the UN system, was requested to expand its ongoing activities in monitoring and to report on the status and progress of community water supply and sanitation throughout the Decade.

From this brief sketch, it is clear that monitoring has always been perceived as an external audit of country progress towards national goals. The process of such externally-driven monitoring has been:

- governments establish sector plans and goals;
- WHO, supported by its UN partners, monitors progress towards these goals;
- WHO reports back to governments through the UN General Assembly and other UN governing bodies.

The result of this process was the compilation of national water supply and sanitation statistics which were merged into regional and global totals. This information was used primarily by the United Nations' agencies to assess overall sector progress towards Decade goals and by the donor agencies to justify programmes of development assistance. Little effort, however, was made to use the monitoring information to influence directly the programmes or performance of national agencies responsible for water supply and sanitation services.

The experience of monitoring during the 1980s demonstrated several strengths and weaknesses of the above approach. Among the strengths were:

- it quantified global water supply and sanitation conditions and focused on problems and inequities;
- it proved a useful advocacy tool at the national and international levels;
- it enabled both the successes and failures of the Decade to be identified;
- governments and the international development community began to appreciate the value of monitoring.

The weaknesses of the system included:

- it was externally driven and responded mainly to international needs;

- no feedback machanisms were developed to use monitoring information at the country level;
- little improvement in national monitoring systems was achieved;
- little qualitative analysis of services was possible.

In summary, water supply and sanitation monitoring during the 1980s responded mainly to the mandates of Mar del Plata rather than individual country needs. While the initial goals of sector monitoring, as perceived at the start of the Decade, were achieved, the limits of this approach became increasingly evident over time. Monitoring during the Decade, therefore, not only showed that sound information was essential to sector development, but that new directions were needed to make it an effective tool at country level.

A PHILOSOPHY FOR MONITORING IN THE 1990s

Basically, the philosophy for monitoring during the 1990s is to build on previous experience and respond to the deficiencies of past efforts. To do this, the approach of the past has to be revised to make the first priority the strengthening of water supply and sanitation monitoring capabilities at country level, in order to improve sector planning and management (national capacity building). The second priority is a by-product of the first: to improve monitoring at the regional and global levels, in order to assess sector progress and to channel external aid flows.

For monitoring to be used at the national level as a management tool, there are three basic questions to answer:

- what are existing needs for water supply/sanitation?
- where are the service inequities?
- what are the key constraints/problems to sector development?

The answers to these questions can help to direct monitoring activities towards the following objectives:

- better utilization of existing resources;
- increase in total sector investment;
- increased ease of sector implementation;
- improved targeting of needy areas/groups;
- improved sector operational performance;
- improved equity concerning sector investment.

To achieve the above ends, monitoring must be part of a dynamic, iterative process, whereby it provides the basic information to policy/decision makers, who then use it in the preparation of national plans of action, advocacy and management. The resulting implementation of the action plans then becomes an input back into the monitoring system, which in turn provides continuous data for updating the plans.

Sector planning for water supply and sanitation requires considerable information on the type and quality of services to be provided to communities. National monitoring systems can respond to this need for detail in terms of types of technology currently being applied. For planning, it is important to know whether water is being served through house connections, public stand posts, or protected wells, for example, as well as if sanitation is through connections to public sewers, septic tanks, or pit latrines. This information provides not only a picture of the current situation but also the basis for planning the upgrading and expansion of systems.

In the past, it was often possible to say, for example, that only 80% of the population had an adequate and safe water supply. It would be much more useful to know that 25% of the population are provided through house connections, 20% through yard taps, and 35% through protected dug wells. With such statistical breakdown, two courses of action become evident: first, to provide services to the 20% still unserved and, second, to reduce the proportion served by protected dug wells by increasing the number of yard taps. Detailed information of this type is directly applicable to the development and implementation of water supply and sanitation programmes.

Another prime planning consideration at the national level is the geographical distribution of population and facilities. To plan and manage water supply and sanitation services effectively, it is not sufficient simply to have national statistics. Information must also be available at the provincial, district and even the municipal and community levels. This may be difficult to achieve in the short term, but it should be possible, over time, for countries to strengthen progressively their capability to extend monitoring activities down through the administrative hierarchy, and thereby develop a monitoring network which reaches into the user communities themselves.

ACTION FOR THE 1990s: WHO/UNICEF JOINT MONITORING PROGRAMME (JMP)

In response to the deficencies of previous monitoring programmes, but at the same time building upon the crucial foundations laid down by monitoring efforts during the 1970s and 1980s, WHO and UNICEF decided at the end of the Decade to combine their experiences and resources in a Joint Monitoring Programme for Water Supply and Sanitation (JMP). The programme was initiated in 1990, with the objective of strengthening country level monitoring capabilities in all developing countries by 1995.

To respond to the these needs, the JMP methodology contains the following features:

- it is designed to monitor a minimum set of water supply and sanitation indicators;
- it is further designed to meet country requirements as defined by national officials;
- it has the capability to collect data down to five administrative sub-levels of government;
- it distinguishes among seven different technologies for both water supply and sanitation.

Since the main objective of the JMP is to build national capacity for monitoring water supply and sanitation conditions, the system has been designed with simplicity in mind and with the capacity to be expanded as needed. To do this, the basic JMP approach contains three basic parameters: service coverage, operation and maintenance, and capital investment.

The first parameter, service coverage, measures the population having access to functioning safe water supplies and adequate excreta disposal facilities. Coverage is further broken down into the different water supply technologies (house connections, yard taps, public standpipes, etc.) and sanitation facilities (public sewers, septic tanks, latrines, etc.). The second parameter, operation and maintenance, assesses the financial contribution made by different organizational groups (government, external agencies, beneficiaries, etc.) to supporting water supply and sanitation services. And finally, the third parameter, capital investment, assesses the financial contribution made by the same groups to the construction of new water and sanitation facilities. In all three parameters, there are distinctions made between rural, urban low income, and urban high income populations.

Computer software has been developed within the JMP to support information processing and to assist countries in the compilation and analysis of the data. The software is flexible, yet user-friendly, and has the following features:

- it is menu driven, with no special training or software manuals required;
- it operates in four languages;
- it converts between national currencies and US dollars;
- it merges data from different national administrative levels;
- it is "open-ended", thus allowing the user to add parameters to correspond to specific national requirements;
- it contains a mapping facility and has the capability to link with proprietary Geographic Information Systems (GIS).

To date, the JMP has been introduced through a series of sub-regional workshops to countries in Central America, the Caribbean, and sub-Saharan Africa. Current efforts are now concentrated on the implementation of country level monitoring programmes in these regions and on the introduction of the JMP to Asia and the Pacific Islands.

CONCLUSIONS

The need for improved monitoring systems in water supply and sanitation was identified in the late 1980s as a result of the experience gained in monitoring the International Drinking Water Supply and Sanitation Decade. In the 1990s, monitoring will become an increasingly important input to the planning, management and implementation of water supply and sanitation services in the developing world. The crucial importance of monitoring is essential not only to water supply and sanitation, but to all sectors of development activity. The difficulties of programme development and implementation in the absence of reliable information show that no sector can be effectively managed without a sound monitoring system.

The efforts of the 1990s now must be to promote the introduction of monitoring systems at country level and to develop monitoring networks as integrated components of sector management. It is through such an approach that the data generated through monitoring will be systematically and routinely used in the planning and management of water supply and sanitation services.

Research and development on drinking water supply and sanitation

The International Drinking Water Supply and Sanitation Decade (1981-1990) brought substantial attention to bear on the problems of expanding water and sanitation services, particularly to those in both the greatest number and the greatest need — the rural poor. Although the results of the Decade fell short of the ultimate objective of universal access to a reasonable supply of water and a sanitary latrine, service expansion was an impressive achievement — an additional 1.3 thousand million people with safe water supply and 750 million with improved sanitation. This was made possible at least in part by the adoption of less expensive and more sustainable technologies, particularly in rural areas. However, it is the rural and marginal urban populations that still suffer the greatest service deficiencies (Table 1). Despite the achievements, a significantly accelerated rate of service provision is needed if full coverage is ever to become a reality. This will require widespread adoption of low-cost technologies — at least as a first step which can subsequently be upgraded when circumstances permit. The WHO/UNICEF Joint Monitoring Programme (1992) states, however, that "most developing countries have yet to convert and switch to the large scale use of low-cost technologies...".

This paper will describe the role and experiences of the UNDP-World Bank Water and Sanitation Program in the research and development of technologies for low-cost water supply and sanitation in rural areas of developing countries and will attempt to draw some conclusions. Box 1 provides a brief but more general overview of the Program.

WATER SUPPLY TECHNOLOGIES

The Handpumps Revolution

Traditional sources of water in rural areas include: surface sources such as rivers, ponds and lakes; rainwater; and groundwater where it is accessible from springs or open dug wells, but only groundwater is sufficiently widespread and accessible to provide the main source of supply for widely dispersed rural populations.

CASE STUDY 3
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TABLE 1
Global access to water and sanitation

	Percentage of population with access to safe water and adequate sanitation			
	Water supply		Sanitation	
Sub-sectors	WHO 1990[1]	JMP 1990	WHO 1990	JMP 1990
Urban		95		95
Marginal urban		36		45
Urban total	82	83	72	65
Rural total	63	67	49	22[2]

1 Refers to the "Decade Monitoring Report by WHO, where 1988 sector data were extrapolated to 1990.
2 The large discrepancy in relation to the earlier WHO extrapolations for 1990 is most probably due to the absence of JMP rural data from China.

Groundwater is also generally free from the pollution typical of other sources (even rainwater, which has to be collected and stored). It is, however, not so easily accessible. In many situations handpumps represent the most cost-effective means of obtaining groundwater as they are a simple technology which communities can afford and maintain with their own resources. For these reasons, the UNDP, the World Bank, and a number of major donors undertook a project for the Laboratory and Field Testing and Technological Development of Community Water Supply Handpumps as a contribution to the Water Decade efforts.

Some 2700 pumps of 70 different models were tested and monitored over a 5-year period in 17 countries. The results were published in 1987 (Arlosoroff *et al.* 1985) and have changed the approach to rural water supply service delivery. Why was this so? Handpumps have been around since Roman days. Most handpumps have their origins in designs developed in Europe and the United States 100 years ago. However they have changed little since then. The industrial revolution brought mass production techniques, and large numbers of handpumps were supplied for use as family backyard pumps which operated for 10-30 minutes a day. When these same pumps were later installed in developing countries, serving up to 500 people and in continuous use 10 hours a day, it was not surprising that they suffered high failure rates. It became equally apparent that centralized maintenance systems, such as there were, could not keep pumps in satisfactory operating condition.

From the handpumps project emerged the VLOM principles — Village Level Operation and Maintenance. Originally, the VLOM concept was applied only to hardware, and pumps were specifically designed to be:

- easily maintained by a village caretaker, requiring minimal skills and few tools;
- suitable for in-country manufacture, primarily to ensure the availability of spare parts;
- robust and reliable under field conditions; and
- cost-effective.

VLOM principles were well-received and manufacturers either moved quickly to improve their designs or lost market share. At the same time, responsibility for handpump maintenance was passed on to the users, and caretakers from the village as well as area mechanics were trained to provide the various maintenance requirements. This has led to the realization that "software" aspects were of crucial importance and that different models work best in different circumstances, requiring an extension of the VLOM principles. The "M" was changed to stand for Management of maintenance, meaning that communities should have the choice of when to service pumps, who should service pumps, and to pay directly for those services.

It is not possible to describe here the full range of handpumps that have emerged to find a significant market today. A few should be briefly mentioned however. These are the public domain designs that have emerged from the combined efforts of the UNDP-World Bank Program, UNICEF, and a number of donors and manufacturers:

- The **India Mk II** deepwell handpump evolved from UNICEF sponsored R&D in India and appeared around 1978. Almost 2 million have since been installed. The UNDP-World Bank Program assisted with the introduction of a VLOM version, the **India Mk III** which, although slightly more expensive, is a much simpler and easier pump to maintain.

- The **TARA** handpump (Kjellerup, Journey and Minnatullah 1989) was developed in Bangladesh to resolve the problem of water tables falling below the limit of suction pumps as a result of irrigation practices depleting the groundwater. The TARA is a direct action pump making extensive use of mass-produced items, is compatible with the indigenous and very low cost "sludger" method of borehole construction, provides adequate capacity but is still usable by children, eliminates the need for hand tools to service pumping elements, and protects moving parts from corrosion and abrasion. Versions are now in use in Central and South America as well as other Asian countries.

- The **Afridev** handpump, which evolved from development work in Malawi in the early years of the Decade, introduced many new features such as engineered plastics for several components, snap-fit rod connectors, uPVC rising main and an open-top cylinder to enable easy withdrawal of pumping elements and footvalve. The pump is now manufactured in eight countries under an international specification and has become the national standard for deep well applications in an increasing number of countries.

These experiences have shown that technological "breakthroughs" are possible even with a technology (handpumps) that is certainly not new. However, technology cannot be isolated from the circumstances of its application. Perhaps the attention focused in the past on the nuts and bolts of VLOM designs detracted from sufficient consideration of other factors — social, financial, institutional — that determine a technology's sustainability. This is where attention is now focused.

Other Systems

Technological initiatives of the UNDP-World Bank Water and Sanitation Program has been focused on handpumps because of their wide application for delivering affordable water supply services to the maximum number of people in rural areas. Advances have been made simultaneously in a number of other technologies which deserve mention:

Slow sand filters/roughing filters

Slow sand filters have been employed in small and not so small (e.g. London) water supplies for some time. They have the ability not only to remove fine particulate matter but also to produce a water of good bacteriological quality without resort to chemicals, power or

BOX 1 **UNDP-WORLD BANK WATER AND SANITATION PROGRAM**

The UNDP-World Bank Water and Sanitation Program is a long-term collaborative effort of the Bank, UNDP, and a number of bilateral donors to expand the access of the poor to safe water and adequate sanitation on a sustainable basis. The Program's two basic activities are the dissemination of the lessons of experience and the provision of technical assistance. Accordingly, the large majority of the 85 staff are located in the field, in five regional offices and a number of resident country teams.

During the 1980s the Program focused primarily on low-cost technologies. Now the emphasis has shifted to institutional and capacity-building issues, and especially the role of informal institutions, in recognition of the limited success which formal sector institutions and agencies have had in reaching the poor. Alterative institutional arrangements (including NGOs, user and community groups, and the local private sector) will be essential if projects and programmes are to be sustainable. The Program's focus on rural water supply and sanitation and urban sanitation and waste management, also developed during the 1980s, will continue.

Over the next three years the Program's strategy involves a three-pronged approach:

- **Building capacity at the national and local levels:** Here the Program will assist countries to create the enabling environment of policies necessary to encourage local efforts; improve human resource development and training; and work with local institutions and user groups to help them plan and manage services.

- **Supporting sustainable investments:** The Program's support to the Bank and other external donors in the design and implementation of projects will continue, but with special concentration on projects where a "structured learning" approach can be used. This approach avoids normative solutions, emphasizes flexibility in design, and builds in a process that encourages innovation and experimentation, feedback, and learning on the part of all parties involved of what works and does not work.

- **Dissemination of lessons and knowledge:** The Program will analyse experiences from the structured learning exercises, its capacity-building work, and selected applied research in technology and other areas. Lessons and best practices will be disseminated through publications, workshops, and conferences, so that countries and donors are encouraged to follow successful examples.

Many Bank Sector Operations Departments and the Program's donors see the structured learning approach as a promising way of improving project design, implementation and learning from experience. The Program is furnishing this kind of support to the Bank in Brazil, Indonesia, Pakistan, Nepal, Sri Lanka and the Philippines, and is working to set the stage for similar involvement in a number of African countries and in Bolivia, Ecuador and Central America.

sophisticated equipment. Their limitation has always been that a reasonably clean raw water was required for them to function satisfactorily. That has now changed as a result of work led by the International Reference Centre for Wastes Disposal to develop roughing filters that can improve the quality of raw water to a stage that is acceptable for the use of slow sand filters (Wegelin 1986). This technology is now widely applicable to produce potable water without power, chemicals or skilled operation.

Upgraded wells

Traditional open dug wells continue to supply enormous numbers of rural dwellers with their water supply. These wells have been frowned on by health and development agencies because the water was generally contaminated and a source of infection as well as water. The installation of a drilled borehole and handpump was usually seen as an improved water supply, allowing traditional sources to be abandoned. Instances abound, however, of users, through preference (objections to the cost or taste of the water) or necessity (failure of the handpump), reverting to their traditional source. Innovative work by the Blair Research Institute in Zimbabwe has demonstrated that with simple and inexpensive improvements, the water in the well can be protected from contamination and provide users with an entirely satisfactory supply of water at very low cost. Improvements are simple and cheap, and include deepening and lining if necessary, construction of an apron and cover, and the provision of a windlass and bucket. For community wells, a bucket pump or handpump is recommended. A study by the Program in Indonesia confirmed findings in Zimbabwe and elsewhere that dug wells can supply good quality water if simple and reasonable measures are taken to protect the well from contamination (Blair Research Institute 1992).

SANITATION TECHNOLOGIES

Historical Practices and their Deficiencies

Sanitation technologies have been historically utilized for a variety of reasons. Conventional sewerage, for example, evolved in the industrialized countries of Europe to enable open drainage ditches to be covered over. Nightsoil collection has been practised in China for generations, driven by the need to sustain intensive agricultural production, and simple pit privies were constructed in many countries to provide privacy for defecation.

The health benefits of improved sanitation have not been fully appreciated until fairly recent times, and are now a driving force behind sanitation service promotion by government agencies and donors (Esrey *et al.* 1990). The users, however, do not always perceive the potential health benefits as sufficient to invest some of their meagre resources in a better sanitation facility. They are often motivated by other reasons where a direct benefit is more readily perceived such as convenience, status, privacy, or agricultural use of the wastes. Hygiene eduction is therefore an important component of sanitation and water supply improvement programmes.

Some traditional sanitation technologies from industrialized countries have distinct disadvantages where applied in developing countries. A few examples include:

- Conventional sewerage was developed in situations of copious water use and high affordability; it is much less relevant to the circumstances in many developing countries of low affordability and relatively low water consumption. Other forms of sewerage may be more appropriate, but are less familiar to designers and planners. Although primarily an urban technology, simple sewerage can also find application in smaller rural towns.

- Septic tanks have found widespread applications in many developing countries, promoted by colonial powers or well-meaning donors. They have two major disadvantages: the mechanical services needed to remove accumulated sludge are rarely adequately available and leaching facilities almost inevitably fail due to neglect or poor design, resulting in the discharge of effluent as hazardous to health as the raw wastes.

- Practices in industrialized countries have only rarely promoted the use of human wastes as a resource. The approach to treat wastes as a disposal problem has tended to

TABLE 2
Average annual on-site, collection and treatment costs per household (1978 US dollars)

Facility	Mean TACH	On-site costs	Collection costs	Treatment costs
Low cost				
PF toilet	18.7	18.7	-	-
Pit privy	28.5	28.5	-	-
Communal toilet	34.0	34.0	-	-
Vacuum-truck cartage	37.5	16.8	14.0	6.6
Low-cost septic tanks	51.6	51.6	-	-
Composting toilets	55.0	47.0	-	8.0
Bucket cartage[1]	64.9	32.9	24.0	6.0
Medium cost				
Sewered aquaprivy[2]	159.2	89.9	39.2	30.2
Aquaprivy	168.0	168.0	-	-
Japanese vacuum truck	187.7	128.0	34.0	26.0
High cost				
Septic tanks	369.2	332.3	25.6	11.3
Sewerage	400.3	201.6	82.8	115.9

1 To account for large differences in the number of users, per capita costs were used and scaled up by the cross-country average for six persons per household.
2 Total annual costs per household.

discourage reuse practices in developing countries, rather than promote what already exists or to introduce new opportunities. Practices such as nightsoil use in agriculture and aquaculture, biogas generation from human and animal wastes, and the use of wastewater for irrigation have generally originated and grown as local initiatives.

Research and Development

The Program's involvement in R&D on sanitation technologies had its origins in the late 1970s when the World Bank President at the time, Robert McNamara, called for a greater focus on the poor, in terms of their productivity and access to essential public services, specifically including water and sanitation. Recognizing in particular that sewerage, the conventional method of human waste disposal, was generally not available in developing countries, the Bank launched a two-year research project on appropriate technology for water and waste disposal in developing countries. The project assessed public health and social objectives as well as technical, economic, environmental and institutional constraints. The results were published in 1980 (Kalbermatten *et al.* 1980). Table 2 lists the sanitation technologies studied, which were grouped in terms of low, intermediate and high cost.

As a direct result of these studies, the Bank subsequently executed a number of projects financed by UNDP and a number of donors, that included Sanitation for Low Income Communities. The current UNDP-World Bank Water and Sanitation Program evolved from those projects. The Bank research project singled out two technologies in particular as suitable for wide-scale replication — the pit privy and the pour-flush toilet. The Program has emphasized the use of these technologies through promotion, demonstration projects and information dissemination (Mara 1984; 1985). Pour-flush latrines are now widely used in Asian countries where better water availability has encouraged the use of "wet" systems, whereas the dry ventilated improved pit (VIP) latrine, another example of the Blair Research Institute's pioneering technology work, has become popular mainly in Africa.

The benefits resulting from the broad-scale adoption of these and other low-cost sanitation technologies is difficult to quantify. The study by Esrey *et al.* (1990) on health impact alone has already been mentioned. Monitoring data, however, draw attention to the fact that there are still 1.7 thousand million people lacking adequate sanitation (cf. 750 million served during the Decade) so there is still a long way to go.

The UNDP-World Bank Program has broadened and modified its scope considerably since its early days. At the project level, it has given attention to mechanisms for service delivery, especially the community participatory aspects, financing and cost recovery, operations and maintenance and other aspects of service sustainability. At the sector level, considerable attention has been paid to the development of sector strategy and action plans, and the strategic sanitation approach. Current Program emphases are described in Box 1.

DISCUSSION

In conclusion, it is worth considering what lessons can be drawn from the Program's involvement in technology development during the IDWSS Decade.

The Linkage of Water, Sanitation and Hygiene Education

An important conclusion that has been drawn is the importance of integrated improvements in water supply, sanitation and hygiene behaviour if maximum health benefits are to be achieved. The Mirzapur project (Aziz *et al.* 1990) demonstrated that the health impact of hand-pumped water supply improvements alone was significantly less than when accompanied by complementary improvements in sanitation and hygiene education. This is not to say that all service delivery must be integrated, but it does show that each of the three interventions is a necessary but not sufficient condition for maximizing health improvements. A second conclusion is that progressive upgrading of services is a more realistic and more cost-effective strategy than providing a high standard of services initially. This observation lies at the heart of The New Delhi Statement of "Some for all rather than more for some".

A third conclusion relating to the linkage of water and sanitation service technologies relates to resource recovery and the long-term sustainability of services. That water is a finite resource has been recognized in water-scarce regions for some time. It is becoming increasingly aspparent everywhere that conservation, re-use and recycling have economic attractions. The nutrients and organic matter in human wastes, the recyclable content of solid wastes, and the water and nutrients in wastewater are resources, and this realization is expected to have a significant impact on technological development in future.

Promotion of Low-cost Technologies

The appliction of low-cost technologies for service expansion in rural areas is widely recognized but still limited. The reasons are many. A common feature of the technologies described is their public ownership. All designs are in the public domain and most sanitation technologies do not even incorporate many manufactured products. The intensive marketing of proprietary or manufactured items by manufacturers or their agents is therefore lacking. This may explain, for example, why packaged water treatment plants, manufactured out of mild steel and with their requirements for power and chemicals and skilled operators, are often preferred over slow sand-roughing filters which are likely to last much longer. Even manufacturers of the public domain handpumps are not particularly aggressive in marketing their products to users, generally preferring to leave that to the governments and the donor agencies to whom they sell the pumps. The Delhi Consultation in 1990 advocated that governments become promoters, rather than providers, of water and sanitation services. In either role, motivated personnel with appropriate education and training are generally lacking, although many are trained at high cost in overseas institutions to become familiar with the conventional technologies used in those countries.

The Answer Lies with the User

An appropriate note to finish with is the role of the users themselves in water and sanitation technology use. Whether low-cost or conventional technologies are utilized, experience has shown that it is the users that are the key to service sustainability. This is not a new realization. The Handpump Option stated that "... the technology chosen should give the community the highest service level it is willing to pay for, will benefit from, and has the institutional capacity to sustain". It has proved more difficult than expected to put this maxim into effect. Much of the current work of the Program is focused on methodologies for assessing willingness-to-pay, and re-orienting service delivery to be demand-driven rather than responsive largely to supply considerations.

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Research and development on irrigation and drainage technologies in Turkey

GENERAL CHARACTERISTICS OF TURKEY

Geography

Turkey has a total area of 779 452 km^2, of which 765 152 km^2 is land and the remaining 14 300 km^2 is water surface. The country has influential geo-political status because its location serves as a natural bridge between Europe and Asia. It is surrounded by the Black Sea in the north, the Mediterranean Sea in the south and the Aegean Sea in the west, and is divided into two main parts -Anatolia with 755 688 km^2 and Thrace with 23 786 km^2.

Climate

Generally Turkey is in the subtropical belt having a semi-arid climate with extremes in temperatures. Summers are hot and dry, winters are cold, rainy and snowy in the east. Along the coastal area a sub-tropical mediterranean climate is dominant with short, mild and rainy winters and long, hot and dry summers. Arid and semi-arid continental climates prevail in the interior parts. Geographical location and geological formation cause climatic conditions suitable for the production of many kinds of crops in the several climate regions.

The average annual temperature varies between 18-20°C on the South Coast, falls to 14-15°C on the West Coast, and finally in the interior areas, according to the location of the place from the mean sea level, fluctuates between 4-18°C.

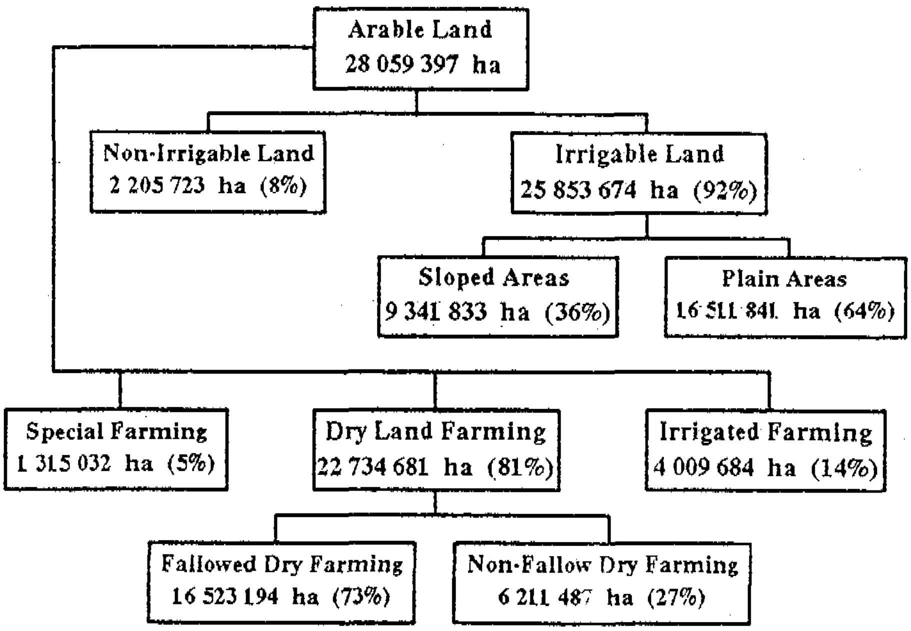
Turkey is subject both to a continental type of climate characterized by rainy weather throughout the year and also to a subtropical climate distinguished by dry summers. The annual average precipitation is 643 mm, but it varies from 250 mm in the central part to 3000 mm in the eastern Black Sea region.

CASE STUDY 4
Süleyman Kodal, Faculty of Agriculture, University of Ankara
Erkan Benli, The Undersecretary, Ministry of Agriculture and Rural Affairs, Turkey

TABLE 1
Agricultural land use (in thousand hectares)

Years	1950	1960	1970	1980	1985	1990
Area sown	9868	15305	15591	16372	17908	19656
Fallow land	4674	7959	8705	8188	6025	5324
Vegetable gardens	*	*	448	596	662	635
Vineyards	561	782	845	820	625	580
Orchards	608	730	1019	1386	1489	1583
Olive groves	297	548	731	813	821	867
Total cultivated area	16008	25324	27339	28175	27530	28645

FIGURE 1
Arable, irrigable and irrigated lands



Population

Turkey has experienced steady population growth since the 1920s. Provisional results of the most recent census in 1990, put the total population at 57.16 million, indicating an average annual growth rate of 2.41% since 1985. At the 1986-90 rate, the population can be expected to reach about 70 million by the year 2000 and 91 million by the year 2025. The population density is 65 per square km.

Agriculture

The total area of Turkey is about 78 million ha, of which about 28.6 million is cropped land, 20 million is forests. 20% of cropped area is usually lying fallow at any given time. Table 1 shows the agricultural land use.

The potential agricultural area, plain areas and slopes to 6%, is 16.5 million ha, and the country's limits of potential agricultural area were reached in the 1970s. Rotation of fallow with small crops has been the primary cropping pattern in most of the rainfed areas. This has changed significantly in recent years with the implementation of the project "Utilization of Fallow Areas", fallow lands decreasing from 8.2 million ha in 1980 to 5.3 million ha in 1990. The central Anatolian Plateau is one of the largest dryland areas. Further growth in agricultural production can result only from gains in productivity per hectare. Bringing additional rainfed crop land under irrigation may contribute to this growth.

The average yield in Turkey of irrigated land is 7.6 times that of rainfed land, and the average value added per irrigated ha is 2.6 times that of one rainfed ha.

There has been a substantial development and improvement in the agricultural sector since the foundation of the Republic of Turkey, both in terms of the expansion of arable land and increase in agricultural productivity. During this period, agricultural land has increased from 11.7 million hectares up to 28.6 million hectares and this reflects an improvement of 2.5 times in the total area of arable land. On the other hand the increase of the population has gone up 5.5 times. The ratio of productivity and net income per hectare have gone up by 2-10 times and 10-20 times, respectively, depending on the variety of agricultural products. All these developments have made Turkey one of the seven or eight countries in the world which are self-sufficient in food and fibre production.

LAND AND WATER RESOURCES

Land Resources

The total area of Turkey is 77 945 200 ha, separated into 28 059 397 ha of arable land, 21 506 028 ha of pastures and common grazing lands, 1 159 207 ha of water surfaces areas, 23 248 297 ha of shrubs and forests; 3 972 271 ha of residential areas. Of the arable land, 25.85 million ha is irrigable and 2.21 million ha is non-irrigable land. The irrigated area is 4.01 million ha (Figure 1).

FIGURE 2
Irrigable land

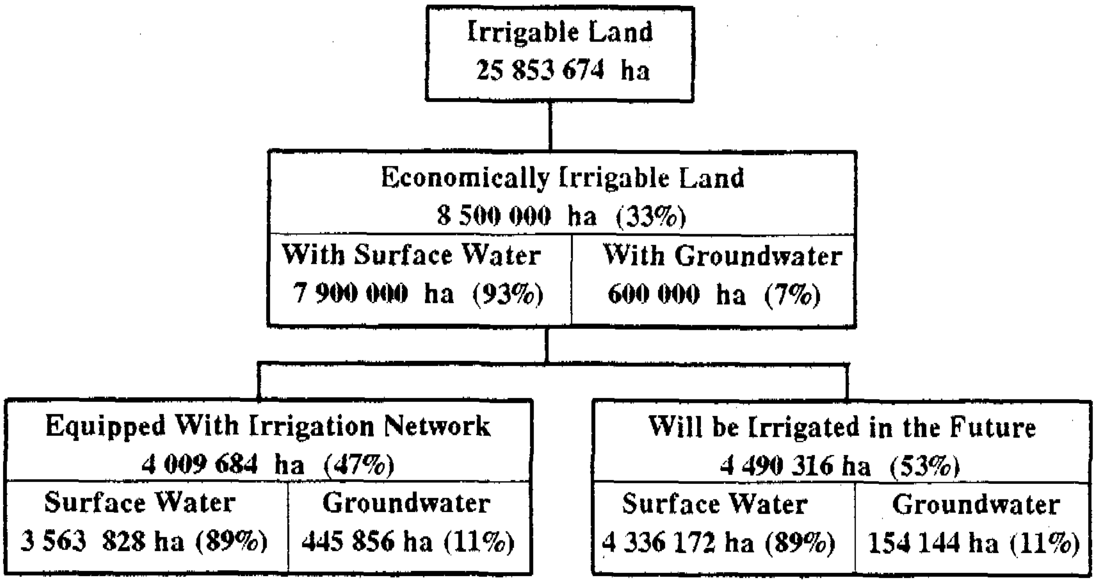
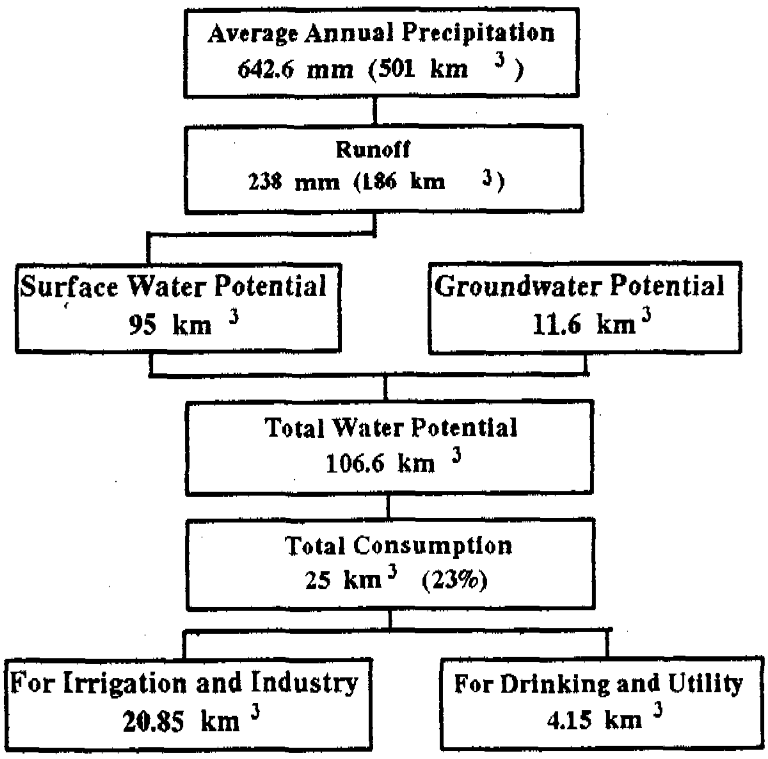


FIGURE 3
Water potential



According to the recent studies based on available land and water resources, it would be economically feasible to irrigate an estimated 8.50 million ha with major and minor irrigation works. A further 17.35 million ha could be irrigated using advanced technology (Figure 2).

Water Resources

The average annual precipitation of the country is 642.6 mm, this corresponds to a water potential of 501 km^3 per year. Runoff amounts to 238 mm, an average rate of 37%, and the remaining 63% is lost to evapotranspiration. A certain amount of the runoff is allocated to meet the water rights and requirements of the neighbouring countries. Consequently the amount of surface water which is utilized for consumptive purposes is in the range of 95 km^3 per year. According to the studies based on groundwater resources, the total safe yield of groundwater resources is estimated to be 11.6 km^3. The potential of total available water resources from surface flow and groundwater would amount to 106.6 km^3 per year (Figure 3).

In order to regulate the whole surface waters in the country the construction of 662 dams is required. It is obvious that the possibilities mentioned above require great amounts of investment and a long period of construction. The water supplies from these dams would be regulated to achieve the following: irrigation of 6 609 382 ha; drainage of 135 801 ha; flood control of 636 794 ha; conveyance of 7 726 hm^3 of water to urban areas and generation of 121 884 MKwh of electric power by the hydroelectric power plants with a total capacity of 34 484 MW of generated electricity. The actual yearly consumption from water potential is 25.0 km^3 (23% of the potential).

From the figures given about land and water resources potential, it is obvious that water resources are limited, water is a constraint to agricultural productivity in comparison with the extent of existing irrigable land resources. Interbasin water transfer is possible, but very expensive in today's conditions. To implement supplemental irrigation, the Central Anatolia Region, recognized for cereal production, and some of the inter-zone areas between the coast and central region would be the most profitable areas.

DEVELOPMENT OF IRRIGATION AND DRAINAGE TECHNOLOGIES

Responsibilities of Government Organizations

State Hydraulic Works (DSI) is responsible for the planning, design construction and operation and maintenance of irrigation and drainage systems, flood protection, investigations, research, planning, programming, workshops and other facilities.

General Directorate of Rural Services (GDRS) is responsible for the development and efficient use of land and water resources by farmers, the construction, maintenance, repair and operation of rural roads, water supply, electricity and sewage facilities for villages and settlement schemes, bringing stony, acidified, alkaline lands or muddy and dry fields into suitable condition for agriculture, preparing and carrying out on-farm development works, such as on-farm irrigation and drainage facilities, quaternary canals, land levelling, land consolidation, sub-surface drainage, infrastructural improvements; planning construction and

FIGURE 4
Area equipped with irrigation network

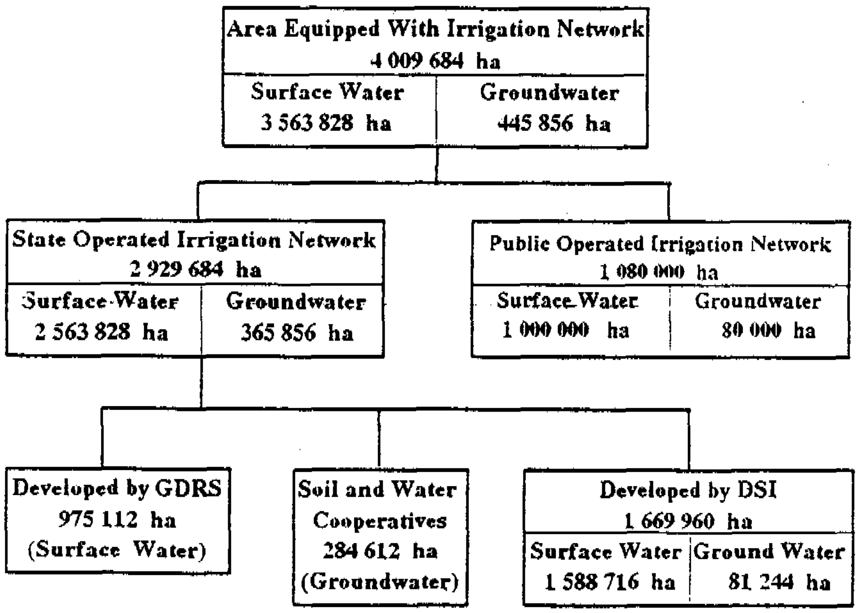
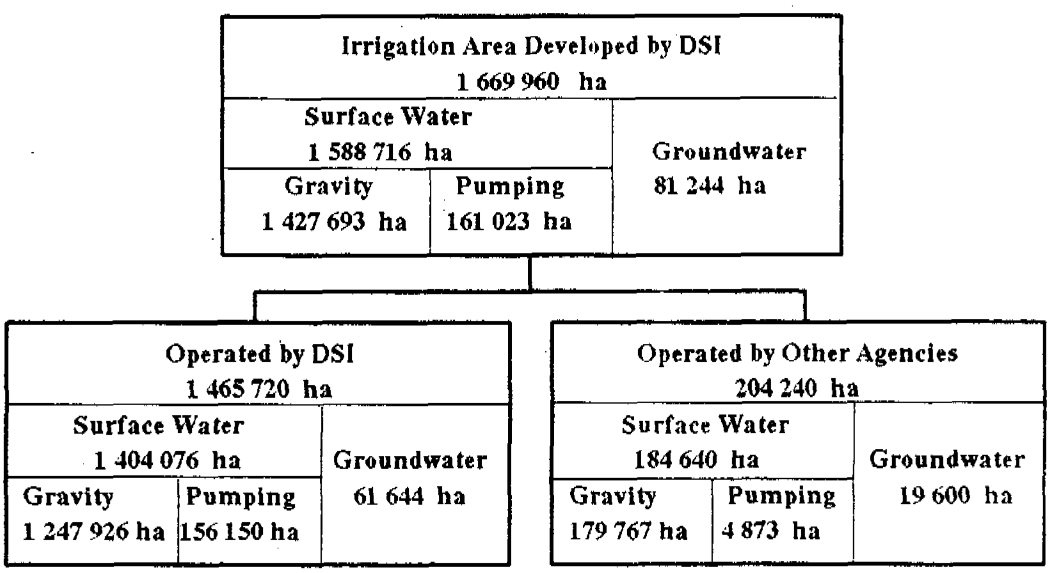


FIGURE 5
Irrigation area developed by DSI



operating small-scale irrigation facilities (supplying less than 500 litres of water per second or irrigating less than about 1000 ha), construction and operating buildings, workshops, laboratories, research stations and other facilities.

Ministry of Agriculture and Rural Affairs (MARA) is responsible for the development of villages, the development of agriculture, assistance in the development of water and soil resources, carrying out investigations and research, planning programmes and projects to meet the needs for protection and development of water and soil.

The Ministry of Agriculture and Rural Affairs consists of 13 General Directorates of which the General Directorate of Organization and Supply is responsible for agricultural extension services. Another, the General Directorate of Agricultural Enterprises (TIGEM) is responsible for producing goods and service to be used in agriculture by the farmers.

Activities and Problems

The first irrigation and drainage project constructed under Government responsibility was the Çumra Irrigation Project, constructed between 1908-1914. In the early years after establishment of the Republic of Turkey, the attention was mainly focused on the reclamation of swamp and wetland areas. Towards 1940, studies started for the irrigation of the previously reclaimed areas.

Up to the end of 1991 approximately 4.01 million ha (47%), were irrigated, out of an estimated total area of 8.5 million ha considered suitable for irrigation (Figure 4). The irrigation area developed by DSI is 1.67 million ha, by GDRS is 0.98 million ha. The area operated by soil and water cooperatives is 0.28 million ha and public irrigation is 1.08 million ha. Of the area developed by DSI, approximately 1.59 million ha, 95%, are irrigated by surface water (with gravity or pumping), and 0.08 million ha, or 5%, by groundwater sources.

The main part of the irrigation area (88%) developed by DSI is being operated by DSI, the other part of the area is being operated by other agencies (Figure 5).

By the end of 1991, construction of 150 large dams had been completed and put into service for single purpose or multipurpose demands such as irrigation, energy, flood control and domestic water supply. Most of them are earthfill or rockfill dams, having a total storage capacity of 78 000 million m^3. Also 53 dams are under construction.

The total small-scale irrigated area developed by GDRS was 975 112 ha in 1991 and will reach 1 100 000 ha with the completion of the 1992 investment programme which covers 13 385 ha from small earth dams. GDRS completed more than 500 such dams, irrigating 115 000 ha by the end of 1991. GDRS has also completed about 1 700 earth dams for livestock watering.

GDRS have carried out quite a lot of on-farm water development works during the last three decades; sub-surface drainage and reclamation of saline and alkaline soils in 300 000 ha, open drains in 238 000 ha, land levelling in 513 000 ha and land consolidation works in 107 000 ha.

By the end of 1988, TIGEM had carried out some on-farm water development works in its farms; land levelling on 91 357 ha, drainage on 155 971 ha, land reclamation on 44 697 ha and irrigation on 220 120 ha (114 375 ha by surface irrigation method and 105 247 ha by sprinkler irrigation method). The Government has invested large resources in the development of irrigation. At present DSI is responsible for the operation of over 190 irrigation schemes covering an area of 1.47 million ha. The total DSI investment in DSI-operated irrigation schemes, including dams, is estimated at US $ 5.6 thousand million in 1991 prices.

A major problem in many irrigation schemes is the low irrigation ratio, i.e. the ratio between actual and potential irrigated land within a scheme. The national average for the irrigation ratio lies somewhere between 64% and 72%, with wide regional (88%-22%) and annual (59%-76%) fluctuations. The fact that winter wheat does not normally require irrigation is the major reason for low irrigation ratios. Reasons given for the lack of irrigation are: water shortage, enough rain, topographical conditions, shallow soils, high water table, uncultivated agricultural land, unirrigated pasture and system deficiencies.

In 1990, 25% of the schemes reported water shortages which were on average over 50% of requirements based on the farmers' cropping plans. Despite the water shortages reported, the average scheme irrigation efficiency is rather low: 41% in 1990. The main reasons are probably: the improper matching of supply and demand during the season; the reluctance of farmers to attend to irrigation at night; insufficient density of the system; lack of on-farm development works; low efficiency field irrigation methods (56% of the area is irrigated through wild flooding).

In Turkey about 95% of the total area is irrigated by surface irrigation methods (such as furrow, basin, border or flooding). The remaining 5% is mostly hand-move sprinklers and some micro-irrigation mainly in the Aegean and Mediterranean Regions.

In the last ten years, more sophisticated irrigation methods have been adopted to increase the irrigation efficiency. Drip or trickle irrigation and other micro-irrigation systems are becoming more popular especially in Western Turkey and Mediterranean regions, where the climate is suitable for vegetable and flower production in greenhouse and also for more valuable crops such as bananas, citrus, grapes. It is estimated that approximately 2000 ha of land is irrigated by micro-irrigation systems in these regions.

On the other hand, conventional (hand-move) sprinkler irrigation is very common all over Turkey among the farmers. According to the 1990 figures, the number of the sprinkler sets is 96 183 and it is estimated that about 200 000 ha of land is irrigated by sprinkler. Although there are very big single-sprinkler irrigated projects such as 9000 ha in Ceylanpinar and 1450 ha in Akcakale, most of the sprinkler irrigation sets belong to small farm holdings.

On the irrigation schemes operated by DSI, 51 568 ha are irrigated by sprinkler irrigation (especially sugarbeet, pulses, cereals, alfalfa, cotton, sunflower, melons and vegetables) and 210 ha by drip irrigation (especially vineyard, citrus, vegetables, strawberries, melons). The areas irrigated by sprinkler and drip irrigation method are shown in Table 2.

The greatest technical causes of decreasing production on many irrigated projects are waterlogging and salinization of soils. Waterlogging is not an inevitable result of irrigation.

It is due to excessive input of water into systems that have limited drainage capacity.

TABLE 2
Area irrigated by sprinkler and drip irrigation methods (DSI)

Year	Sprinkler irrigation (ha)	Drip irrigation (ha)
1985	41 450	-
1986	41 015	-
1987	45 133	-
1988	39 554	-
1989	53 734	-
1990	49 994	-
1991	51 658	210

Investigations indicate that the cultivated area constrained by poor drainage conditions is about 250 000 ha or 20% of total DSI-operated irrigation area. It was also reported that in heavy bottom soils, crop yield reduction was significant due to temporary waterlogging. A study conducted by FAO in collaboration with the Çukurova University in the Lower Seyhan Irrigation Project indicated that poor layout and inadequate lateral spacings of on-farm drainage system have resulted in the rise of water table. In an estimated 50% to 60% of the project area, the water table was found between 0 to 1 m below the surface.

In general, the quality of irrigation water, particularly from surface water sources, is found to be good. Very little information is available on the quality of groundwater used in agriculture, although potential quality problems exist when groundwater is abstracted excessively beyond safe yield limits, particularly in coastal areas. A good network of surface water quality monitoring stations exists in Turkey.

The Southeastern Anatolia Project (GAP)

The Southeastern Anatolia Project (GAP) is the largest and most comprehensive regional development project in Turkey, and one of the largest in the world. The project implementation area covers 8 provinces that correspond to 9.2% of the total surface area (7.4 million ha) of Turkey.

Currently, agriculture is the dominant economic sector, and the population is very dynamic in the region with a 3.87% annual rate of increase in spite of an outward movement from the region to the larger cities in the country.

The project area is rich in soil and water resources. Roughly 25% of surface and groundwater, irrigable lands and hydroelectric potential of the country are found in the region. In spite of these rich resources, today only 2% were developed for irrigation and 0.2% for hydroelectric energy production. The economy mainly depends on dry farming and extensive sheep husbandry. Major crops of the region are cereals, lentils and pistachio nuts. Annual rainfall is less than 300 mm in most of the great plains of the project. Moreover, in four months beginning from June to September there is practically no rain. Irrigation will enable diversification of production and second or third crop harvesting under favourable ecological conditions of GAP. If a high-yielding irrigated agricultural system can be materialized, anticipated production value increases will be around 10 to 20 times the current figures. With the full development of the project, cotton, rice, oil-seed and forage crop production of the entire country may double.

To utilize the potential of the region, plans have been made and 13 project groups have been established. These project groups, when completed, will include 22 dams, 19 hydropower plants and numerous irrigation schemes. A total area of 1.7 million hectares of land will have been opened to irrigation and a hydroelectric power capacity of approximately 7,500 MW will have been created with an average annual generation over 27 thousand million kilowatt-hours.

The GAP water resources development projects are in different phases of realization. The Karakaya Dam, with a generating capacity of 1,800 MW, has already been completed and in operation for several years, as well as a number of other dams and irrigation networks. The biggest structure in the project (the largest dam in Turkey and ninth in the world as to the embankment volume), the Atatürk Dam is nearly complete; the largest irrigation tunnel system in the world, the Ptanliurfa tunnels have reached a completion rate of 80% and many other water resources structures are under construction.

RESEARCH AND EDUCATION

In Turkey, GDRS which is responsible for on-farm research works has 11 Research Institutes. Tasks undertaken by these research institutes include the development of soil and water resources, producing optimum yield per unit area, searching for effective and economic solutions to the erosion problem, adopting the most modern farm mechanization, developing techniques for land preparation to provide the soil with optimum moisture-holding capacity in dry farming, and collecting data needed by engineering units in climate and soil conditions of the region. All these tasks are carried out by five sections specialized in their respective fields of research: hydrology and hydraulics; soil and water conservation; irrigation and drainage; agronomy economics and statistics; equipment and machinery. The research subjects of the sections related with irrigation and drainage can be summarized as:

- to collect engineering data in view of the capacity of both water storage and distribution structures,
- to define the hydrologic characteristics of farming areas and basins and to relate findngs to similar areas,
- to specify the sediment coming from farming areas and basins to storage structures and to determine the available storage capacities,
- to specify the rainfall-runoff relations in representative and experimental basins, to convey the findings to similar areas,
- to establish guidelines for soil and water conservation,
- to determine the water consumption, monthly and yearly, and irrigation periods and times of crops cultivated in central Anatolia region,
- to make the connection between actual water consumption of crops and empiric models clear by use of lysimeter,

- to establish irrigation guidelines for irrigation networks within the regional boundaries,
- to specify the most effective and economic crop pattern in pond or dam irrigation areas,
- to define fertilizer-water-yield relations in crops,
- to specify the criteria for designing the drainage projects,
- to conduct research on the amount of water for leaching the chemicals (fertilizer, gypsum material, sulphur) as required by the improvement of saline, alkaline and boron soils and, on the duration of soil improvement,
- to compare the efficiencies of drainage systems.

These institutes provide technical assistance to the other research institutes. Some experiment and demonstration stations have been organized within these institutions in order to realize the expected increase of benefit and income through the more rapid development of irrigation networks which have been constructed by the state at a high cost.

The Technology Division of the General Directorate of State Hydraulic Works (DSI), responsible for planning, design, construction and operation and maintenance of irrigation and drainage systems, organizes seminars in Ankara, or in the regions, for different levels of staff. It is proposed to establish a Central Training Department in DSI headquarters and subsidiary training facilities in different climatical zones and to develop a variety of training and refresher courses. The Department of Research and Quality Control of DSI carries out research on hydraulic models, soil mechanics, concrete material, chemistry, quality control etc.

The General Directorate of Agricultural Planning of the Ministry of Agriculture and Rural Affairs has assumed wide-ranging responsibilities for the preparation of rural agricultural development projects including the rehabilitation and reclamation of land and water resources with agricultural production potential. The General Directorate of Agricultural Research, of the same Ministry, has assumed overall responsibility for all agricultural research activities of 52 agricultural research institutes, 9 plant protection research institutes, 30 veterinary institutes and laboratories, 6 foodstuff and food processing and preservation research institutes.

The Universities, the Turkish Scientific and Technical Research Institute (TUBITAK), State Planning Organization and Food and Agricultural Organization of the United Nations (FAO) support the research and education activities on irrigation and drainage in Turkey.

The FAO programmes and projects in Turkey cover diversified areas to match the Government's regional and sectorial priorities and respond to the Government's wish for regional emphasis in attaining a more equitable distribution in agricultural development. FAO's resources, know-how and experience contribute to strengthen both national and international capabilities in exploiting Turkey's enormous agricultural potential.

FAO support to the Ministry of Agriculture and Rural Affairs and relating agricultural institutions is mainly implemented by resources development projects in specific sub-sectors.

Additional non-programmed quick action projects (TCP) are an indispensable tool in generating new activities with promising follow up. In execution of projects funded by international funding agencies, close cooperation is maintained with the United Nations Development Programme, the World Bank and the European Investment Bank. During 1989, 39 projects were FAO-executed in different regions of Turkey.

The National Action Programme of Turkey was formulated in accordance with two guiding principles of the International Action Programme for Water and Sustainable Agricultural Development (IAP-WASAD), namely;

- an integrated approach to development, management and water conservation research, to promote sustainable agricultural development, and

- a cohesive programme that would address major issues related to sustainability and strengthen the capacity of the national institutions.

The programme consists of 31 individual projects under 6 elements, namely; Water policies and strategies; water resources management; farm water management; water and the environment; watershed management; and fisheries.

Water resources management and use of wastewater: The Sultanate of Oman

WATER RESOURCES AND WATER CONSUMPTION

There are no perennial rivers in Oman reaching the sea, though the upper reaches of some wadis have surface flow all year round. These waters drain through the sand and gravel to feed the groundwater aquifers, so considerable underground reservoirs can be found in many parts of the country. The best known of these are at the Batinah plain north of the Oman mountains, and in the Salalah plains in the south. Springs are found in the northern Oman mountains as well as in the Dhofar mountains in the south, while groundwater has traditionally been collected through developed Falajs systems (infiltration galleries) and drilled boreholes.

The average rainfall in the Sultanate is just over 100 mm per year. In most of the country rain comes from infrequent storms, and the annual average varies widely from year to year. In the Muscat region, on the north coast, for example, wet years are followed by several years with very little or no rainfall at all.

Records show a 7-year drought from 1918 to 1925, and another 8-year period during the 1950s. The most recent was from 1983 to 1986. Out of the 12 900 MCM (million m^3) of the average rainfall per year in Oman, only about 800 MCM (6%) become runoff, and roughly 650 MCM (5%) is added to the groundwater resources.

Current consumption of groundwater resources, for all uses, is over 950 MCM per year, 46% more than the 650 MCM per year that is replenished by rainfall. The difference between water use and recharge is drawn from storage in underground aquifers, causing significant depression in water levels and the consequent intrusion of sea water.

Most of today's 75 MCM/year domestic water demand is provided by expensive desalination plants. This figure is expected to rise to 150 MCM/year by the year 2004. In order to eliminate the prospect of supporting even a small part of the country's agriculture through unaffordable sea water desalination, the Ministry of Water Resources is effectively

CASE STUDY 5

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implementing an action plan to reduce water consumption, and to improve the economic and social benefits from all sources of water available in the country, including low quality waters.

Priority actions being implemented by the Ministry of Water Resources to provide a sustainable water resources management in the country are:

- **Increase public awareness on the need to reduce water consumption**: The Ministry is implementing an information centre to promote and encourage the adoption of appropriate management procedures.
- **Improve agricultural efficiency**
- **Change agricultural patterns from perennial to winter-only crops**
- **Change of agricultural land use to optimize water resources**: The Nedj Region, north of the Salalah Plain, for example, would produce fodder crops for export and the Salalah Plain could use its better quality water to grow more sensitive crops.
- **Development of unused water resources**: Under the hydrogeological survey programme being carried out, there is a major investigation of the wadi Dayqah to verify where two thirds of all the wadis flow when they disappear between Massara and Hayl al Gulf (about 50 km), south of Muscat; the main question to be answered is whether this flow can be recovered, and if so how that would affect salt intrusion in the region.

  The probability of utilizing brackish waters for the irrigation of tolerant crops is also being investigated in the desert areas. The wadi Dank (in the north western region of Amman) and the wadis Adam and Halfan (in the north central part of the country) are potential sources of brackish water, particularly during the wet periods.
- **Artificial recharge of aquifers**: It is expected that the planned recharge dams will enhance the natural supply with as much as 20 MCM annually.
- **Use of treated wastewater**: It is planned to extend the sewerage system in Muscat and many other medium size cities in order to increase the volume of available wastewater. Treated effluent will be utilized for the recharge of aquifers, creation of underground barriers along the coast, and for the irrigation of green areas and crops.

VOLUMES OF RECLAIMED WATER IN OMAN - PRESENT AND FUTURE

Currently, the installed wastewater treatment capacity in the Sultanate is about 27 MCM/year. The Darsait plant, one of the largest in Muscat, treats about 4.2 MCM/year (11 500 m^3/day) collected by a sewerage system covering about 460 hectares in Ruwi and surrounding areas of Muscat. The Al Ansab plant, also in Muscat, presently treats about 1.8 MCM/year (5000 m^3/day only, while its design capacity is about 12 000 m^3/day) of tankered septage/sewage collected in holding tanks from areas not served with sewerage system.

Assuming that on average, the country's treatment plants operate at about 80% of their capacity, there is 22 MCM/year of effluent produced in Oman with roughly 8 MCM/year being used for the irrigation of landscapes, the remainder being discharged to wadis or into the sea. A major treatment plant is planned to start operation in 1995 in the region of Salalah (in the south, about 100 km from the border with Yemen). This plant will treat about 5.0 MCM/year during its first phase of operation. As part of the national programme to increase water resources, most of the medium and large cities will be provided with sewerage systems and wastewater treatment plants.

The beneficial use of reclaimed water will certainly become one of the key options for the overall management of Oman's water resources. The highly populated coastal areas of the country will provide sufficient volumes of reclaimed water to be utilized for irrigation and for protective recharge of groundwater. Other cities in the interior, such as Nizwa, will also be provided with wastewater collection and treatment systems, and will be able to use most of their effluent for irrigation and for the recharge of wadi aquifers.

THE USE OF WASTEWATER IN OMAN - NATIONAL STANDARDS FOR REUSE

Currently, only ornamental trees, shrubs and public lawns alongside roads and main streets of the large cities are irrigated with treated wastewater in the Sultanate. Wastewater is applied through drip, subsurface irrigation showing only emitters and bubblers above the ground surface. In the city of Muscat, most of the effluents from the treatment plants of Darsait, Al Ansab, Jibroo and Shati Al Qbum (about 17 350 m^3/day or 6.3 MCM/year) are utilized for landscape irrigation.

Some of the 55 000 hectares which presently rely on the wadis and on groundwater for irrigation will be using treated wastewater in the future. It has been planned that wastewater irrigation of alfalfa can be done through surface irrigation, and date palms by drip irrigation. Some consideration has also been given to irrigate vegetables growing above the ground by subsurface irrigation. However, social, ethical and religious concerns have to be overcome before irrigation of edible crops with treated wastewater can be fully implemented in Oman.

As far as groundwater recharge with wastewater is concerned, there is no doubt that aquifers have for a long time been recharged from sources such as septic tank effluents from urban areas, and latrines and soak pits from rural settlements. Since this is an unplanned, unconscious process, the volumes involved are not known. On one hand, they may significantly contribute to aquifer recharge, but on the other, they represent a potential source of groundwater pollution by micro-organisms and by inorganic contaminants such as nitrates.

The Royal Decree 10/82 and its amendment on the conservation of the Environment and Prevention of Pollution, promulgated in 1982, and the Ministerial Decision 5/86 "Regulations for Wastewater Reuse and Discharge" (Ministry of Environment and Water Resources, 17 May 1986) establish the conditions and restrictions for the discharge and use of wastewater in the Sultanate of Oman. Article 6 refers to reuse for irrigation, groundwater recharge and industrial processes, while Article 7 deals with discharge of treated effluents to open lands, wadis or other water courses. Only discharge to sea is not included in Article 6, since it is dealt with by the regulations concerning the disposal of Liquid Effluents to the Marine Environment issued by the Council Decision 7/84. Article 5 specifies that all wastewater effluents to be discharged into the environment or used for irrigation or recharge of aquifer should attain the quality shown in Table 1.

The standards established in the country are very restrictive and can be achieved only through advanced treatment systems including activated sludge, filtration and disinfection. The standards are commonly referred to as 10:10:1 standards (10 mg/l BOD; 10 mg/l Total Suspended Solids and 1 mg/l Ammonia Nitrogen, as N). The microbiological limits are also very restrictive: not more than 2.2 total coliforms/100 ml and no eggs or cysts are allowed in the effluent for reuse.

TABLE 1
Table of parameters for reuse and discharge of wastewater

All units are mg/l unless otherwise stated		
Parameter	Limits (not greater than)	
	Maximum	Monthly average over any four consecutive weeks
PHYSCIAL		
Total Dissolved Solids	1500	1000
Total Suspended Solids	15	10
Turbidity (N.T.U.)	5	2
CHEMICAL		
Aluminium	5	1
Ammoniacal Nitrogen (as N)	5	1
Arsenic	0.2	0.05
Barium	2	1
Beryllium	0.3	0.1
Biochemical Oxygen Demand (5 days)	15	10
Boron	2	1
Cadmium	0.03	0.01
Chemical Oxygen Demand	100	50
Chloride	350	250
Chlorine, Free Residual (After 60 min contact time)	0.5 (min)	0.5 (min)
Chromium	0.5	0.1
Cobalt	0.5	0.1
Copper	0.3	0.2
Cyanide	0.1	0.05
Dissolved Oxygen	2.0 (min)	2.0 (min)
Fluoride	2	1
Iron	5	1
Lead	0.5	0.1
Lithium	10	2.5
Magnesium	150	30
Manganese	1	0.2
Mercury	0.005	0.001
Molybdenum	0.05	0.01
Nickel	0.5	0.2
Oil and Grease	5	2
pH (pH units)	6-9	6-9
Phenols	1	0.1
Phosphorus (total as P)	30	20
Selenium	0.05	0.02
Sodium	200	70
Sulphate	400	200
Sulphide	0.1	0.05
Organic Nitrogen (Kjeldahl)	10	5
Total Nitrogen	50	30
Total Organic Carbon	50	20
Vanadium	1	0.1
Zinc	5	2
BACTERIOLOGICAL		
Total Coliforms (MPN/100 ml)	23 (Not to be exceeded in any sample)	2.2 (Determined over last 7 days of completed analyses)
Viable Pathogenic Ova and Cysts	None detectable	None detectable

THE SITUATION IN THE BATINAH AND DHOFAR REGIONS

Developmental programmes associated with the use of wastewater vary from one region to another in Oman. This is due to the wide variation of available local resources, water demand and the level of sea water intrusion in the groundwater.

Two of the most developed and populated regions of the country — the Batinah plains including the capital Muscat, and the Dhofar region — have plans to use wastewater for protection against sea water intrusion along the coast, and for irrigation.

The Batinah and Muscat Regions

These two adjacent regions are located in the northern upper part of the country, in a coastal area of more than 300 km, facing the Gulf of Oman. Muscat, the largest city in the Sultanate and the neighbouring cities of Mutrah, the new developments in Ruwi and its neighbourhood represent the largest population concentration in the country. Along the coast, there are many other population centres such as Seeb, Barka, Suwaya, Khabura and Sohar, which is a very rapidly developing coastal town about 230 km west of Muscat.

The excessive pumping of groundwater has slowly depleted water storage in the Batinah and water levels are so low that sea water is causing an overwhelming increase of groundwater salinity. The Ministry of Water Resources estimates that at current water use, all the existing agriculture seaward of the Batinah highway will be completely lost due to groundwater salination. Valuable soils of the coastal zone as well as the existing agricultural infrastructure will be abandoned and high costs would be incurred for the development of new farms and irrigation systems.

The rapid dewatering of the Batinah aquifer will force farming further away from the coastal plain where aquifers have much less storage, and are consequently more vulnerable to droughts. It is estimated that to restore the water balance and to stabilize the sea water intrusion in the region, water consumption would have to be reduced by 250 MCM/year. At an irrigation rate of 2 m/year, this volume is equivalent to the water needed to irrigate about 12 500 hectares, which represents about one quarter of the cultivated area in the country. Calculations made for the Batinah and Muscat regions have shown that by the year 2010, there will be a deficit of nearly 400 MCM/year.

In order to improve sanitary conditions and to increase the volumes of wastewater to be used for groundwater recharge and irrigation, feasibility studies were carried out to extend the sewerage coverage for the whole city of Muscat whose present population is estimated at about 350 000. For planning purposes the city was divided in four sectors. The capital cost for providing sewerage and treatment systems according to the 10:10:1 national standard for reuse is estimated at about 243 million RO (Oman Rials), equivalent to approximately US$ 750 million.

The Salalah Plain, Dhofar Region

The Salalah Plain is a small stretch of land in the Dhofar region, located on the coast between the Arabian Sea and the Jabal al Qara mountains. It is the most important economic area of Dhofar and one of the most stressed in terms of water resources management.

TABLE 2
Increase in agricultural areas - Salalah Plain from 1982 to 1991

Agricultural enterprise	Cultivated area (ha)		
	1982	1991	% increase
Small farms	943	1277	35.4
Garsiz farms	280	324	15.7
Sahalnawt farm	150	242	61.3
Bazat farm	360	286	-20.5
Palaces	43	79	83.7
Ministry of Agriculture & Fisheries	54	240	344.4
Total	1830	2448	33.8

Salalah is the largest city in the region with an estimated population of 77 000. It is expected that the population will reach about 180 000 by the year 2000, and 200 000 by the year 2010. In central Salalah, a fully developed area, there is a long strip of agricultural land along the coast, one to two kilometres wide and from half to one kilometre from the sea. This strip contains many small farms that comprise the traditional agricultural base of the area. All communities of the Salalah Plain are currently dependent on groundwater for their water supply. Continued pumping is causing a rapid shrinking of the freshwater zone, allowing the intrusion of sea water and adjacent brackish water. This continuously increasing salinity is threatening the possibility of growing salt-sensitive crops including bananas and many vegetables.

Present groundwater quality varies from less than 800 microsiemens/cm in the freshwater zone to over 16 000 microsiemens/cm in the west, around Raysut. The total water use in the central Salalah Plain is today about 50 MCM per year, and it is estimated that each year about 5 MCM of water is being pumped in excess of the annual recharge.

The reserve of fresh groundwater in the plain is about 340 MCM, but the tendency is towards increasing deficits in the water balance due to the significant rise in both potable and agricultural water demand. Table 2 shows how the agricultural area in the region has expanded from 1982 to 1991.

THE WASTEWATER MASTER PLAN FOR THE SALALAH PLAIN

Salalah has no public sewerage system. Apart from 16 government installations that are served by package treatment plants, wastewater from residences, commercial and industrial premises is discharged to concrete-block open-bottomed soaking plants, or in the Saada area, to holding tanks. A very small number of premises are served by septic tanks, followed by separate soakage pits.

The groundwater aquifer outside the densely populated central area has shown no contamination from residential or commercial premises, although a few dug wells have shown evidence of direct contamination by surface runoff. However, bacterial contamination analysis has revealed sewage contamination of the groundwater in the city centre near the central agricultural zone, in an area where the groundwater table is close to the surface. This groundwater is largely used in the central agricultural area for irrigation and, although not with official approval, for domestic consumption as well.

In order to avoid pollution of the groundwater and to contribute more substantially to aquifer replenishment, the wastewater master plan has established two separate collection/ treatment systems to receive the industrial, domestic and commercial wastewaters.

Industrial and trucked wastewaters will be taken to the wadi Qaftawt lagoon treatment system. The central wastewater systems will collect domestic and commercial wastewater and carry it to the wadi Daha treatment plant. This plant will treat about 13.3 million litres per day (about 4.9 MCM/year) at its initial phase in 1995. Two other units of the same capacity will be added in 2007 and 2020. The treatment system will include activated sludge (with anaerobic and aerobic reactors to provide nitrification-denitrification), filtration, and chlorine disinfection in order that the effluent quality is under the 10:10:1 national standard for reuse. The projected volumes of wastewater which will be available for reclamation are indicated in Table 3.

TABLE 3
Expected flows of wastewater available for reclamation - Salalah Plain

Year	Wastewater flows	
	million litres/day	million m^3/year
2000	18.6	6.8
2005	22.8	8.3
2010	34.7	12.7
2020	42.6	15.5

The treated effluent is to be used for the recharge of the freshwater aquifer and also for part of the brackish water aquifer in areas of substantial withdrawal for irrigation of high value crops in the central agricultural area.

Recharge by well injection was preferred to direct surface spreading, for the following reasons:

- Minimal interference with other land use.
- The opportunity to recharge and improve the brackish water aquifer in central Salalah, where infiltration areas are not available, as well as supplementing the freshwater aquifer.
- Better control of distribution and application rates.
- Avoidance of problems such as algal blooms, mosquito breeding and water loss through evaporation.
- Lower cost and simpler maintenance. Costs to construct and operate the aquifer recharge injection system have been estimated at 64 Baiza (about 0.2 US$) per cubic metre. Water desalination, which would be the alternative to recharge, including operating costs and recovery of capital costs would be about 660 Baiza (2.0 US$) per cubic metre.

However, subsurface investigations are needed to confirm the feasibility of injection recharge and disposal. If these do not clearly support injection methods, studies will be conducted to enable the establishment of suitable final design criteria for infiltration/ percolation disposal.

An effluent disposal system will be provided as a back-up to the aquifer recharge system in case there may be periods when reclaimed water cannot be accepted for recharge. The intended disposal method is also by well injection, in this case into another unusable aquifer. Although the disposal system is not expected to operate continuously, and is seldom expected to carry the full flow of effluent, it will be designed for the possibility of carrying the full flow, at least for a limited period.

SOME CONSIDERATIONS ON OMAN'S REUSE SYSTEM

It is very fortunate that the Sultanate of Oman has found the means of compensating water shortages through adequate management of all its available water resources. The use of treated wastewater for recharge of aquifers in a safe and controlled manner will certainly provide the country with the needed volumes to cover water demand and will avoid indefinitely the need to resort to seawater desalination, particularly for irrigation purposes.

Even for the Sultanate of Oman, the allocation of resources needed to provide adequate water supply and sanitation to the whole country is an almost herculean task. To extend the wastewater collection and treatment to the whole of the capital city alone, the estimated resources are in the order of 250 million US dollars.

The magnitude of the problem and the high costs involved, particularly in relation to wastewater reclamation and aquifer recharge by well injection, deserves further consideration. As in most of the Middle-East countries, Oman has adopted very restrictive standards for reuse. The 10:10:1 national standard (see Table 1), inspired by the State of California standards for reuse, requires advanced wastewater treatment which includes biological treatment, filtration and disinfection.

Presently, only landscaping irrigation is done in the Sultanate. Since the treated wastewater is applied through sub-surface methods in areas with no direct public contact, there is practically no group at risk. Even so, the wastewater used for this purpose is fully treated to the levels established by the 10:10:1 standard.

The National Seminar on Wastewater Reuse held in Muscat in April 1992 gave consideration to the high costs involved in wastewater treatment, and recommended that "the Review Committee set by the Ministry of Regional Municipalities and Environment, examine the current regulations (for reuse) with particular regard to the WHO report and recommendations relating to public health protection and environmental preservation".

In the case of Oman where wastewater is being utilized for groundwater recharge (and subsequently for irrigation), the expensive above-ground treatment followed by well injection should be considered against alternative soil-aquifer treatment (SAT) systems. Under favourable hydrogeological conditions these latter systems can significantly reduce all biodegradable organic, suspended solids, bacteria, viruses and also the concentrations of phosphorus, nitrogen and heavy metals.

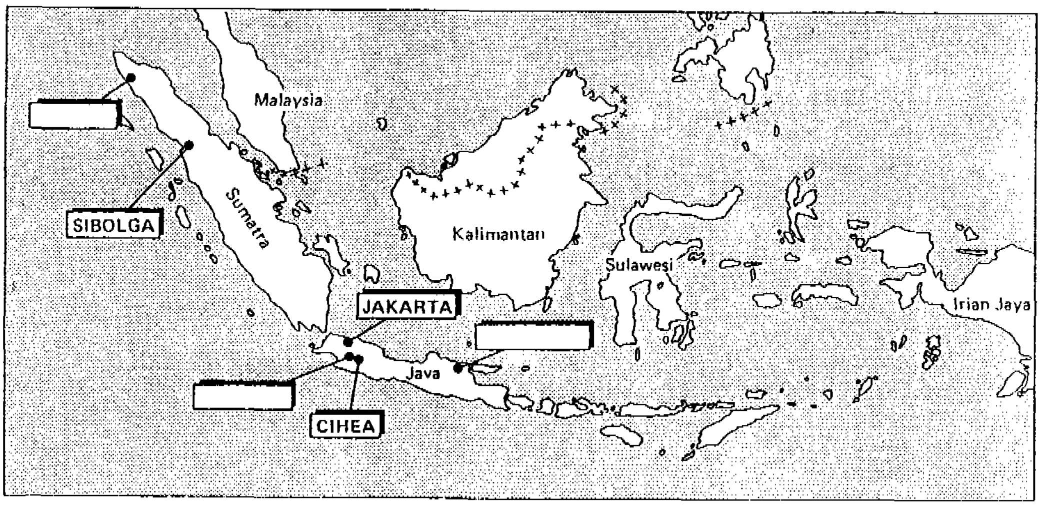
The cost of SAT systems operating all over the world has been shown to be from 30% to 40% of the cost of equivalent above-ground treatment. The additional advantage is that the system will eliminate the direct recharging of aquifers by injection wells, which are expensive and difficult to operate.

Environmental management for disease vector control in rural water resources development projects: four case studies

As one of its activities as a Collaborating Centre of the WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control (PEEM), ILRI collected and reviewed literature on malaria control under the colonial administration of the Dutch East Indies — now Indonesia — prior to 1940, with special emphasis on measures related to land and water development. For this paper, three case studies from Indonesia have been selected (Figure 1). The Indonesian examples demonstrate the benefits of integrated rural development, both in terms of improved agricultural productivity and effective control of vector-borne diseases. They also show that building up knowledge and experience of environmental management for vector control leads to better cost-effectiveness.

A Pilot Study initiated in 1984 on the Mushandike Irrigation Project in Zimbabwe provides a recent example of disease vector control in rural water resources development

FIGURE 1
Location of Indonesian case studies



CASE STUDY 6
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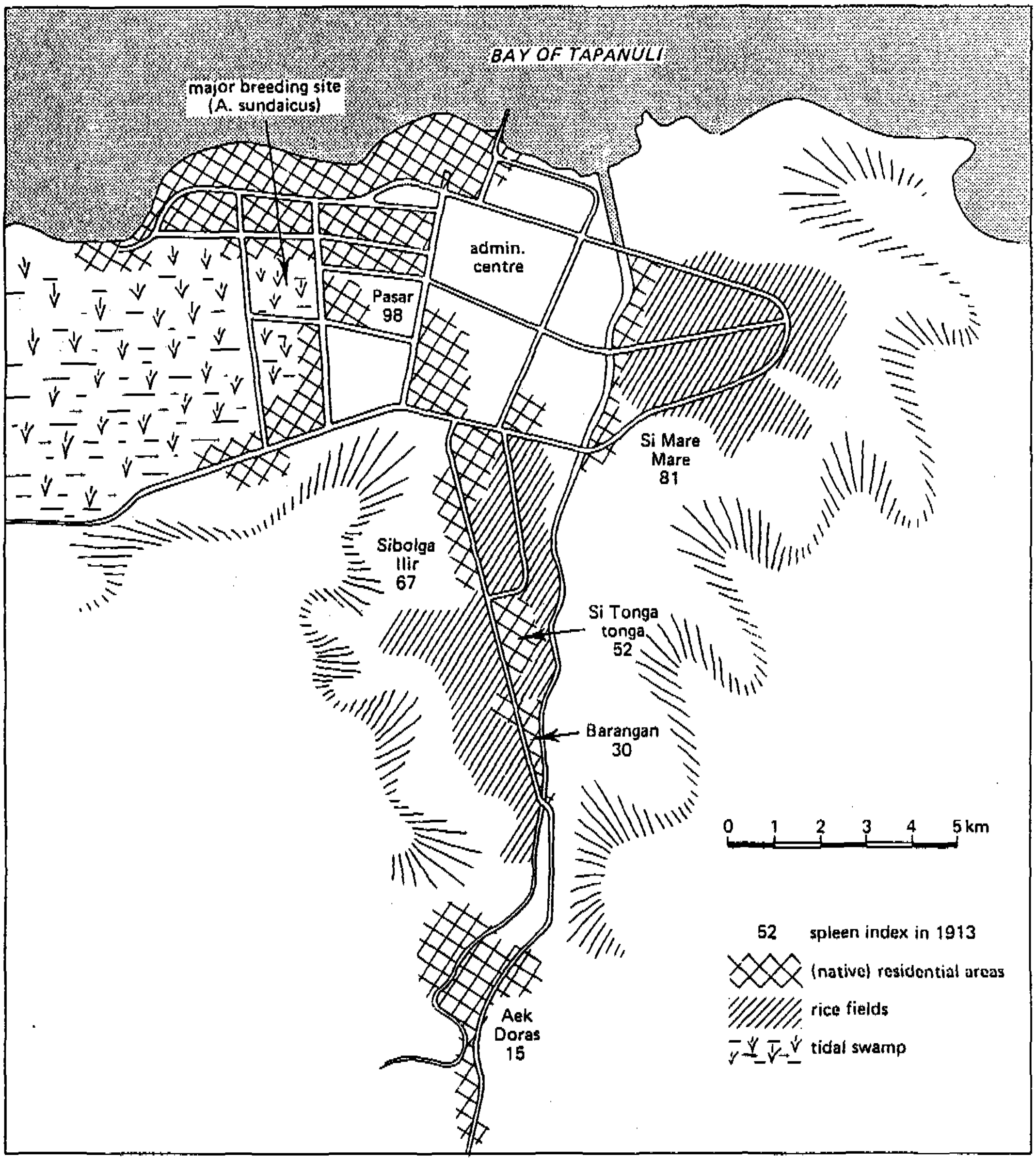
FIGURE 2
Map of Sibolga and spleen indices for each residential area



projects through environmental management. This study was a joint effort of the Blair Research Laboratory and the Department of Agricultural, Technical and Extension Services in Zimbabwe and the Overseas Development Unit of Hydraulics Research, Wallingford, UK.

SIBOLGA: A COSTLY SANITATION

The first case study describes one of the earliest examples of sanitation for malaria control in Indonesia. It was implemented from 1913 to 1919 in Sibolga, an administrative and trade centre on the West coast of Sumatra.

Sibolga is situated on the Bay of Tapanuli (Figure 2), which more than any other bay on the West coast of Sumatra offers safe anchorage. In the first decade of this century, considerable investments were made in the construction of roads connecting Sibolga with the interior. In the period 1903 to 1911, the total value of imports and exports traded through Sibolga more than doubled. In 1906, Sibolga also became the administrative centre of the regency of Tapanuli. The population in 1913 was about 4500.

Malaria investigations

In 1912, the chief administrator of Tapanuli asked the central government for financial assistance for filling the tidal swamp on the south of Sibolga, in order to improve the health situation. In response to the request, malaria investigations were carried out in 1913.

Mortality figures were available for the "down-town area" near the market place (Pasar Sibolga) for the year 1912 and the first two months of 1913 only. Average yearly mortality for 1912 was 80 per thousand.

TABLE 1
Results of spleen investigations in Sibolga in 1913

Name of area	No. of children examined	No. of enlarged spleens	Spleen index %
Pasar Sibolga	218	214	98
Si Mare-Mar	42	34	81
Sibolga Ilir	66	44	67
Si Tonga-Tonga	60	31	52
Baranga	122	37	30
Aek Doras	100	15	15

The results of spleen investigations among children under 12 in each of the native residential areas are given in Table 1. The locations of these areas — and also the spleen index for each area — are indicated in Figure 2. The spleen index is the number of persons with an enlarged spleen out of every 100 persons examined. Malaria causes enlargement of the spleen; the spleen index represents the percentage of the population that had malaria recently.

The investigations showed that malaria was most severe in the area near the market place, which is only just above sea level, and decreased as one moved away from the sea. In kampong Barangan — at some 2 km from the sea at an altitude of 20 to 30 m above sea level — only about one third of the children had enlarged spleens.

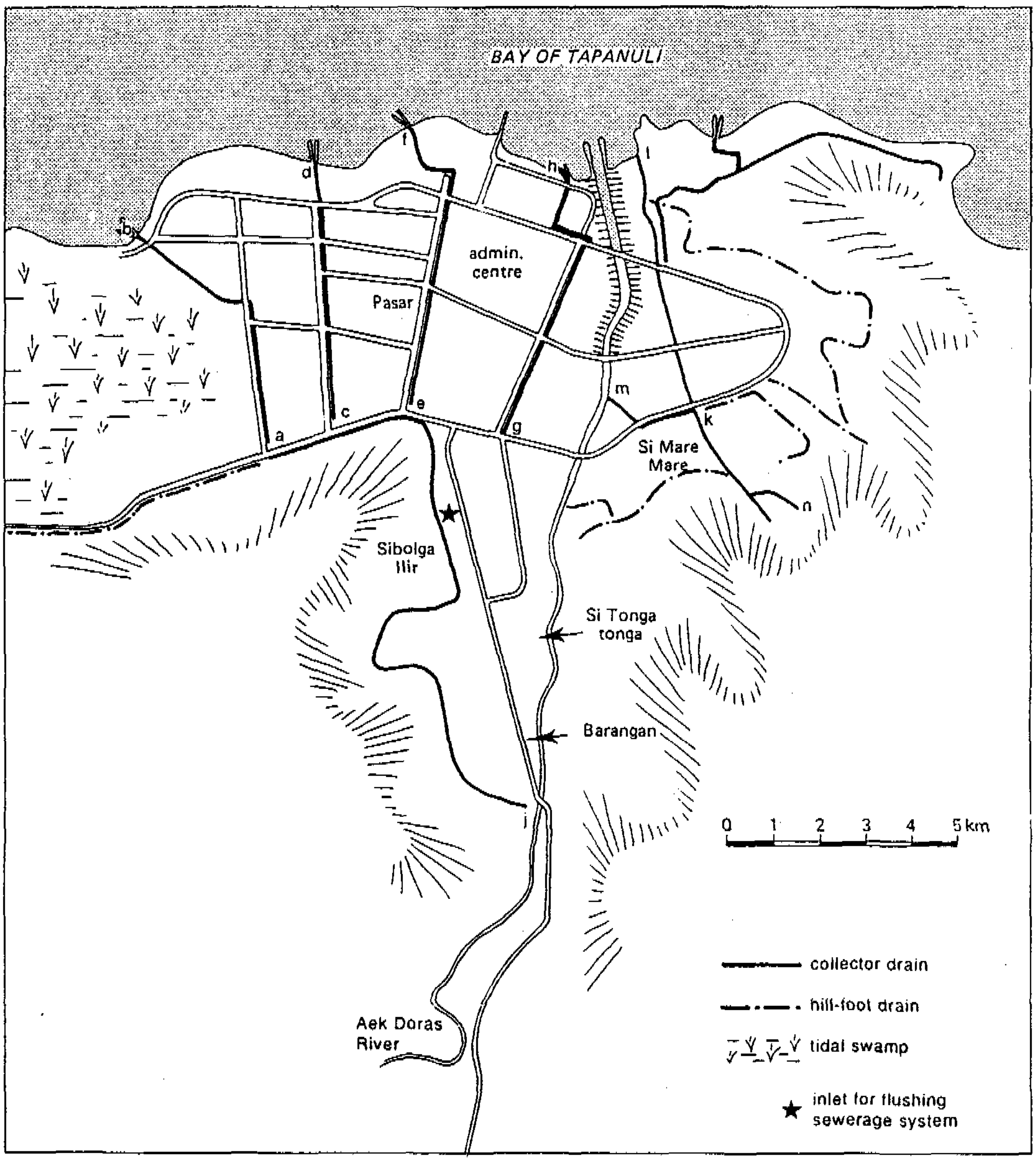
Breeding sites

Sibolga lies at the mouth of a small river and is surrounded by steep foothills (Figure 2). The river has created a narrow valley, that starts at a distance of some 2 km from the sea at an altitude of 20 to 30 m above sea level. At 600 m from the sea, the river valley passes into a coastal plain of some 900 m wide. The European residential area and administrative buildings were located on the river's left bank. The commercial centre and native housing quarter, Pasar Sibolga, was located between the administrative centre and a large tidal swamp.

Sanitation plan

De Vogel (1913) recommended elimination of all breeding sites through improved drainage. He did not specify how the drainage problems needed to be resolved, this being a matter for the Public Works Department. De Vogel made it quite clear, however, that he strongly

FIGURE 3
Layout of drainage system



objected to an earlier plan to fill the tidal swamp, put forward by a previous administrator who saw the swamp as the cause of malaria in Sibolga; he was backed by the Public Works Department, partly because the plan provided the additional land needed for the expansion of Sibolga's port facilities. According to De Vogel, filling the swamp was not required for health reasons. He recommended to plan the extension of the harbour on the other side of the river and to acquire the additional land by transforming the ricefields there into building sites.

TABLE 2
Breeding sites of Anopheline mosquitoes and elimination measures (based on Nieuwenhuis 1919)

Location	Breeding sites	Control measures
Tidal swamp	Depressions at edge of swamp, above the normal high-tide level. These are filled by seawater only at spring tide and after dilution with rainwater become pools with stagnant and brackish water	Edge of swamp filled above spring tide level; grading and levelling; construction of stone-lined embankment
Town (coastal part)	Stagnant rainwater in depressions due to poor drainage (high water table and low soil permeability)	Filling depressions and raising surface level to 0.15 m above spring tide level; surface grading 1:1000 towards drains; improve drainage system
Town (all parts)	Stagnant water in unlined drains Stagnant water in concrete-lined drains during periods with low rainfall	Replace open drains with closed or semi-closed drains. Provision of narrow central channel to take dry-period flow
Town (hillside parts)	Stagnant water in depressions, due to seepage from the hills	Install hill-foot drains
River	Stagnant brackish water in silted-up river mouth in periods with low discharge	River training and construction of piers

De Vogel's recommendations on this issue were not taken up. Part of the swamp was filled and the harbour authorities obtained their additional land where they wanted it — at the expense of the Health budget. In his report on the implementation of the sanitation works in Sibolga, Nieuwenhuis (1919) does admit that filling the swamp had not been really necessary, but he puts it in such a way as to suggest that this fact was discovered only after completion of the works, without mentioning De Vogel's early objections.

Description of sanitation works

Table 2 indicates the breeding sites of Anopheline mosquitoes and the measures that were taken to eliminate them.

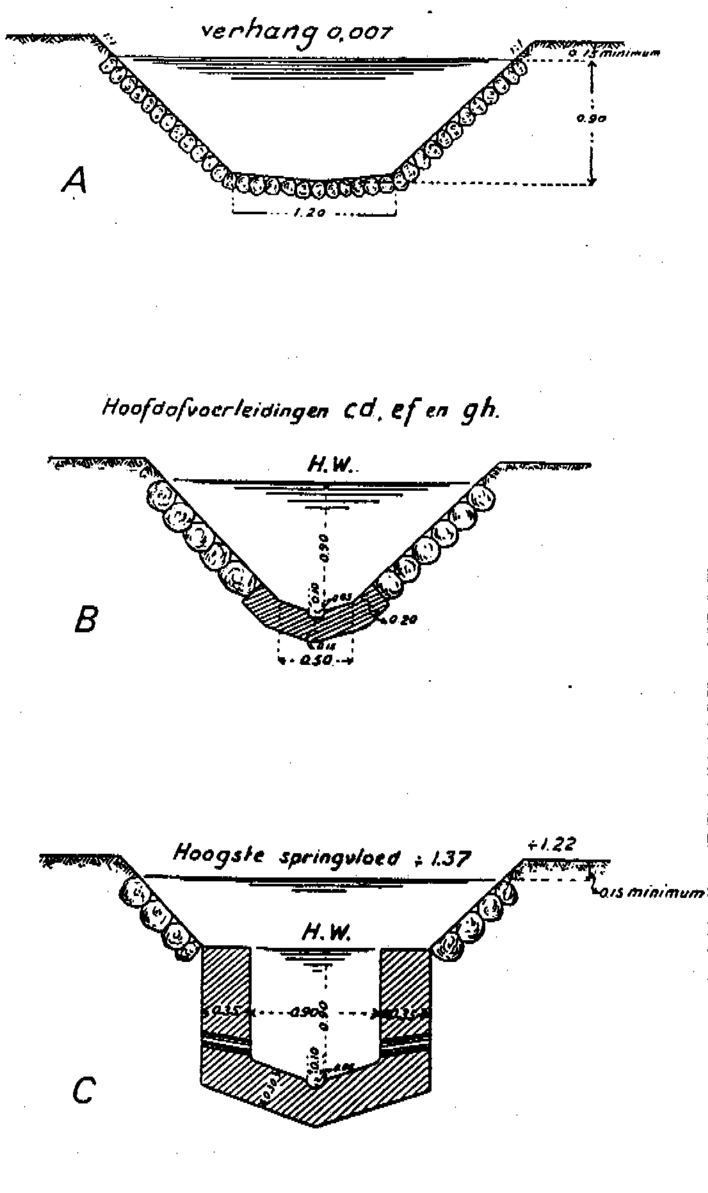
Drainage system

The drainage system aimed at removing all surface water within two days after a rainstorm. To achieve this, it was designed with a capacity of 10 $m^3/sec/km^2$ for the coastal zone, and 15 for the hill areas.

Nieuwenhuis did not describe in his report how he calculated these design capacities. Because the drained areas served by individual collector drains are all less than 1 km^2, the sizes of collector drains remain within the range of 1.0 to 5.5 m^3/sec.

The layout of the collector drains is indicated in Figure 3. Figure 4A presents the cross-section of collector drain j-a. In order to allow the canal to act as an interceptor drain as well, the sides of the canal are lined with rocks but without mortar. Figure 4B is a cross-section as applied in the first part of the drains c-d, e-f, and g-h. The bottom parts of these drains are plastered and provided with a narrow central channel. This should prevent stagnant pools during periods of low discharge. As in 4A, the sides of the canal are lined with rocks without mortar. Figure 4C gives the cross-section of the downstream part of the drains described under 4C. Due to lack of space, these sections were made with vertical walls. To allow water to enter from the sides, bamboo pipes with an internal diameter of about 0.15 m were placed through these walls at 1.0 m intervals. Seawater would move into the lower sections of the drains; the water level at spring-tide and at (normal) high-tide are indicated in Figure 4C. To avoid siltation of the drains, piers were constructed. The length of the piers was such that they reached to the point where the sea bottom was 0.50 m below the bottom of the drain. The piers for the drains c-d and e-f were 50 m long, because of the sewerage pipes which were laid under these drains.

FIGURE 4
Cross-sections of collector drains
A : drain j-a at a
B : upper part of drains c-d, e-f and g-h
C : lower part of drains c-d, e-f and g-h



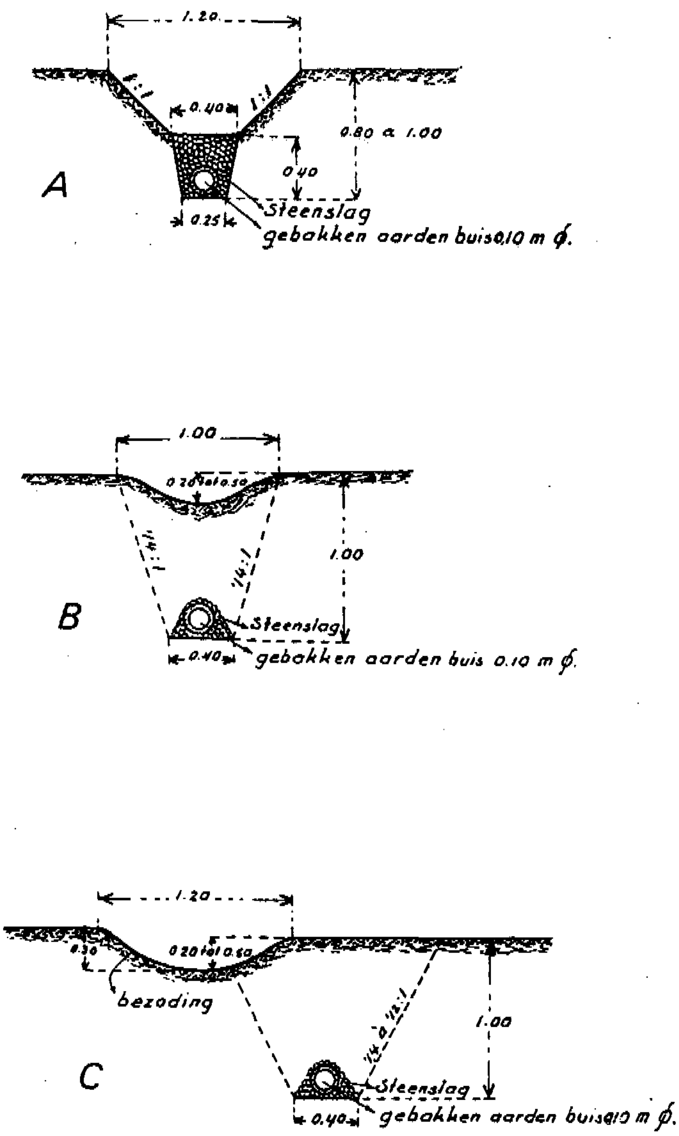
Interceptor drains

These are the small ditches that run along roads and sometimes between houses; they discharge into the collector drains. Because of impermeable soil, high groundwater table and limited available slope, the bottom of these drains remained wet for considerable periods. The Public Works Department spent considerable effort in producing locally baked clay pipes. These pipes were laid under the bottom of the interceptor drains. Figure 5 presents cross-sections of three alternative arrangements that were applied in Sibolga.

Hill-foot drains

Hill-foot drains were applied to intercept runoff and seepage from the steep foothills surrounding Sibolga. Their location is indicated in Figure 3. Figure 6 presents cross-sections of both the closed and open types. The diameter of the pipes was chosen in such a way that the permanent flow would fill up about one quarter of the pipes. If necessary, several pipes of 0.10 m or 0.15 m were laid in parallel. Nieuwenhuis indicated in his report of 1919 that in due course all of the open hill-foot drains would be replaced with those of the closed type, in order to prevent breeding of Anopheles in the hollows between the stone lining of the open type drains.

FIGURE 5
Three alternative arrangements for interceptor drains with underground clay pipes. *Steenslag* = gravel; *gebakken arden buis* = clay tile



Sewerage system

As part of the sanitation programme, a closed sewerage system was installed. The closed system was chosen in the first place to reduce diseases such as cholera, typhus and dysentery. Poorly maintained open sewerage systems, according to Nieuwenhuis, also represent a malaria risk through leakage and subsequent creation of stagnant water bodies. For lack of a pressured water supply system, the sewerage system had to be flushed with water from the river. The location of the inlet is indicated in Figure 3.

Costs and effects

Figure 7 presents annual and cumulative costs of the sanitation works, and their effect on mortality rate in Pasar Sibolga (Kuipers 1937).

FIGURE 6
Cross-section of hill-foot drains. A : closed hill-foot drain. B : open hill-foot drain
graszoden = turf; *berghelling* = mountain side; *gebakken aarden buis* = clay tile

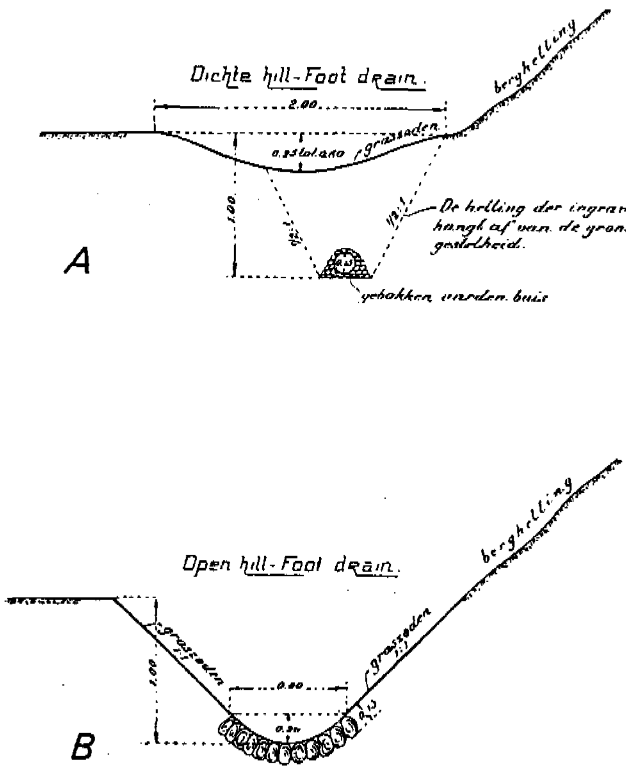


TABLE 3
Effects of sanitation works on spleen index

Name of area	Spleen index Apr-May 1913 (%)	Spleen index Dec 1917-Jan 1918 (%)
Pasar Sibolga	98	50
Sibolga Ilir	67	25
Barangan	30	10
Aek Doras	15	10

Table 3 gives the effects of the sanitation works on the spleen index for Pasar Sibolga and the three other native residential areas.

Table 4 gives the annual trade figures for Sibolga. The fact that the Administration was prepared to spend over one third of the annual export value on a sanitation programme illustrates the economic importance of malaria control in those days.

The total cost of the sanitation works of Dfl. 650 000 or Dfl. 144 per inhabitant were very high, considering e.g. that labour wages were about Dfl. 1.00 per day and the cost of rice about Dfl. 0.10 per kilogram.

FIGURE 7
Annual and cumulative cost of sanitation work in Sibolga and the effects on mortality rate in Pasar Sibolga (after Kuipers 1937)

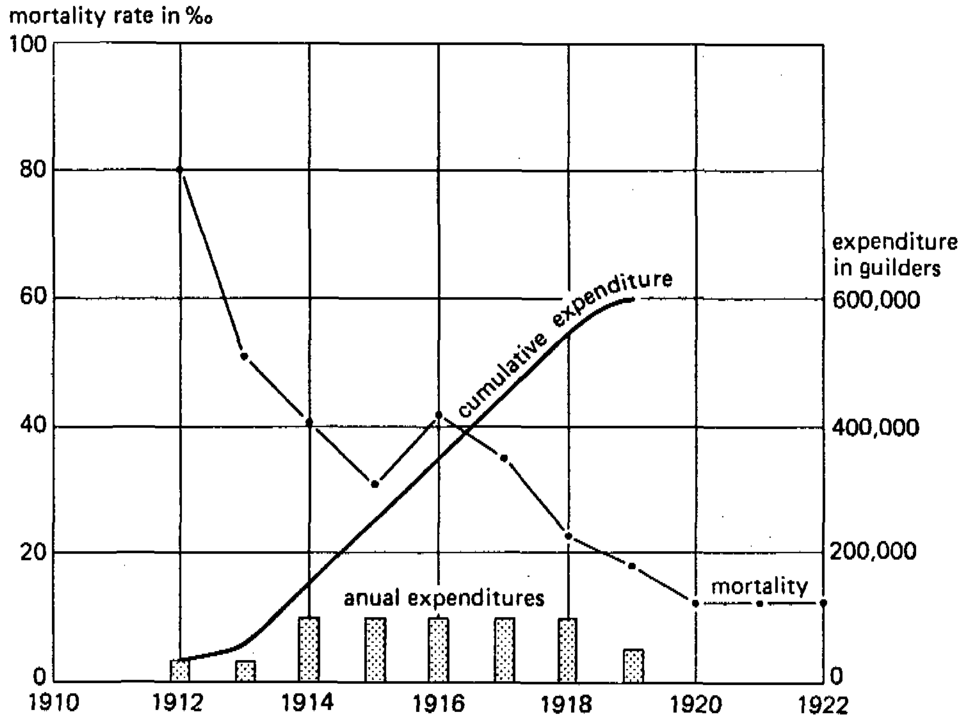
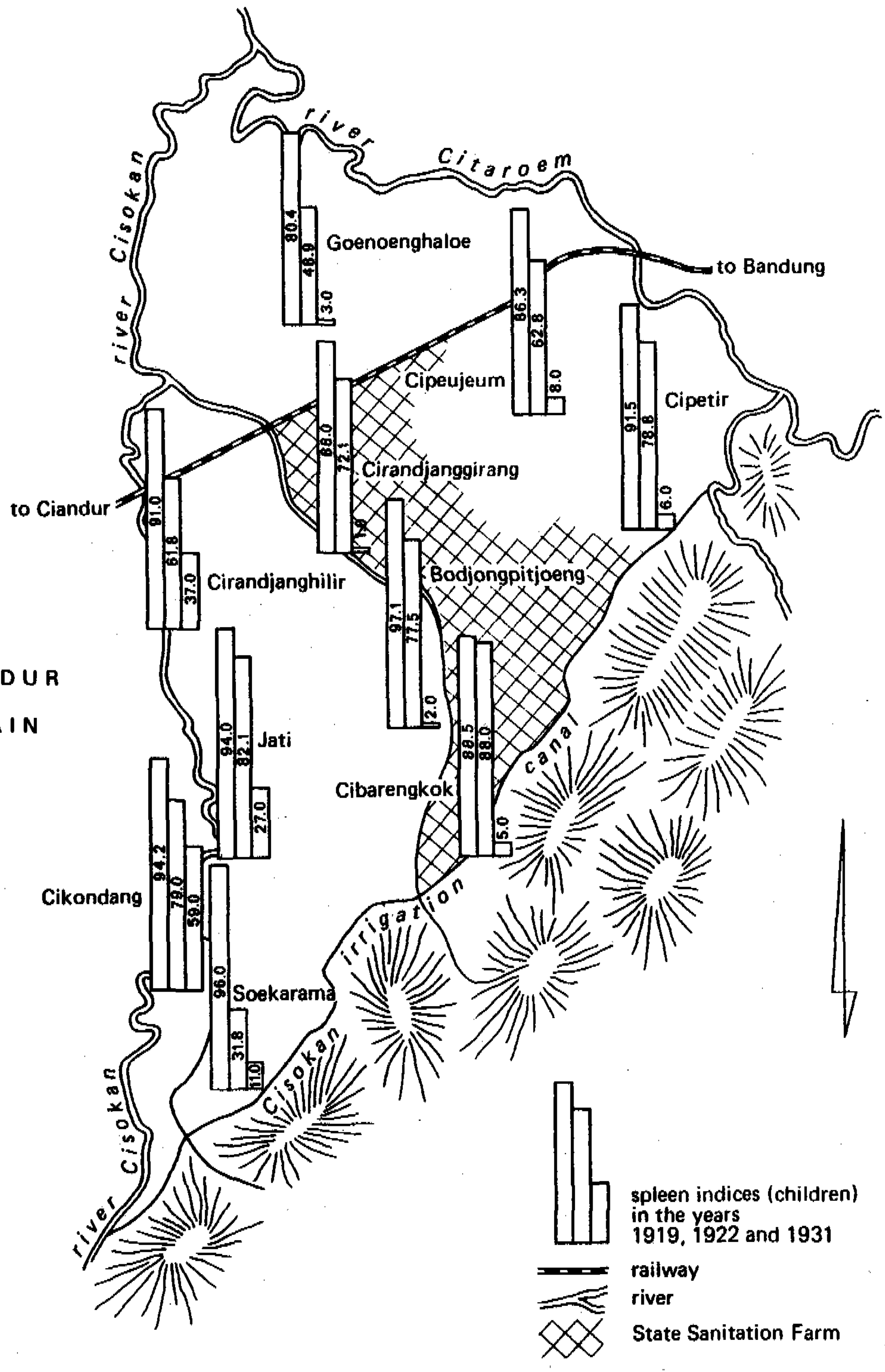


TABLE 4
Annual trade figures for Sibolga (in Dfl)

	1903	1911	1918
Value of imports	1 228 641	2 351 333	4 429 400
Value of exports	742 042	1 776 931	4 790 700
Total trade volume	1 970 683	4 128 264	9 220 100
Relative increase in trade volume (1903 = 100)	100	210	468

The main reason for the high cost of the sanitation works in Sibolga was that each and every water collection suspected of breeding Anopheles mosquitoes was dealt with. Later malaria control programmes were based on the principle of **species sanitation** which was discovered in Malaya by Dr Malcolm Watson. In 1911, Watson had discovered that not all Anopheles mosquitoes transmit malaria. He found that malaria had disappeared in areas where the forest had been cleared for rubber cultivation, in spite of an abundance of Anopheles mosquitoes. Clearing of the forest had destroyed the breeding sites of *Anopheles umbrosus*, which require shade, but had not affected the breeding sites of other Anopheles species. It appeared that malaria in this area was transmitted only by Anopheles umbrosus.

FIGURE 8
Map of the Cihea Plain and spleen indices for ten villages in the years 1919, 1922 and 1931



When Watson visited Indonesia in 1913 he met with Dr N.H. Swellengrebel, who immediately realized the importance of Watson's discovery: instead of having to eliminate all breeding sites, malaria could be controlled by concentrating only on the breeding sites of the local vector species.

The next two case studies provide examples of such species sanitations.

CIHEA: INTEGRATED RURAL DEVELOPMENT

The Cihea irrigation project took 40 years to build, from 1854 to 1894. After a short period of high productivity, yields went down and many fields remained uncultivated because the population was too ill with malaria to grow rice. It took a joint effort by the Irrigation and Medical Services, the Department of Agriculture and the local administration to emerge from the swamp that the Cihea irrigation project had become. After many difficulties, a regulation was introduced in 1919, that restricted planting dates and periods in which irrigation water was supplied. Once the farmers' reluctance to this '**plant and water regulation**' had been overcome, rice production increased and malaria was reduced to an acceptable level.

Irrigation Development

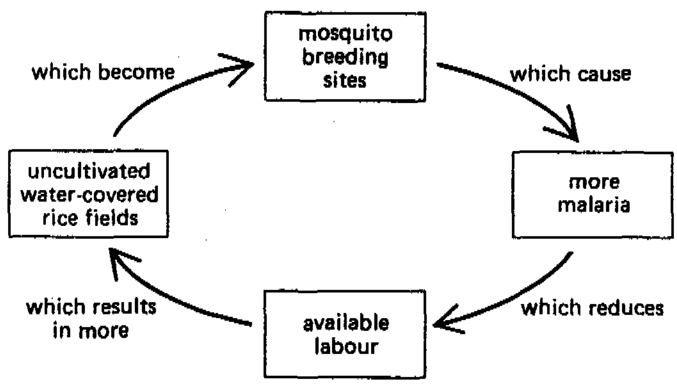
The relatively dry plain of Cihea is located West of Bandung, Java, about 300 metres above sealevel (Figures 1 and 8). In 1854, the Regent of Bandung conceived the plan of making a canal to divert water from the Cisokan river. Because of the deep and steep-walled river gorge, it took a long time to find a suitable diversion point. In spite of an input of 50 000 labour days, the population managed to construct only 1300 m in the period 1865-1868. They stopped working on the project altogether in 1874, when the Regent died.

In 1888, in an attempt to alleviate poverty in the area, the Governor proposed the project anew. In 1891, the Government allocated a sum of Dfl. 312 852 for the implementation of the works. The first and second section were completed in 1894, and people began to migrate into the plain. They could only obtain land, however, in the parts that had not been brought under irrigation, as speculators had already taken possession of the irrigable land. Then the works stagnated, because all the allocated funds had been used. Many of the immigrants left again, because they feared that the Government would not complete the works. In 1896 another Dfl. 143 050 was allocated, but the Government also counted on 69 900 days of statute (unpaid) labour to complete the works. To avoid having to work without pay, more people left the plain. Much of the land sold by the emigrants came into the hands of speculators again, who lived in the towns of Bandung and Cianjur.

In 1904 the irrigation works were completed, at a total cost of Dfl. 933 843 and 120 000 days of statute labour. The primary canal was 17.2 km long, with a capacity of 7 m^3/sec, the total length of the secondary canals was 35.4 km and that of the tertiary canals 267.4 km. No less than 255 structures were built, among those were four tunnels and several aqueducts. The total irrigable area was 5202 ha, which means that the cost of irrigation development amounted to Dfl. 180/ha (Koorenhof, Corts and Vroon 1933/34).

Malaria Investigations

FIGURE 9
Circulus vitiosus



In October 1911, the tea company Tiedeman & Van Kerchem, owners of a tea plantation east of the Cihea river, addressed a petition to the Governor General of the Dutch East Indies, requesting to have such measures taken as required to improve the health situation on their plantation, "also for the benefit of the local population". In response, the Chief Inspector of the Health Service for West Java, Dr. W.J. van Gorkom, visited the estate from 17-19 December 1911. He examined the native workers and their family members who lived on the estate and found a spleen index that was not exceptionally high: 37.5% for the factory workers and 42.5% for the estate labourers; he found no patients with excessively large spleens. The estate's administrator claimed that malaria was brought to the estate by temporary workers from the Cihea plain. From a survey in which he examined 635 people from 7 villages in December 1911 and another 4110 people in 12 villages in August 1912, van Gorkom found a spleen index well over 50% in most villages, and a high number of patients with excessively large spleens. The spleen index for children was much higher, with an average of 79%. Van Gorkom paints an overall gloomy picture of the Cihea plain: unhealthy looking people, high infant mortality, houses and villages in poor state of repair, weed-covered and ill-maintained irrigation ditches, fish ponds and rice fields. According to the local Civil Service, many fields remained uncultivated because of the lack of labour, which again was caused by malaria. Van Gorkom described this situation as a "circulus vitiosus" — the vicious circle indicated in Figure 9 (Gorkom 1913).

To break the cycle, van Gorkom recommended the local administration:

- to stop the irrigation supply to fields which are not cultivated;
- to improve the physical drainage system;
- to ascertain that fish ponds are kept clean;
- to promote the use of mosquito bed-nets and of quinine;
- to distribute quinine to the needy, at no cost whenever there is an upsurge of malaria.

To the tea company Tiedeman & Van Kerchem van Gorkom recommended:

- to employ temporary workers only after a medical examination;
- to introduce systematic quinine prophylaxis for their workers;
- to set up their own company medical service rather than relying on government measures.

Five years later, in 1917, van Gorkom's successor — van Lonkhuyzen — visited the Cihea plain, together with S.T. Darling, from the Rockefeller Institute. Their main interest was hookworm disease; yet they also looked at various Anopheline species; van Gorkom had only made a distinction between anophelines and other mosquitoes. Based on the high number of *An. aconitus* caught in native houses, and its reputation as a malaria vector in other countries, they arrived at the preliminary conclusion that *An. aconitus* was the main vector.

TABLE 5
Distribution of Anopheles species (after Mangkoewinoto 1923)

	No. of Anopheles caught in houses		No. of larvae found* 1919**	
	1917	1919	ditches	ricefields
An. aconitus	163	1155	3845	555
An. rossi	126	8	1	7
An. punctulatus	1	6	-	3
An. kochi	4	8	3	74
An. fulginosus	25	3	83	34
An. barbirostris	-	23	55	640
An. sinensis	26	44	71	467

* No. of larvae found by same no. of people in same time span.
** Mangkoewinoto mentions that larvae search in 1919 was done when many ricefields were already being drained.

Subsequently a government doctor, Mangkoewinoto, was sent to the plain for a more thorough investigation. Table 5 indicates the various species caught in houses. Only *An. aconitus* was found to be infected, which confirmed the earlier hypothesis of this species being the principal vector.

The preferred breeding site appeared to be the inundated, uncultivated and weed-covered ricefields. Ditches with luxurious grass hanging into the water also produced large quantities of *An. aconitus* larvae.

Mangkoewinoto found that the spleen index in the villages had increased con-siderably since 1912. The percentage of ricefields that remained uncultivated had also increased (Figure 10). According to Mangkoewinoto, very little had been done about the actions recommended by van Gorkom; in 1917 the plain still looked like one big swamp.

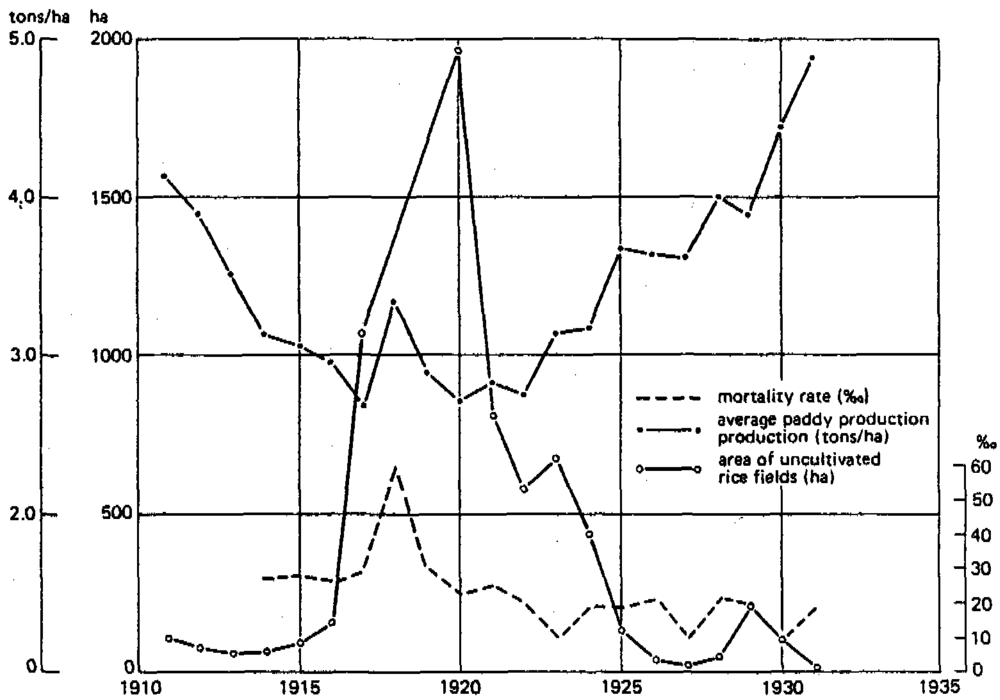
At that time, the local representative of the colonial administration was negotiating with the sugar company "Handels Vereeniging Amsterdam" (HVA), who had offered to bear the costs of a sanitation programme, provided they could plant sugar cane in the plain and build a factory.

In his report of 1917, Mangkoewinoto supported these proposals and said that large scale sugar cultivation was the best and most rational way to control malaria in the Cihea plain. In spite of strong support from the administration and the Health Service, the plan did not materialize. According to Mangkoewinoto because HVA only wanted the best plots of land; according to Koorenhof, Corts and Vroon (1933/34) because HVA after further study had concluded that sugar cultivation was not economically feasible because of adverse soil and climatic conditions.

On the basis of his findings Mangkoewinoto proposed the following measures to combat malaria in the Cihea plain:

1. Complete drainage of ricefields after harvest;
2. Simultaneous planting of ricefields;

FIGURE 10
Effects of the 'plant and water regulation' on the area of uncultivated ricefields, paddy production and mortality rate (per thousand)



3. Cleaning of irrigation and drainage ditches;
4. Distribution of quinine to the population whenever there is an upsurge of malaria.

Mangkoewinoto explains that measures 1, 2 and 3 had in fact already been put into effect by the Irrigation Service for reasons other than malaria control. Drainage of ricefields after harvest was considered necessary to reduce root rot, which was assumed to be caused by continuous submergence of the soil. Simultaneous planting and cleaning of farm ditches was required for a proper water distribution.

The local irrigation superintendent was reported to be quite taken with Mangkoewinoto's conclusion that not only the inundated ricefields represented a health risk, but also the poorly maintained farm ditches: this provided him with another good reason for persuading farmers to clean the ditches. The superintendent was facing great difficulties in introducing the water regulations; for fear of his own safety he did not go into the plain unarmed. In an attempt to achieve better cooperation from the farmers, Mangkoewinoto, together with the local administrator and the irrigation superintendent, organized a demonstration of his mosquito research for the village leaders and landowners. He showed them various anopheline species and their larvae, infected mosquito stomachs, blood slides etc. and explained to them the transmission mechanism of malaria and the importance of the proposed measures for the well-being of the region.

'Plant and Water Regulation' and the Irrigation Service

Mangkoewinoto's recommendations of 1919 were not much different from those of van Gorkom in 1912. Why had the Irrigation Service not acted upon van Gorkom's recommendations to improve drainage and stop the irrigation supply to uncultivated ricefields? The answer can be found in the annual reports on the Cihea irrigation project from the Department of Civil Works (1917-1922).

> Report 1917: "...this year a start was made with a preliminary water regulation, for which several discussions were held with the local administration and the population. The need for a plant and water regulation had been felt for a long time, but attempts at introduction were always opposed by the farmers, who could not be persuaded to put some regularity in their time of planting. Because of the low population density there are not sufficient labourers available for preparing all the fields in a short time. The result is that farmers in the area are planting throughout the year."
>
> Report 1918: "The introduction of the plant and water regulation met with great difficulties. The farmers, who are accustomed to planting when they please did not keep to the regulatory planting periods."
>
> "In view of problems with food supply, the local administration decided to start the irrigation supply to the first group in August rather than in November. Although there was an ample supply of irrigation water - about 3.5 l/sec/ha - land preparation was difficult because the soil had developed deep cracks through which a lot of water was lost. In addition, the farmers were reluctant to plant so early and did not start land and nursery preparation until the end of the year. The preliminary plant and water regulation must be considered a failure."
>
> Report 1919: "Based on the experience in 1918 it was decided to start the irrigation supply to the first group on 15 September and the second on 1 December. Although in places there was some opposition from the farmers, it appeared the regulation was more readily accepted. By December 70% of the fields had already been planted or were being prepared. This was the result of the efforts of the irrigation superintendent and the wholehearted support received from officials of the local administration."
>
> Report 1920: "On February 1, and every 2 weeks thereafter, the irrigation supply was reduced by 1/6 and finally stopped on April 15. After this date only so much water was supplied as to meet the requirements for drinking, bathing, washing and watering of non-rice crops. Fish cultivation was restricted, for health reasons. The same procedure was followed for the second group, with gradual reduction of the irrigation supply starting on April 1."
>
> ..."The Health Service made available an amount of Hfl. 4000 for the maintenance of tertiary irrigation and drainage ditches. With this amount a total of 62 km of

ditches was restored to design profile and regularly maintained afterwards. Due to this improvement, the favourable weather conditions, and the interruption of the irrigation supply, health conditions during the reporting year were favourable."

Report 1922: "...the planting of rice proceeded smoothly; it can be noted with satisfaction that the initial opposition against the 'plant and water regulation' by now has completely disappeared."

Results and conclusions

In the period from 1919 to 1932 the population increased from 13 223 to 24 493. Due to increased productivity the *per caput* rice production increased from 470 kg in 1917 to 660 kg in 1932 (Koorenhof *et al.* 1933/34). The increase in rice productivity is the result of higher yields and decreasing area of uncultivated rice fields (Figure 10).

Mortality rate in the Cihea plain decreased from about 30 per thousand around 1920 to below 20 per thousand in 1930. The spleen index for the whole of the plain decreased from 90.7% in 1919 to 15.9% in 1931. Figure 8 shows the spleen index for children in ten villages in the plain for the years 1919, 1922 and 1931. Although this reveals significantly decreasing spleen indices, in 1931 malaria still prevailed in the western part. This was attributed to the malarious areas in the Cianjur Plain, on the other side of the river Cisokan. There, no 'plant and water regulation' had been implemented because the indigenous irrigation systems did not provide sufficient water control.

On the basis of the results achieved in the Cihea plain it was decided to replace the village-type systems with a 'technical' irrigation system — with separate canals for irrigation and drainage — and to introduce a similar 'plant and water regulation'. The irrigation works for an area of 12 680 hectares started in 1937.

NORTHERN JAVA: MARINE FISHPONDS — A SOURCE OF INCOME AND MALARIA

Cultivation of fish in artificial ponds in the coastal zone has been practised for centuries in Northern Java. The earliest reference is a Javanese code of law from around 1400 AD, which specifies punishment for stealing from a marine fishpond (Reijntjes 1926).

In 1864 the agricultural inspector van Spall investigated both fresh and saltwater fishpond cultivation practices of local farmers. Marine fishponds in Java at that time occupied an area of 33 000 ha. Van Spall recommended the government to support the expansion of the cultivated area, by transforming mangrove forest into fishponds. This would provide extra food, income and tax revenue, and improve health.

By 1926 marine fishponds occupied an area of 55 000 ha, producing more than 17 million kilogrammes of fish with a market value of almost 7 million guilders. The Health Service however, was not at all happy with the expansion. In a manual for government officials on malaria matters, published by the Health Service in 1925, Professor Rodenwaldt wrote:

"Concerning the large population centres on Java's northern coast, we are confronted with a fatal error. Here one has propagated the establishment of fishponds in the mangrove coastal zone, which was held responsible for malaria, in the conviction that by doing so the zone would be made safe. At present we know that *An. sundaicus*, the most dangerous malaria vector of the Netherlands-Indies, breeds in these fishponds which are therefore the cause of heavy endemic malaria in coastal settlements. It is the task of the hygienist to try and eliminate these marine fishponds from the surroundings of human settlements. The matter is further complicated by the fact that *An. sundaicus* has been found to be able of flying very long distances, which means that all fishponds within at least 3 km from human settlements need to disappear. Tens of years will be needed to accomplish this task and even then it remains to be seen whether in certain regions economic considerations will not prevail over hygienic ones. One lesson however has to be learned from the results of biological and hygienic studies of the last ten years: that in the Netherlands-Indies under no circumstances it can be permitted that new fishponds are established in the coastal zone, or ponds that have been given up are taken into production again."

In spite of Rodenwaldt's strong objections, the area of fishponds increased further from 55 000 ha in 1926 to 82 000 ha in 1941.

This case study examines how opinions on the relation between malaria and marine fishponds changed over the years and the effect of these changes on the control measures.

Extensive breeding of anopheline mosquitoes

In a malaria survey in the capital Jakarta, Kiewiet de Jonge (1908) found that the mortality rate in the second half of the year 1907 among the local population in the district Pendjaringan near the coast was three to four times higher than in the other districts of the city. Also, the percentage of people with enlarged spleens was much higher in the coastal districts.

Kiewiet de Jonge then searched for breeding sites of anopheline mosquitoes. He found them almost everywhere: in ricefields in all parts of the capital — which was in fact more a collection of villages — in the marine fishponds, in numerous puddles, wheel ruts, hoof prints, near wells, wash-places, so that he exclaimed: "yes, where didn't we find anopheline breeding sites !"

In his report, Kiewiet de Jonge considered the following control measures:

1. Elimination of all breeding sites;
2. Construction of mosquito-proof houses;
3. Evacuation of the unhealthy town districts;
4. Drug treatment of malaria patients.

Kiewiet de Jonge considered the alternatives 1, 2 and 3 as unfeasible. He recommended the local administration to set up a programme for the distribution of quinine — free of charge — to all malaria patients. The administration provided funds and made Kiewiet de Jonge responsible for the implementation of the programme. From his report of 1908, it is apparent that Kiewiet de Jonge considered the programme as a temporary solution at best, and also that he was rather disappointed to find that the population responded with indifference to his efforts.

Jakarta sanitation project, 1913

In 1913, the Public Works Department began an ambitious sanitation project in the capital. Since its foundation in 1610, Jakarta had been an unhealthy place. The Dutch founders had considered the location amidst swamps a strategic advantage. After Dutch fashion, a network of canals was put in place in the mid 17th century.

In 1699 there was a large volcanic explosion of mount Salak, 60 km south of Jakarta. Subsequent floods carried enormous amounts of eruption material, which blocked the canals and drains and created evil-smelling swamps. In the 18th century, several attempts to improve the situation by diverting floodwaters away from the city failed.

In order to escape the poor hygienic conditions in the old city, a new administrative and residential area was built on higher grounds, early in the 19th century. After the exodus of the Europeans, the sanitary conditions in the lower city deteriorated even further. By 1910, three centuries after the foundation of the city, the health condition was considered no longer acceptable.

The estimated cost of the sanitation works that began in 1913 was 4 million guilders. The major components were (Breen 1913):

- flood diversion works;
- construction of a drainage and sewerage system;
- groundwater level control;
- elimination of stagnant water.

Although the works would reduce the number of mosquito breeding sites, the plan was not specifically aimed at malaria control. The ricefields and the marine fishponds, in which Kievit de Jonge had found anopheline larvae, remained unaffected.

Marine fishponds: breeding sites of malaria vectors

Already five years later, the chief designer of the 1913 sanitation plan made an urgent request to the administration for allocation of an additional 1.6 million guilders for the expropriation and reclamation of the fishponds in the coastal zone of Jakarta, and to allocate annually a sum of 25 000 guilders over a period of 30 years, for pumping costs and gradual filling of the area with sludge from dredging operations in the Jakarta harbour and waterways.

This change of ideas was brought about by the outcome of the malaria investigations by van Breemen and Sunier in 1917 and 1918, which were widely published. The following is based on a summary of their research conclusions which were an integral part of the advice of the Health Committee to the City Council of Jakarta (De Waterstaats Ingenieur 1919):

"In the summary below we briefly indicate what we at present know for with certainty about the relationship that exists here in Batavia [=Jakarta] between the marine fishponds and the spread of malaria.

a. In Batavia spleen index and mortality are highest in the marine fishpond zone and gradually decrease from there to the south [refer to Figure 11].
b. Larvae of the very dangerous malaria transmitting mosquito *Myzomyia ludlowi Theobald [An. sundaicus*] were found, with very few exceptions, in the marine fishpond zone only and mainly in the fishponds themselves.
c. Breeding-sites of other anophelines, which do not play a role here, were found all over Batavia. In these breeding-sites, however, no *ludlowi [An. sundaicus]* larvae were found.
d. In locations south of the fishpond zone with high spleen indices, where many *ludlowi* mosquitoes were caught in the houses, we could not find any *ludlowi* breeding-sites.
e. The fish cultivated in the marine fishponds *[Chanos-chanos, see Figure 12]* is vegetarian and feeds on submerged water plants which grow close to the surface. These water plants grow best when salinity is around 20 o/oo; growth decreases at higher salinity levels.
f. In addition to the cultivated fish, the marine ponds often contain enormous quantities of a small fish *[Haplochilus panchax, see Figure 12]* which in the literature on malaria control is mentioned as one of the best destroyers of mosquito larvae.
g. In spite of these larvae-eating fish, the ponds which contain the water plants mentioned under e. - and also the overgrown banks of the ponds - produce a large number of mosquitoes, varying from a few up to several hundreds per square metre. In absence of larvae-eating fish mosquito production figures as high as 6000 per m^2 per night have been observed.
h. The production of mosquitoes decreases with increasing salinity and stops completely when salinity in the ponds is considerably higher than seawater.
i. The level of salinity at which mosquito production stops is so high that it is not even reached in a year with a less pronounced dry season. This indicates that stopping mosquito production through maintaining a high salinity level in the ponds is not feasible.

..... From the above it should be clear for everyone that the actual source of heavy endemic malaria in Batavia is located exclusively in the brackish water zone and specifically in the marine fishponds".

The researchers, and with them the Health Committee, recommended the City Council of Jakarta as follows:

"Short of moving Batavia to a location outside the sphere of influence of the brackish-water zone, there is only one permanent and effective solution: to fill the fishponds and reclaim and bring under cultivation the entire brackish-water zone North of Batavia."

In their summary report the researchers indicated that various parties had asked whether it would not be possible to exploit the fishponds in such a way that they are unsuitable as

FIGURE 11
Map of Jakarta indicating location of marine fishponds and the spleen indices for the various quarters in the years 1917 and 1935

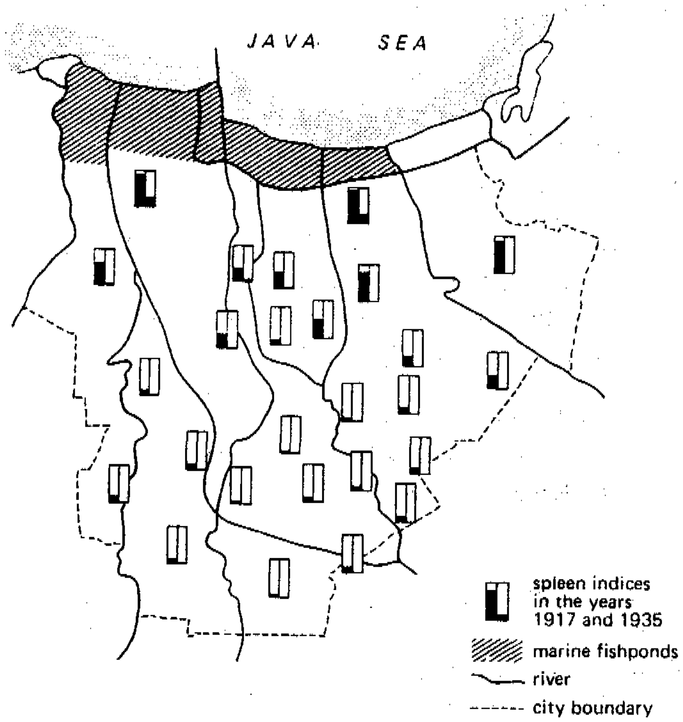
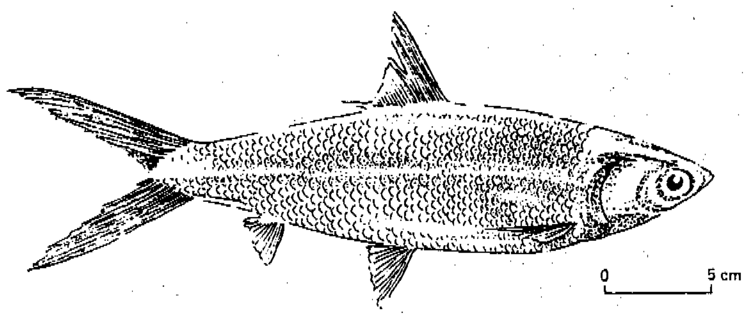
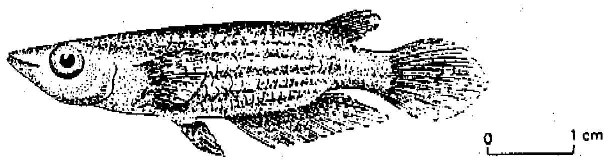


FIGURE 12
***Chanos-chanos*, the cultivated fish in the marine fishponds and *Haplochilus panchax*, an effective larvae-eating fish**



Chanos - chanos (Bandeng)



Haplochilus panchax (Kepala timal)

breeding sites for the malaria vector. For instance, by getting rid of the water plants near the surface, which provide shelter from larvae-eating fish. The difficulty involved here — as was pointed out by the researchers — is that the cultivated fish depend on these water plants for adequate growth. They mentioned the idea of conducting trials on artificial feeding of the cultivated fish, yet warned strongly against such attempts:

> "Even if such a way of exploitation were technically possible, it remains questionable whether fishpond owners could be made to adopt the new methods. And apart from that, exploitation of the marine fishponds in such a way that they no longer present a danger to public health would require permanent close supervision. .... the undersigned are of the opinion that from a public health point of view such attempts to 'run with the hare and hold with the hounds' are totally unacceptable. Only a radical and permanent clearing of all the water collections in the brackish-water zone can save the population of Batavia from the paralysing pressure of endemic malaria with certainty and forever."

The words of the researchers did not fail to make an impression on the City Council of Jakarta. They adopted the proposal for a radical and permanent solution and requested the government for funds to implement the works as part of the sanitation programme that had started in 1913.

The government was slow to react and perhaps not without reason: not only was implementation of the plans very expensive, it also meant loss of a popular source of high protein foods, loss of income and job opportunities for the owners of the ponds, and loss in tax revenue. It was not until 1928 that a sum of any significance became available for malaria control in the marine fishponds in Jakarta. The time lag provided the opportunity for the initiators and those opposed to their plans to get together.

An appeal from East Java

E.J. Reijntjes — inspector of the inland fisheries department in Surabaya, East Java — wrote an article on malaria and fishponds in the agricultural journal *Teysmannia* in 1922. Reijntjes disagreed entirely with the researchers in Jakarta on the crucial issue of the type of plants the cultivated fish feed on. As indicated above, the researchers in Jakarta claimed that the water plants floating near the surface which provide shelter from the larvae-eating fish were essential for adequate growth of the cultivated fish. Hence, their conclusion that fish cultivation and breeding of malaria mosquitoes go hand in hand.

Reijntjes, however, conducted experiments which indicated that the cultivated fish feed mainly on the blue-green algae that develop at the bottom of the ponds. He allowed water plants to develop in one of two otherwise similar ponds. He then stocked the ponds with an equal number of fish. Two months later, the fish in the pond without floating plants had gained most in weight, while the mass of water plants remained untouched. The number of fish in the pond with the water plants was then doubled. After two months there was still an abundance of water plants, while the fish had lost weight.

Reijntjes pointed out that in East Java the fish were cultivated in ponds with hardly any plants at the water surface. The common practice there was to drain the ponds for a few days every month to expose the bottom to sunlight, which stimulated the development of the bottom algae and killed the floating water plants. Subsequently the ponds were filled with seawater. By applying this method in Jakarta, Reijntjes felt, it would be possible to combine the interests of fish cultivation and malaria control. The method depends on adequate water management in the ponds, which requires a system of drainage and supply canals. As a first step, Reijntjes recommended trials on improved water management in the fishponds of Jakarta. Unfortunately, the appeal from East Java took a long time to reach the researchers in Jakarta and the trials only started six years later.

Experiments in pond-water management

Unaware of the practices in East Java and lacking funds for the implementation of the radical and permanent solution they favoured, the malariologists in Jakarta started looking for less costly control measures; later on they initiated the very type of trials that they had warned against earlier.

A low-cost method was to give up fish production and simply cut away a few metres of the dykes of the fishponds, providing free access to the seawater. The tidal movement then would render the ponds unsuitable as breeding sites for the malaria vector. Dr Mangkoewinoto had successfully applied this method in neglected fishponds at Probolinggo (East Java) in 1921.

Van Breemen tried this method on a fishpond complex at Tandung Periuk — the harbour of Jakarta — in 1923 and again in 1924, with very poor results. It appeared that the tidal amplitude at Jakarta, which is about 1 m at spring tide against 2.5 - 3 m in East Java, was too small to suppress the production of floating algae and therewith breeding of mosquitoes.

After this failure, van Breemen conducted an experiment on an area of 10 ha of fishponds in which he achieved a clean water surface by overstocking the ponds. While the productivity of the ponds was lower than usual, the experiment demonstrated that it was possible to produce fish without producing mosquitoes.

The leader of the Central Malaria Bureau at that time was Dr Rodenwaldt, who was very much opposed - as van Breemen had been - to any form of 'hygienic exploitation' of the fishponds, on the grounds that it would be impossible adequately to supervise such activities (Rodenwaldt 1925).

Inventory of exploitation methods

In mid-1927 Professor Walch was appointed leader of the Malaria Bureau. He immediately called for an inventory of the various methods of fishpond exploitation in the archipelago, and their effects on malaria (Walch and Schuurman 1929). This study brought into contact — for the first time — the malariologists from Jakarta and the fisheries inspector Reijntjes from Surabaya. Reijntjes took them to the district of Pasuruan (East Java), which represented the type of 'hygienic exploitation' he had described in his article of 1922. They witnessed how the mass of floating green algae in the centre of the ponds turned into whitish powder after the ponds had been drained and exposed to sunlight for a day or two, while the fish remained in a 0.3 m deep and 1.5 m wide ring channel. (The researchers from Jakarta were quite impressed: in the course of their own attempts at obtaining a clean water surface they had once had a few hundred men working for two days to clear the green algae from a single pond.) After the green algae were killed, a shallow layer of water was maintained for several days, which again under the influence of sunlight provided a suitable medium for the development of blue green algae on the bottom of the ponds. After this, ponds were filled again with seawater.

The malariologists found the fishponds in the district free of floating algae and the villages full of healthy children. This favourable impression was confirmed by a spleen index survey. Higher spleen indices encountered in a few villages could be explained by local imperfections, such as:

- ponds with too shallow water depth, which allowed regeneration of floating green algae; the remedial action required was deepening of these ponds;

- ponds that were supplied by rivers rather than directly from the sea could often not be drained in the rainy season because of high water levels in the river; this resulted in poor development of blue-green algae on the bottom while production of floating green algae remained unchecked and was even stimulated by the lower salinity levels; remedial action here was digging a combined drainage-supply canal directly to the sea.

The excursion to East-Java convinced the malariologists that the 'Parasuan method' of fishpond exploitation was worth trying in Jakarta.

In Semarang, on the North coast of Central Java, the researchers came across another exploitation method: fishponds were not drained monthly, but daily, under influence of the tide. This practice had developed without any guidance from the fisheries department, and also resulted in a water surface that was free of floating algae. The malariologists were quite pleased with their 'discovery'. Firstly because the 'Semarang method' proved that the concept of 'hygienic exploitation' was possible with about the same tidal amplitude as that of Jakarta. And secondly, because such exploitation was accomplished without any supervision.

The inventory took the malariologists also to Probolinggo and Banyuwangi, both in East-Java where, as a malaria control measure, fishponds had been abandoned to the sea. Their main observations were that this method did not really provide a low-cost solution because of the compensation payments that had to be made to the owners of the fishponds, and not even a permanent one, because additional canals had to be dug to ensure sufficient tidal action, and continuous surveillance was needed to keep farmers from rebuilding the dykes and resuming fishpond cultivation.

'Hygienic exploitation' after all

Reijntjes' recommendation of 1922 — of trying the 'Parusuan method' in Jakarta on an experimental basis — was finally put into practice in 1928. A fishpond area of 60 ha, due north of the city centre and west of the old harbour canal was selected. The objective of the experiment was explained to the owners of the ponds in a meeting that was also attended by the burgomaster and the Regent of Jakarta. In case of lower fish production than usual as a result of the new exploitation method, the owners would receive compensation. The owners agreed to cooperate and preparations started in 1928. These involved:

- replacing two narrow, winding and overgrown supply ditches by a 7 m wide canal; the capacity of this canal made it possible to fill the ponds in two days;
- constructing a main sluice at the entrance of the supply canal;
- installing a new intake sluice for each of the 23 ponds;
- levelling the bottom of the ponds and where necessary raising the bottom elevation between 0.1 to 0.3 m above low tide level;
- digging of a ring channel in each pond.

The works were executed by the Technical Department of the Ministry of Public Health and completed in two-and-a-half months.

The trial

The first difficulty was to get the owners to stock their ponds with fish. Normally they would not do so until a fair amount of green floating algae had developed. By 20 November 1928, all 23 fishponds were finally stocked. To stimulate development of blue-green algae, the water level was allowed to vary daily with the tide, as in the 'Semarang method'. But after this the researchers wanted to maintain the water level as high as possible, to suppress the development of floating green algae, which they saw as the source of malaria and the pond owners as the food source their fish could not do without.

Walch, van Breemen and Reijntjes (1930) provide details of their dealings with individual owners and their actions in individual ponds. It suffices here to say that by implementing the principles of the 'Parusuan method' they managed to obtain a water surface without floating algae and also free of mosquito larvae, while producing a sufficient quantity of fish to make exploitation economically viable.

From the production data until the end of 1929, the researchers calculated that the first, second and third harvest gave the owners an average return on working capital of 23%, 108% and 189% on a yearly base. In their calculations of working capital, they included an annual rent of Dfl.210 per ha, which was not actually paid by the owners in the experiment.

New sanitation plan

Based on the outcome of the experiment, the researchers recommended sanitation of all fishponds in a 4 km long zone north of Jakarta. Unlike in the experiment, the ponds would have to be expropriated and then rented back to the owners. The reason for this was that most ponds were long and narrow, which made them unsuitable for digging of ring channels, so that reallotment was necessary to obtain ponds with a suitable shape. The researchers estimated the cost of sanitation of all 1000 ha of fishponds at Dfl. 5 600 000.

In the period 1928-1932 the sanitation of 291 ha of fishponds was carried out, at a cost of Dfl. 2 000 000. Due to the worldwide recession, no more funds were available for the sanitation of the remaining 700 ha.

Effects of 'hygienic exploitation' on malaria

Figure 11 gives the spleen index for the various quarters of Jakarta in the years 1917 and 1935. Quarters closest to the sanitized ponds showed the best improvements. After hygienic exploitation of the fishponds started, the overall mortality rate in Jakarta also decreased substantially, from a stable 39 per 1000 in the period 1925-1929 to 27 per 1000 in 1931.

Effects of 'hygienic exploitation' on fish production

Markus (1941) reported that while productivity in many fishpond areas under 'hygienic exploitation' remained high (500 kg/ha/year), productivity decreased to as low as 50 kg/ha/year in others. Markus found that high productivity was related to ponds with a black, homogeneous, soft mud with a high organic matter content. Low productivity was associated with brown to greyish, heterogeneous, often cloddy mud, low in organic matter. Frequent drying of the mud layer appeared to reduce the organic matter content.

Vaas (1947) reported that to improve the productivity of the ponds they were no longer drained completely and were fertilized with a compost made out of weeds from the pond and vegetation from the banks. Vaas recommended to plant leguminous crops on the banks, to be incorporated into the compost as a green manure. He did not indicate how successful the above measures were in restoring productivity of the fishponds.

THE MUSHANDIKE PILOT PROJECT: A RECENT EXAMPLE

A Pilot Study initiated in 1984 on the Mushandike Irrigation Project in Zimbabwe provides a recent example of disease vector control in rural water resources development projects through environmental management. The study was a joint effort of the Blair Research Laboratory and the Department of Agricultural, Technical and Extension Services in Zimbabwe and the Overseas Development Unit of Hydraulics Research, Wallingford, UK.

The Mushandike dam and canal were built in the 1930s to irrigate ten commercial farms. Seven of these farms with a total area of 600 ha have now been purchased by the government for resettlement of some 400 families.

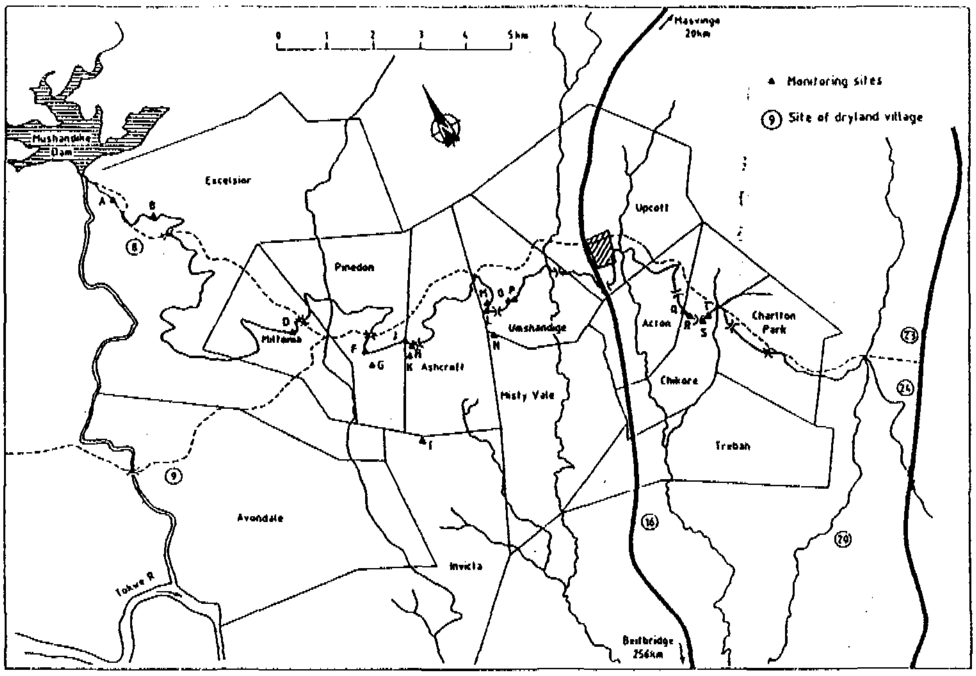
The area is located at 20 km from Masvingo (Figure 13) at 875 above sea level and receives an annual rainfall of 615 mm, which falls during the summer months (November to April). The majority of the settlers come from the surrounding communal land, where lack of water is the main constraint on agricultural production.

Measures to control schistosomiasis

Irrigation

Engineering measures aimed at preventing the creation of favourable conditions for snail colonization and breeding in the irrigation system:

FIGURE 13
Mushandike Irrigation Scheme : General Plan (reproduced from Chimbari *et al.* 1991)



Canal lining. All secondary and tertiary canals were lined with concrete to eliminate vegetation, allow higher flow velocities and rapid and complete drying of the canals when not in use.

Free draining structures. Standard designs for drop structures with sunken stilling basins have been replaced with a free-draining drop structure using baffle blocks. Long weirs for regulating upstream water level at canal off-takes have also been avoided, because these weirs prevent complete drainage of the canal section upstream.

Water scheduling. Micro-computer assisted irrigation scheduling was introduced to improve efficiency of water use and to operate canals and reservoirs in such a way that the time a particular canal remains dry is maximized.

Routine maintenance. Weed clearance of canals and reservoirs were done when the canals were dry, to avoid infection of the workers. Canals and structures were periodically checked for cracks, to avoid pools and swamps in which disease vectors can breed.

Water supply and sanitation

Village location. Villages should preferably be located as far as possible from the main canal and night-storage reservoirs. Safe drinking water should be provided nearer to the houses than the irrigation canals. Application of these criteria was not always possible in Mushandike, as the location of several villages had been determined by existing boreholes.

Domestic water. Villages were supplied with locally made handpumps to extract water from the boreholes that already existed on site. Laundry slabs with adequate drainage were constructed to discourage the use of irrigation canals.

Sanitation. All households were encouraged to have their own pit latrine, by issuing free cement for this purpose, and several communal latrines were built in the irrigated fields.

Monitoring and results

The transmission of schistosomiasis was monitored by a field team comprising two research technicians and various field assistants. All settlers were screened for *S. haematobium* (diagnosed from urine specimens) and *S. mansoni* (using stool specimens) infections, soon after their arrival. Infected settlers were treated with praziquantel. Repeat surveys were undertaken at three-monthly intervals. Figure 14 gives the prevalence (the number of positive cases as a percentage of the number of people surveyed) of *S. haematobium* for three settler schemes and for the Chikore farm, where no control measures were taken. The graphs show that prevalence fell rapidly after blanket treatment with praziquantel. The prevalence at the Misty Valley and Invicta schemes remained below 5%. At Ashcroft, however, prevalence increased until it reached a level comparable with that at Chikore.

Monthly sampling of snails, during three years, in the main canal reaches passing through the redeveloped schemes produced only 12 *Bulinus globosus* (host of *S. haematobium*). In contrast, more than 600 snails a year were caught in the reach passing through the Chikore farm. For *Biomphalaria pfeifferi*, the host snail of *S. mansoni*, these figures were 3 and 196, respectively.

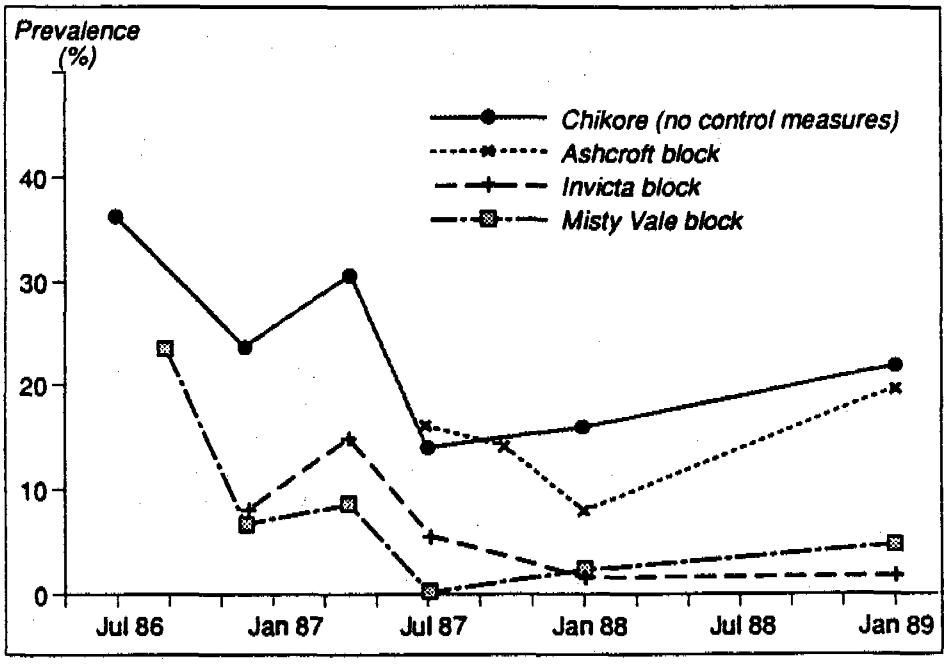
Appreciable numbers of snails were found in night-storage ponds. The lined canals and in-field structures of the redeveloped schemes remained free of aquatic snails. On the Chikore farm considerable numbers of snails were found at the in-field structures and in pools behind deteriorated canal linings (Chimbari *et al.* 1991).

Discussion and conclusion

The surveys indicate that control measures implemented at the settler irrigation schemes aimed at reduction of snails were effective. The high level of prevalence at the Ashcroft scheme, however, shows that this reduction is not enough to control transmission. The researchers suspect that high prevalence at Ashcroft is caused by its proximity to the main canal.

Another important factor is the availability of safe water supply. Although boreholes have been provided for the resettlement villages, their number is low (one per 40 to 50

FIGURE 14
Prevalence of *S. haematobium* in adults and non-school children (reproduced from Chimbari *et al.* 1991)



households), pump breakdowns occasionally occur and users have expressed reluctance to wash clothes in the "hard" water.

Equally important for the reduction of disease transmission is the availability and proper use of latrines.

Dr. Peter Bolton of Hydraulics Research, when addressing the Forum on performance of irrigated agriculture in Africa in Nairobi in January 1988 stated:

> "The most important conclusion which I have reached from my involvement in the Mushandike study is that, although physical measures can contribute towards reducing the transmission of schistosomiasis, the control of the disease can never be reduced to a set of physical criteria alone. Close cooperation with other disciplines is required together with a willingness to see engineering control measures as only one element within a combined strategy of disease control incorporating all the available methods of control at our disposal."

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Country-level monitoring of water supply and sanitation as a management tool: case study — Togo

Togo, a relatively small West African country with a total land area of 56 600 km^2, has a total population of around 3.5 million, of which around 29% are urban and 71% rural. From the standpoint of population distribution between urban and rural areas, it is typical of many African countries.

Administratively Togo is divided into five regions which, in turn, are divided into districts. The regions and their populations are given in Table 1.

Approximately 68% of the urban population live in the Maritine Region, which contains the capital city of Lomé.

WATER SUPPLY AND SANITATION SECTOR PLANNING

Togo was one of the countries of Africa to take up the challenge set out by the United Nations Water Conference in Mar del Plata, Argentina, in 1977. By early 1981, it had established a Decade water and sanitation programme with intermediate targets for 1985 and final targets for 1990, as had been recommended in the Mar del Plata Plan of Action.

Although in retrospect the goals which Togo set itself for the 1980s were over-ambitious, in other ways the programme demonstrated a certain pragmatism of approach. The coverage targets of the plan are presented in Table 2.

At the start of the Decade (1980), it was estimated that 50% of the urban population had access to an adequate and safe water supply but only 10% of the rural population were so served.

For the water supply targets of the Togo plan to be achieved, the population coverage would have had to develop as shown in Table 3.

CASE STUDY 7

G. Watters and D.B. Warner, Community Water Supply and Sanitation Unit, World Health Organization, Geneva, Switzerland

TABLE 1
Regions and their populations

Regions	Population		
	Urban (000)	Rural (000)	Total (000)
Centrale	93.23	250.72	344.95
Maritine	686.74	723.57	1410.31
Kara	103.25	382.80	486.05
Plateaux	87.07	745.43	832.50
Savanes	42.93	378.86	421.79
Total	1014.22	2481.38	3495.60

TABLE 2
Togo Decade Plan (Outline)

WATER SUPPLY			
Community type	Type of service	Plan coverage %	
		1985	1990
Large towns	House connections/ public standposts	100	100
Secondary towns	House connections/ public standposts	70	100
Rural areas	Public standposts	75	90
SANITATION			
Large towns	Sewered drainage	80	100
Secondary towns	Sewered drainage	80	100
Rural areas	Separate latrines	40	80

TABLE 3
Togo Decade Plan (Populations served with water supply)

	1980 (Actual)	1985 (Plan est.)	1990 (Plan est.)	1990 (Actual)
Population (000)				
Urban	491	670	909	-
Rural	2124	2358	2622	-
Total	2615	3028	3531	-
Population served (000)				
Urban	50	100	100	77
Rural	10	75	90	53
Total	17.5	80.5	92.5	59
Population served (000)				
Urban	245.5	670	909	700
Rural	212.4	1768.5	2359.8	1390
Total	457.9	2438.5	3268.8	2090

Among the interesting points about the plan are the following:

- Rural expansion of WSS coverage was foreseen at a steady rate throughout the Decade.
- Urban WSS development was intended to be slightly more intense during the first half of the Decade.
- Varying standards of service in terms of technology and *per caput* consumption levels were planned for different population groups.

DECADE RESULTS

Unfortunately, despite the planning and commitment to the goals of the Decade, Togo did not succeed in reaching these goals. In fact, at the end of the Decade, the situation was:

- 77% of the urban residents had an adequate and safe water supply;
- 53% of the rural residents had an adequate and safe water supply;
- 56% of the urban residents had appropriate sanitation;
- 10% of the rural population had appropriate sanitation.

At the end of 1990 there were 2 090 000 people in Togo served with adequate and safe water, and 862 000 were served with an appropriate means of excreta disposal.

The extent of water and sanitation coverage at the end of the Decade left a total of 1 400 000 people without adequate and safe water, and 2 700 000 without access to appropriate means of excreta disposal. By the year 2000, the population of Togo is expected to increase by 1 400 000. This means that to reach a universal coverage by the turn of the century, 2 800 000 more people will have to be provided with water and 4 100 000 with sanitation.

THE ROLE OF MONITORING IN SECTOR PLANNING

To cope with the unserved populations, the Government of Togo has initiated a major water supply and sanitation sector planning exercise, the foundation of which is an improved monitoring system. The need to upgrade sector monitoring was identified as fundamental during the implementation of the Decade programme in Togo.

The monitoring system in Togo utilizes the methodology of the WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme (JMP), which has been developed to help countries collect and utilize data for decision making at the regional and national level. A network of regional monitoring focal points has been established in Togo and data collection is now undertaken annually. Information for 1990, 1991 and 1992 is available.

Available data comprise demographic information, service coverage, the financing of operation and maintenance, and capital investment activities. These are the JMP "core indicators". In addition, information on coverage is collected on the basis of the type of technology used to provide services. To date, Togo has not been able to differentiate between urban high-income and urban low-income populations.

Urban water supply coverage data can be used to demonstrate useful information for planning, as the following examples show:

- Population is very unevenly distributed throughout the country, with more than half of the urban residents being in the Maritine Region (where Lomé, the capital, is located).
- The proportion of urban to rural population varies greatly between regions. This could influence the priority given to urban or rural problems, depending on the region.
- Almost all urban population served by house connections is in the Maritine Region.
- One possible priority for the regional centres would be to upgrade services from public standposts to yard taps. This is certainly a viable option in the Maritine Region where a distribution system for Lomé already exists.
- Maritine Region has the largest total service coverage, but it also contains the largest number of urban unserved, with the Kara Region containing the least. This could indicate Maritine as a priority for future capital investments.
- Although the total number of urban residents unserved in the Maritine Region is greater than in the Kara and Plateaux Regions, the percentage of population unserved is lower in Maritine than in Kara and Plateaux Regions. If equity is the objective, therefore, equalizing the level of service coverage in percentage terms may be a priority.
- Togo now has information on the technologies used to provide urban water supply in the different Regions and, therefore, has the basic data on which to base a programme for upgrading.
- In the rural subsector, the number unserved is again greatest in the Maritine Region. However, the percentage served is lower than in the Kara, Plateaux and Savanes Regions.

The above are simple examples of the types of conclusions that information from systematic monitoring, as applied in Togo, can provide. This information is now being used by the Togolese Authorities to plan and manage their water supply and sanitation development programmes for the 1990s.

Technical Session III

Capacity building

Capacity building for water sector development

Population and economic development can no longer be considered separately from water resources and the environment. Based on the experience of the past decade, UNDP and its partner agencies are better equipped with know-how about managing water resources. The best guardians of water resources and the environment are people working hand in hand with institutions. We find institutions at all levels, with each of them playing its part and interacting within a larger whole: e.g. women caretakers of wells, farmers' associations, utilities, government ministries and external support agencies.

Better trained people and responsive institutions are essential if we are to stay ahead. In addition, people, both as providers and users of water for domestic purposes, agriculture, and industry can no longer live in blissful ignorance of each other. Consumers, technicians, engineers, economists, managers and politicians have no other choice but to understand each other better and to work together if social and economic needs are to be met in a balanced and equitable manner.

Clearly, safe water supply and sanitation, and availability of water for agriculture and industry are the basic underpinnings of an environment for sustainable development.

The international cooperation agenda for the nineties was shaped by four global meetings, each of which looked at the water sector from a different perspective. A common theme in these meetings was the importance of capacity building, which will be UNDP's area of focus in the years to come.

Near the conclusion of the International Drinking Water Supply and Sanitation Decade, in September 1990, UNDP organized and the Government of India hosted the Global Consultation on Safe Water and Sanitation for the 1990s. The Consultation reviewed the progress during the Decade and made a number of recommendations for the future. These recommendations, endorsed by the UN General Assembly, formed the basis of actions which should be taken during the 1990s. During the Decade, the international community as a whole made the provision of improved water supply and sanitation facilities a top priority and rallied support to Decade goals and objectives. Some 1300 million people in the developing world

KEYNOTE PAPER 3
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gained access to safe drinking water and 700 million to sanitation facilities for the first time in their lives.

The New Delhi Statement prepared at the Global Consultation in India contained four guiding principles, two directly related to capacity building: "Strong institutions are essential for sustainable development", and "capacity building is necessary to make community management effective..." Two others, environment and health, and financing and technology, depend for their implementation on strong sustainable institutions. The concept of and prospects for capacity building were further elaborated during the UNDP Symposium, "a Strategy for Water Resources Capacity Building", held in Delft, The Netherlands, in June 1991.

A major issue addressed in the Delft Declaration is the daunting challenge:

> "to satisfy the water needs of the exploding cities, given the equally increasing need for water for irrigated agriculture and the problems arising from urban and industrial pollution. In addition, to do this in a sustainable way, measures have to be taken to protect and conserve water as a major resource and unifying element of our environment. Experience shows that institutional weaknesses and malfunctions are a major cause of ineffective and unsustainable water services. This requires urgent attention to building institutional capacity at all levels. Pressure for improved local delivery of water services suggests that development of institutional capacity be more demand-responsive. Also, the need to manage overall water resources coherently, and to facilitate the allocation of water among all users suggests an expansion of national, integrated planning".

The participants in the Delft Symposium, coming from developing countries, external support agencies and institutions, recognized the importance of the capacity building process for sustainable development at national, sub-regional and local levels. The capacity building concept was articulated as follows:

- the creation of an enabling environment with appropriate policy and legal frameworks;
- institutional development, including community participation; and
- human resources development and the strengthening of managerial systems.

Subsequently, on the road to the Earth Summit in Rio (the United Nations Conference on Environment and Development — UNCED), a unique event took place in January 1992 in Dublin, Ireland: the International Conference on Water and the Environment. This Conference made recommendations for action at local, national and international levels, based on four guiding principles: the finiteness and vulnerability of water resources; participatory approaches to water management involving users, planners and policy-makers; women playing a central part in the provision, management and safeguarding of water; and the economic value of water. Again, capacity building was recognized as a principal element in the development, use and management of water resources.

Finally, the United Nations Conference on the Environment and Development (UNCED, Rio de Janeiro, June 1992) articulated the concept of sustainability in its Agenda 21, which contains numerous recommendations for actions in the water sector from different vantage points, e.g. poverty, human settlements, agricultural and rural development, and integrated approaches to development, management and the use of human resources. Consistently, the vital role of people, communities and institutions was underlined.

What is the response of the international community to the expectations raised and recommendations made by the Conferences in New Delhi, Delft, Dublin and Rio?

Virtually all international development agencies support water-related programmes. International and regional development banks and many bilateral agencies have a substantial part of their grant or lending portfolios devoted to irrigation, water supply and sanitation. Likewise, United Nations system agencies are very active in this area. This is illustrated in Figure 1.

By supporting the principles and recommendations of the above conferences, developing countries and the external support agencies have committed themselves to adapt their water sector programmes to the needs of the nineties and beyond. In spite of promising initiatives by a number of agencies, it is difficult to discern the contours of a concerted programme supported by the international community.

In our view, the United Nations agencies are well placed to take a leading role in the response of the international community by providing policy, technical and financial support to countries which are committed to re-orienting their water sector programmes in line with the afore-mentioned principles and recommendations, as applicable to the countries' conditions. Similarly, there is the need for the United Nations agencies to re-examine and re-orient their role in order to be better equipped for their task.

For its part, UNDP has adopted the following approach to "upstream" water sector development translated into four inter-related global programmes supported by UNDP and partner agencies.

(1) The UNDP/World Bank Water and Sanitation Programme, supported by ten bilateral agencies, which concentrates on capacity building and supporting sustainable investments in low-cost community-based water and sanitation, and increasingly in urban sanitation.

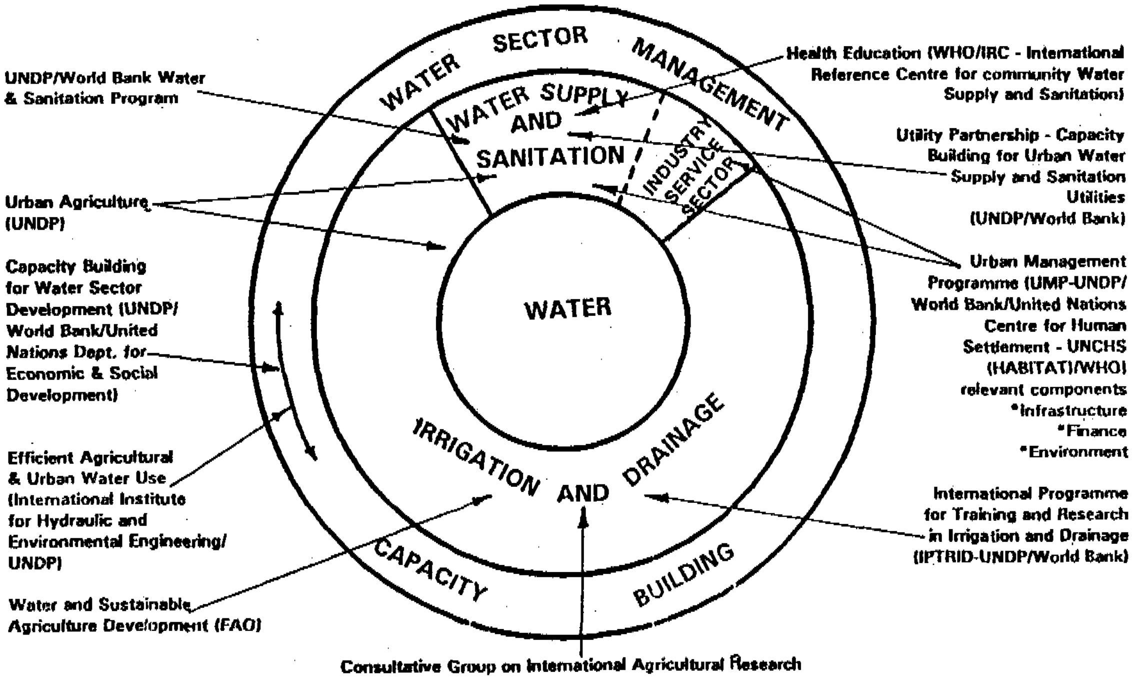
(2) The International Programme for Training and Research on Irrigation and Drainage, supported by UNDP, the World Bank and bilateral partners.

(3) The Utility Partnership: Capacity Building for Urban Water and Sanitation Utilities, initiated by UNDP and the World Bank, which concentrates on improving the efficiency of utilities and water conservation/demand management.

(4) The Capacity Building Programme for Water Sector Development which emerged from the Delft Symposium. This programme, which is currently being initiated by UNDP, UNDESD and the World Bank, places capacity building squarely among the financial, technical, social and economic elements of water sector programmes. To enhance the capacity building process in developing countries, water sector assessments are considered a necessary first step.

These four programmes are prime factors in shaping "downstream" programmes supported by UNDP and other external support agencies at the country level. Under the

FIGURE 1
Water sector development — selected international programmes (Poverty alleviation, Environment and Capacity building)



umbrella of capacity building, UNDP will devote increased attention to the following approaches. In terms of financing, greater efficiency should be combined with mobilization of additional resources. Secondly, new public-private partnerships are vital for sustaining water sector programmes. Thirdly, there is a need for concrete coordination among all participants in this effort both nationally and internationally. Indeed, much money can be saved by avoiding duplicative efforts and applying proven solutions. Fourthly, innovation is essential: fresh ideas, imaginative approaches, appropriate technologies and new attitudes. In this connection, a wide array of technologies and methodologies is available for testing, adaptation and adoption. And finally, strengthening and adaptation of institutions is required at all levels, as well as human resources development, within developing countries and the external support agencies.

In conclusion, UNDP is joining UN partner agencies, development banks, bilateral agencies and other public and private sector agencies in the urgent human development venture to serve the unserved.

Capacity building for integrated rural water management: building managerial capabilities in developing countries

BRIEF SUMMARY OF UNICEF INVOLVEMENT IN RURAL WATER SUPPLY AND SANITATION (WS&S)

Universal access to safe drinking water and sanitary means of excreta disposal are among the goals set for children and development in the 1990s, and embodied in the United Nations Convention on the Rights of the Child. For over four decades, UNICEF has been involved in support to country programmes aimed at the most marginal populations. Essentially uninterrupted support at country level in the WS&S sub-sector has thus been provided as part of the organization's work for the survival and development of children and women.

KEY DEVELOPMENTS THAT HAVE CONTRIBUTED TO IMPROVED COMMUNITY PARTICIPATION AND MANAGEMENT

Prior to independence of many developing countries, the WS&S sub-sector was typically characterized by "service delivery". Technologies and approaches used at that time were directly exported from the western world, with minimal regard to their adaptability and replicability on a large scale in the colonies. Even after independence was achieved by the developing countries, linkages to the ex-colonial powers were frequently kept very strong with a consequent continuation of the past practices.

Even today, when analysing the proportion of investments made in the WS&S sub-sector to appropriate low-cost technologies, one finds that it is still minimal compared to the allocations made for "high-tech". UNICEF has, over the last two decades especially, focused its attention on technologies and approaches which have, as a spinoff effect, enabled the decentralization of WS&S sub-sector management.

DISCUSSION PAPER 9
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Development and Refinement of Technical Approaches

The development of such appropriate and cost effective technologies has played a key role in allowing communities to participate in, and manage, their development process.

UNICEF has been very actively involved in technical developments and refinements in many developing countries. The agency pioneered the development of the India Mark II handpump which opened the door to providing water supply services at a lower cost whilst encouraging a much more decentralized system of maintenance. It was actively involved with the World Bank in the development of the Tara handpump, as a result of the decline of water levels in Bangladesh beyond the suction level suitable for the "No. 6 handpump". Both these new pumps are now extensively used beyond the Indian sub-continent, the former mostly in Africa and the latter essentially in Asia, although "clones" of the Tara handpump are being produced in Central America as well under the trademark "Maya".

UNICEF has also promoted VIP latrines, essentially in rural areas of Africa, and pour-flush latrines in rural areas of Asia where water is easily accessible, and where the use of water for cleansing is culturally more appropriate. Currently, increased efforts are being made by the organization to promote even less costly on-site latrine models to increase service coverage rapidly, given that sanitation services lag seriously behind water supply.

Introduction of an Integrated Approach at the Village Level for Water, Sanitation and Hygiene Education to Bring About Improved Health Benefits

All UNICEF-assisted programmes include sanitation and hygiene education, to maximize the health and socio-economic benefits. The integrated approach is promoted at the community level. However, delivery of services for water and sanitation may be separate or parallel with the involvement of different government departments. The emphasis is placed on stressing the importance of improved hygiene behaviour as a result of the water and sanitation interventions which will lead to a decrease in both water- and excreta-related diseases.

The need for hygiene education is well recognized by all in the water and sanitation sector. It is not enough merely to provide WS&S services, since perhaps in some cases only 20 per cent of the population may be using these properly. UNICEF has been actively involved in many countries in including hygiene education in WS&S sub-sector programmes, but recognizes that concerted efforts are required to strengthen further this programme component. Efforts are now being made to ensure that services are used effectively by trying to understand the socio-cultural and economic factors that may be deterring effective use, and to address these through focused hygiene education and communications interventions.

Such interventions also offer a unique opportunity to enhance WS&S management at community level, through participatory discussions.

Empowerment of Communities Through Establishment of Village Level Committees and Devolution of Management Responsibilities

In several countries (Sudan, Nigeria, Uganda, Guatemala, Honduras etc.) community level water committees have become an effective mechanism to enhance ownership and management capabilities, empower communities, and ultimately devolve post-intervention responsibilities for operation and maintenance of WS&S schemes. No blueprint exists of this mechanism, given that its strength lies in forging it through participatory planning. Frequently however, a prominent role for women is sought, given their central role as domestic water providers in rural areas.

Development of Improved Cost-sharing and Cost-recovery Mechanisms to Encourage "Ownership" of Projects, and Increase the Resource Base to Accelerate Service Coverage

Cost sharing has been encouraged in many countries, especially for the payment of operation and maintenance costs. Most governments have however been reluctant to encourage communities to contribute to capital cost investment due to paternalistic policies of the past, and communities' limited financial resources. However, in India UNICEF undertook a survey which demonstrated that communities are willing to contribute towards both the investment costs and operation & maintenance of facilities, whilst the perception of the government was that no communities would pay more than a small amount towards operation & maintenance costs.

Cost recovery has not been actively pursued by UNICEF-assisted projects in the past, but is rapidly becoming an issue of relevance in UNICEF WS&S programming. In the context of sanitation, cost recovery has been successfully introduced in some countries such as Lesotho where UNICEF supported the development of a National Sanitation Project that developed a revolving fund/credit system for the construction of latrines. In Egypt UNICEF is in the process of formulating a rural WS&S programme where indications are that communities will contribute almost 70 percent of the investment costs. In Niger, even very poor communities are contributing US$ 1500 towards the construction of large diameter hand dug wells used for both domestic supply and livestock.

Despite extreme poverty, willingness to pay is understandable in even countries like Burkina Faso where women can spend up to 4-5 hours a day collecting firewood, and in addition have to walk 3 km back and forth to collect water, not to speak of other routine household chores including child care and food processing/preparation.

Support for Capacity Building of Government and Communities Including Training, Decentralized Planning, Operational Research, Improved Coordination

Capacity building at government, community and private sector levels is becoming increasingly important in UNICEF-assisted WS&S programmes, given the recognition in several assessments undertaken during the 1980s that institutional and human capabilities are crucial to the enhancement of the WS&S sub-sector (and water resource) management effectiveness. UNICEF-assisted capacity building interventions are focused on the empowerment of development counterparts at all levels, with a particular emphasis on the role of women.

While in most countries "on the job" training is a common mechanism of capacity building, some UNICEF-assisted programmes have incorporated specific capacity building interventions with measurable objectives. This is probably one of the most effective means of gradually building capabilities at several levels and enhancing the sustainability of services.

UNICEF's long-term programme approach provides opportunities, through periodic situation analyses, to identify areas of weakness in the WS&S sub-sector requiring capacity building support. By such means, effective and targeted capacity building initiatives can be developed.

Advocacy at All Levels for a Decentralized Approach to Project Planning, Implementation and Management

While demonstrating the devolution of management responsibilities to communities on a pilot scale in many countries, the ultimate motive of UNICEF-assisted programmes is to link such experiences to strategy and policy formulation as well as legislation at the national level. This is undertaken through an array of advocacy initiatives including formal commissioning events and field trips with high-level government officials, videos, workshops, and the full involvement of the media.

CASE STUDIES

Uganda - The Role of Multi- and Bi-lateral Agencies

Although, traditionally, communities have managed their water resources in Uganda, between 1930 and 1980, with the introduction of handpump-equipped borehole water schemes, management and maintenance of water supply was taken over by regional maintenance units. In 1980 a survey revealed that out of the 5089 boreholes then existing in the country, 75 per cent were out of order. Despite a concerted UNICEF/Government of Uganda effort to address this situation through a rehabilitation programme, in 1983 a follow-up survey indicated that 68 percent of the borehole water schemes were still out of order.

By 1984, after verifying that the "India Mark II" handpump was a sturdy alternative to the traditionally used "Uganda I" handpump, a programme was started to replace all "Uganda I" handpumps with "India Mark IIs".

In 1986, in response to a Government request for emergency support to the war-ravaged Luwero District, UNICEF initiated a trial with community management of water supply. This involved inter-sectoral coordination between the Water Development Department (WDD) and the Community Development Department (CDD). Encouraged by the success of this pilot project, UNICEF entered into an agreement with the Government to expand the community management approach beyond the WS&S sub-sector, to incorporate other primary health care components in the what was to be called "The South West Integrated Programme (SWIP)". Following these initiatives, the Danish International Development Agency — DANIDA conceived a community-based rural water and sanitation programme covering seven districts in eastern Uganda, and UNICEF expanded this approach with the support of NGOs to eighteen additional districts. The World Bank has also signed an agreement with the Government to implement a development programme in northern Uganda, and UNICEF has been invited to assist in building capacities in community management.

The SWIP was launched in 1987, initially covering five districts of south-western Uganda. It was expanded in 1992 to three additional districts. The total population covered amounts to 4.2 million people. This programme is jointly funded by the Canadian International Development Agency (CIDA), the Swedish International Development Authority (SIDA), UNICEF and the Government of Uganda. CIDA and SIDA channel their resources through UNICEF.

The goal of SWIP is to:

"Establish in each intervention district by 1995 a sustainable, replicable system for initiating and supporting community-based improvements in health, sanitation and use of safe water supplies integrated into district and community structures."

The above objectives depend upon a series of outputs at different stages of the implementation process, these are:

- Community health, sanitation and water supply improved through:
  - Supply and use of safe water at community level
  - Qualitative improvement of water source development/construction
  - Improved access to sanitation
  - Improved access to, and quality of, water consumed
  - Establishment of community based health care

- Improvement of District Capacity as a Facilitator of Community action through:
  - Enhanced planning, management, supervision and inter-sectoral collaboration at district level
  - Water, health and sanitation improvements integrated into the district institutional framework
  - Strengthening of district capacity for obtaining, delivering and accounting of external inputs.

- Advocacy for:
  - Strengthening, improving national policies on community based water/sanitation and health care

By June 1992, 1188 new boreholes had been constructed, 247 existing boreholes had been replaced, 2712 springs had been protected and 4 gravity schemes had been built. Consideration was also being given to expanding the spectrum of water supply technologies used with hand-dug and augured wells as well as rainwater harvesting.

Capacity building to enhance the district's role of "facilitator", and to devolve management responsibilities to communities involved the following:

District Level:

- Budgeting and disbursement procedures
- Using Community Mobilization as a tool to acquire allies
- Enactment of supportive community management legislation and policies
- Responding rapidly to issues requiring decisions

Community Level:

- Selection, training and equipping of WS&S Committees by districts and the SWIP
- Clear definition of district, SWIP, and community roles in implementation and operation/maintenance of facilities
- Provision of communication skills and basic health messages to selected community health workers

Maintenance of water schemes is undertaken by sub-county area mechanics as well as community caretakers who undertake minor preventive maintenance works. Area mechanics are paid by the communities. An array of different payment and administrative arrangements are determined on the basis of "negotiated collaboration". With the arrival of the India Mark III or "Uganda III" handpump on the market, the potential for full community maintenance is within reach, in time the area mechanics will be phased out.

The Uganda - SWIP experience is demonstrating that devolution of WS&S management responsibilities to communities is a slow process which also has a financial cost. It does however allow communities to reduce eventually their dependence on government. **Community management must be seen as an objective which is the basis for community development, and not just as a means to enhance sustainability of external interventions.**

Guatemala - The Role of NGOs

"Agua del Pueblo" (People's Water) is a Guatemalan NGO which has since 1981 built 125 water schemes benefitting a total over 90 000 people in 150 rural communities. Handpumps, gravity systems, rainwater harvesting, hydrams and mechanized systems have been implemented. Additionally more than 15 000 latrines have been built. Training of 27 local personnel in water system construction has also been undertaken, as has the delivery of hygiene education materials and programmes targeted to the general public. "Agua del Pueblo" has thus buttressed its interventions on a multi-disciplinary approach.

This NGO has established itself in 70 communities. It finances its interventions through community contributions in the form of a down-payment, the balance being recovered over time. The financial policy is thus designed to eliminate dependency on external resources, and financial control is undertaken through qualified personnel equipped with computers. Intensive community participation in the planning, implementation and post-intervention phases reduces investment costs and enhances sustainability.

The population targeted by "Agua del Pueblo" is that portion of society which lacks access to basic services — the majority of the rural dwellers. Illiteracy rate of the target population approaches 95 percent, only 15 percent of the school-age children have access to primary schooling. While most of the adult men are engaged in agriculture some 65 percent work as temporary wage-labourers on large land holdings.

Interventions are initiated through participatory planning sessions, evolve into preliminary technical assessments, establishment of water committees, and final design. Prior to the actual execution of the project the roles and responsibilities of all parties during all phases are clearly defined and agreed upon, and the collection of funds for the down payment is undertaken by the community. Hygiene education is also undertaken at this stage, and technology transfer for latrine construction takes place as well. Construction of latrines is then planned for the periods of the year when the population is not heavily engaged in productive activities.

At the end of this process, communities' water resource management capacities have normally been enhanced as follows:

- establishment of water committees with a strong mobilizing capacity;
- minimum technical capabilities to sustain systems;

- capacity to undertake protective and enhancement works in micro-watersheds;
- better understanding of the linkage between water resources management and health;
- a solid basis for the undertaking of other development activities.

Sustainability of systems is ensured through self-imposed monthly water tariffs, (mostly unwritten) legislation and penalties. So far 80 percent of the communities who have gained access to improved WS&S services have undertaken afforestation works to protect and enhance their water sources. Community water committees frequently refund the "Agua del Pueblo" investment loans prior to the deadline date.

Autonomous micro-regional NGOs have been emulating development projects with an even higher degree of community participation than "Agua del Pueblo". Agricultural projects including coffee, fruit and maize production have been used as a basis to raise funds for other projects.

One can conclude that the proximity of NGOs to communities makes them not only a viable but also a necessary channel and mechanism to enhance community-driven rural water resource management.

CONCLUSIONS

In light of the issues raised, the following points should be considered to enhance community-driven rural water resource management:

Planning Stage

- Involve communities from the beginning. This will increase their sense of responsibility and encourage ownership, and ultimately lead to community empowerment.

- Learn from past lessons and experiences. Review the local history of community involvement and problems encountered in past development of programmes involving (or not) the communities.

- Undertake research to collect relevant information on community needs, willingness to pay for services, present beliefs/perceptions and attitudes. These data should be used in designing suitable projects/interventions.

- Motivate governments to see the advantages of devolution of management responsibilities to communities, as this lessens the burden on limited financial and human resources, which in turn can lead to faster provision/facilitation of services.

- Involve women from the onset in the development of programmes.

- Encourage a decentralized monitoring and planning approach involving continuous flow of relevant information to sub-national and national levels, and feedback to the communities.

- Pursue a fair share of the financial contribution from the community as this encourages ownership of facilities whilst alleviating the burden on government. This is especially important for sanitation since facilities should be provided on a household basis for improved health benefits.

- Standardize technologies and procedures to encourage rapid delivery of services and development of a decentralized, if possible privatized, maintenance system.

Implementation Stage

- Train communities, not only in effective use and maintenance of facilities, but also in financial and management aspects. This facilitates integrated development and empowers communities to resolve their own development problems.

- Use existing village committees where possible to provide project training, this encourages integrated village development activities and avoids creating parallel structures.

- Test different methods and approaches on a pilot basis before taking these to full scale. These can be closely monitored and the results used to influence national policy changes.

- Encourage active involvement of local NGOs to assist governments.

- Use social mobilization as a tool and continuous process to galvanize support for sustainable development.

Post-project Stage

- Provide the necessary tools and equipment to communities to maintain their WS&S facilities.

- Use the momentum generated by water supply interventions to generate interest in sanitation, improved hygiene behaviour and broader water management related issues (afforestation, reduction of runoff etc.). Communities are more likely to be interested if confidence has already been generated by providing what may be the most felt need at the community level.

- Perform rapid assessment surveys of projects undertaken for their effective functioning and utilization, through interviews and observation methods. This will allow project managers to feed back relevant information into the planning process for improved project design.

- Use the private sector to develop an effective delivery system for spare parts of water supply systems and for construction of household latrines.

Technology transfer mechanisms and programmes for rural water management

The view that "access to appropriate technology is a more serious problem than the availability of technology per se" cannot be easily dismissed. The UNCED's Agenda 21 on Transfer of Environmentally Sound Technology, Cooperation and Capacity Building (UNCED 1992) reiterated that the availability of scientific and technological information and access to and transfer of environmentally-sound technology are essential requirements for sustainable development.

On the basis of past experience, it has become evident that the success of water resources development projects is strongly influenced by the availability of technology, and whether or not appropriate choices have been made to suit local conditions. A large body of useful technology lies in the public domain. There is an urgent need to improve accessibility of these technologies to developing countries. Developing countries will also need to have the know-how and expertise for the effective utilization of technologies. This implies that human resources development and local capacity-building aspects, including gender-related issues should also be addressed. Environmentally-sound water management technologies should be compatible with national economic, social and political priorities.

ROLE OF THE UNITED NATIONS SYSTEM

For the past forty years various agencies of the United Nations have been assisting developing countries to implement projects in the field of water resources development and management. Many of them have involved a considerable effort in technology transfer. In most cases, these have been a "North-South Transfer", meaning transferring technologies from developed countries to developing countries. No doubt that many developing countries benefitted, particularly in institution capacity building. Direct assistance in technology transfer has been provided in the form of training courses and workshops, overseas fellowships, study tours, etc. Indirect ways of technology transfer included on-the-job training that national counterparts received from expatriates during project implementation.

DISCUSSION PAPER 10

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In spite of these many and varied efforts, there is still an enormous technological gap between developed and developing countries; there are technological gaps even among developing countries. Lack of policy, ineffective institutions and inadequate trained manpower are major bottle necks. In many developing countries, insufficient trained manpower is a particular problem. In a number of cases, those who have benefitted from specialized training are no longer working in the field of water resources development; public service employees, once trained seek employment elsewhere, virtually taking the technology with them.

Another facet of the problem is that technology itself continues to evolve. This implies that technology transfer is not a "one-time" activity but a continuous process. Lack of a continuing programme is a major impediment.

TCDC

There has been innovation within the UN system with respect to partnership in the technology transfer process. Following the Buenos Aires Conference on Technical Cooperation among Developing Countries (or TCDC) in 1978 a set of guidelines and a framework were drawn up that would encourage the developing countries to seek answers to their technological problems among themselves. This has led to a greater number of South-South partnerships of institutions that would not normally have had a chance to collaborate. Fourteen years after the Buenos Aires Conference, the Plan of Action that had been developed is still considered among UN agencies to be the basic framework for activities in TCDC and its aims remain relevant (FAO 1992).

Recently India conducted a TCDC Programming exercise in which 74 national institutions participated and were inventoried according to their capacities to provide expertise. The exercise included the institutional capacities as well as the perspective of some of their needs. This document can thus be used as a reference to bring together partners on the supply and demand side of technological services. This information was put into a compendium and distributed to members of over 40 countries. This type of TCDC programming exercise has been done in other countries and should be continued. A TCDC catalogue on water management is appropriate in this context.

TCDC offers various advantages over conventional North-South technology transfer solutions. Specialists from the South generally have a better socio-cultural and ethnological understanding of the problems experienced by communities in the South. This helps in identifying relevant problems and formulating appropriate ways to address them. Thus the solutions proposed through TCDC will be better suited and adapted to the local realities. The costs of implementing a TCDC solution are generally less expensive than North-South exchanges due to economies made in the price of expertise and services.

While the global use of TCDC as a modality has increased in the past decade, it is still under-utilized. UNDP allows that up to 10% of Indicative Planning Figure (or IPF) or $7.5 million (**whichever is smaller**) be used for TCDC activities. This financial ceiling, however, is rarely met as many developing countries have not taken full advantage of TCDC possibilities.

Certain obstacles have hindered the widespread adoption of TCDC. There is the misconception that technology coming from the South is always inferior to that coming from the North. Technology transfer packages under North/South collaboration are often accompanied by financial incentives, equipment and fellowships which the TCDC programme cannot match. Another barrier is the lack of information available in order to find the right partner that could undertake a TCDC activity. In spite of these constraints, TCDC should be looked upon as a novel and effective way to bridge technological gaps. TCDC should be considered during the country's annual programming exercise.

INVENTORY OF PROVEN TECHNOLOGIES

Rational development and management of water is important to overcome the problems of food production and development in rural areas in many parts of the world. The standard of planning, design, implementation and rehabilitation of water development projects in agriculture can be considerably improved, and many failures avoided, by the availability of adequate techniques, methods and knowledge. The experience of recent decades in developing countries has shown a need for a global approach to this problem. The Inventory of Proven Operational Techniques and Methods in Water Development and Management (IPOT) of FAO was conceived as a step in such a approach (FAO 1990).

The inventoried methods and techniques, generically called "components", consist of manuals of procedures and general guidance, descriptions of equipment, computer software and training materials. They relate to the activities normally carried out by an agricultural water service. When a component of the IPOT is required, it is retrieved from the institution where it is applied and advice on its application can be obtained.

The aims of the IPOT are therefore:

- to provide an international framework for the integration of existing techniques and methods for assessment, development, management and maintenance of agricultural water resources systems;

- to aid in the applications of, and training in, appropriate technology, especially in developing countries;

- to assist field projects in member countries.

FAO has produced a Catalogue that provides information on the organization and use of the IPOT.

The Catalogue consists of a main text and annexes. The main text describes how the Inventory is organized and operated, while the annexes contain detailed information on available techniques and methods ("components") as well as advice on selecting and using these. The annexes are kept up to date by means of supplements issued once or twice a year. To facilitate the insertion of supplements, the Catalogue is published in a loose-leaf form and a table is provided for noting the supplements inserted.

The components of Inventory are provided by Member Nations of FAO and by FAO itself. They are available for transfer. Each component is a self-contained entity which cannot be further subdivided without destroying its functions or usefulness, and should in general be able to work on its own to perform a specific task. Inventory components are classified by subject matter, dealing with the basic activities carried out by an organization or institution involved in agricultural water development and management.

The inventoried components are available for application in various socio-economic environments. In general, techniques are applicable everywhere, but there may be limitations, for example, some are suitable only for situations in which labour is abundant, whereas other techniques require availability of significant capital or are applicable only in countries where high technology is well established. Within a given socio-economic context, components range from simple manual techniques to those involving sophisticated equipment and computer software. In many instances, two or more components are available to meet a particular need. They may be at different levels of complexity, or simply reflect different approaches to the same basic problem.

The Inventory is managed by FAO through its Water Resources Development and Management Service. FAO's activities with regard to IPOT include:

- preparing and distributing guidelines on the substance and form of Inventory components;
- preparing, updating and distributing the Catalogue;
- assisting and cooperating in transfer and use of Inventory components in national projects;
- monitoring the use of the Inventory, including collection of statistics on transfers and identifying gaps in the availability of techniques and methods;
- requesting new techniques and methods from appropriate institutions to cover gaps identified through the monitoring exercise;
- liaising with other national and international technology data bases and technology transfer systems and, where appropriate, bringing the relevant resources to the attention of the users of the Catalogue.

The techniques and methods that are components of the Inventory are available to all Member Nations of FAO, to their national services and agencies and to all international agencies for use in water resources projects.

FUTURE STRATEGY

The experience in technology transfer is extremely rich and varied. Many approaches have been tried, under different conditions. There are formal and informal approaches; transfer could be horizontal (between inter-disciplinary and institutional groups of the same level) or "vertical" (within a sector or institution, but between different levels). Obviously, it is impossible to make any general statement with regard to which mechanisms are most effective. These approaches must be studied in a given context. Flexibility and adaptability are two key aspects of any technology transfer programme.

Modalities for the implementation of technological transfer should be coordinated and programmed jointly by different UN Agencies so as to avoid duplication and wastage of resources. This can be done at the national level through the Programme Approach during national programming cycles. The notion of lead agencies based on specialization and the topic being dealt with could be adopted through an integrated framework.

Many questions related to the way in which technology should be transferred must be asked. Some of these are very broad and apply to the determination of technology transfer policy in general. Other questions are very specific and must be addressed on a case-by-case basis when establishing a technology transfer programme. The following questions are posed for the purpose of stimulating discussion:

- How can the very diverse experience of technology transfer be utilized to frame future strategies and programmes in technology transfer?
- What goals should be set among the UN agencies with regard to technology transfer for integrated rural water management for the year 2000?
- What resources can be counted upon for any programme focusing on technology transfer?
- How to evaluate/steer the progress of the overall strategies of technology transfer? What indicators are used in this evaluation, as cost-effectiveness alone cannot be the only success criterion? Self-reliance and sustainability should also be considered when looking at the systems that transfer technology in a given environment. Success stories, but also the failures must be carefully documented and diffused.
- What are the major problems that confront the implementation of TCDC?. How can the financial aspects of the TCDC be modified to make it attractive to participating developing countries?
- Is the inventory approach to technology transfer in agricultural water use applicable to other sub-sectors in rural water management? What possibilities exist to expand this inventory system to include all aspects of rural water management?

The UN's role in technology transfer will include, among other things: providing assistance to identify technological needs to different target groups; assisting in the arrangements that facilitate technology transfer; and participating in this transfer itself. This role will have to allow the individual governments to establish their own self-reliance in transferring technology to those in need. The simple provision of capital alone will not do.

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Participatory approaches in planning and management of irrigation schemes

Irrigation and drainage programmes are usually presented as being for the general benefit of the public. However, in the eyes of many, the people running the irrigation systems day to day or receiving water from them are seen as the major beneficiaries, whereas water is considered a common good belonging to all, and demand in sectors other than agriculture is increasing fast. Therefore, all citizens have an important interest in the efficient use of a resource which all share, especially when it is scarce. At the same time, water resources organizations are often accused of thinking in terms of the best engineering solution without adequate attention to social and environmental goals or objectives.

Public participation is thus both demanded and felt to be needed at the planning, project concept, design, implementation and operation stages of water resources development projects. This paper examines the subject first from the standpoint of planning and then of managing irrigation and drainage systems. It then discusses the FAO Plan of Action for People's Participation and the International Action Programme — Water and Sustainable Agricultural Development (IAP-WASAD) which is intended to assist countries in preparing their programme for addressing these important issues.

THE FAO PLAN OF ACTION FOR PEOPLE'S PARTICIPATION

Over the past few decades many governments, development agencies and non-government organizations have recognized that the "top-down" approach characteristic of traditional development strategies has largely failed to reach and benefit the poor. In their search for alternative approaches, they all have come to recognize the importance of people's participation as a principal mechanism for promoting rural development.

FAO's experience has shown that through participatory programmes and activities it is possible to mobilize local knowledge and resources for self-reliant development and, in the process, reduce the cost to governments of providing development assistance. People's

DISCUSSION PAPER 11

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participation is also recognized as an essential element in strategies for sustainable agriculture, since the rural environment can be protected only with the active collaboration of the local population.

In 1989, following requests from Member Governments, the FAO Committee on Agriculture (COAG) and the Council examined the issue of people's participation and its activities in rural development. They recommended that the concept of participatory development be integrated into all development policies and programmes of FAO and also suggested that FAO develop a Plan of Action for People's Participation.

Accordingly, FAO developed a Plan (FAO 1991a) which was adopted by the 25th Session of the FAO Conference in 1991. The overall aim of the Plan is to ensure active participation of people in the achievement of sustainable rural development. While it is recognized that other factors relating to social, economic/financial and technical aspects do play an important role in achieving this objective, the active, voluntary participation of self-reliant organizations is equally important.

The Plan, while fully recognizing and respecting the sovereignty of Member Governments, proposes that action be taken in the following seven areas:

- Promotion of greater public awareness of the role of people's participation and people's organizations in agricultural and rural development;
- Creation of favourable legal and policy frameworks for people's participation;
- Strengthening internal capacities of the rural people's organizations at local and national levels;
- Decentralization of government decision-making;
- Promotion of increased dialogue and technical collaboration between governments, development agencies and people's organizations;
- Introduction of appropriate operational procedures and methods to facilitate wider participation;
- Monitoring and evaluation of people's participation.

It must be recognized that the objective of active participation by the people in the development process can be achieved only through consistent and concerted efforts over a long period. The implementation of the Plan of Action will therefore call for the commitment by Member Governments to both long-term policies and adequate resources. FAO can, and will need to play an important role in the implementation of the Plan and to provide technical and financial support to interested countries in this task, at their request. The Plan envisages FAO acting as a catalyst and an advocate to encourage and assist governments and people's organizations in promoting participatory activities.

WHAT IS PUBLIC PARTICIPATION?

Public participation means different things to different people. "Public" means "of, concerning, or affecting the community or the people: the public good. Connected with or acting on behalf of the people, community, or government, rather than private matters or interests." "Participation" refers to processes involving "taking part or sharing, joining with others." Thus public participation will generally mean the involvement of the people, even those not farming, in decisions related to irrigation and drainage.

For purposes of this discussion, public participation includes being informed about the programmes before the decisions are made regarding them; being given an opportunity to be heard; having an influence on the decisions; and agreeing to the decisions. Of course not all are likely to agree to the final decisions, and that is not always essential. At the planning or project identification stage the "players" are often different from those at the operational stage.

As this paper will illustrate, "public participation" takes very different meanings and shapes according to the context (existing socio-political structures, scale, type and stage of projects, past history of irrigation development, importance of irrigated crops in local farming systems, relative scarcity of the resource and demand from other sectors etc.).

There is often a tendency to think only in terms of farmer participation but to ignore the public at large. For instance, serious consideration is being given in many countries to the transfer of the operation and maintenance of water delivery systems to farmer groups; and an FAO sponsored expert consultation held in Indonesia in 1984 which examined Participatory Experiences in Irrigation Water Management went further, encouraging farmer involvement in the planning, design and construction of the system as well (FAO 1985). But, as the following section will show, there is a need to associate groups other than the farmers directly concerned by the projects, especially at the early planning stages.

PUBLIC PARTICIPATION IN PLANNING IRRIGATION AND DRAINAGE SYSTEMS

The environmental movement in developed countries has drawn increased attention to public participation in major projects. In some countries, public hearings are required at various stages of project planning to ensure that the people are given a voice in deciding how public money is being spent.

An aware public is important at all stages of projects. Community participation will contribute significantly to enforcement during implementation but the process begins during the planning stage. There are many examples of polluters doing a better job of cleaning up the environment when it was made known to the public where the dangerous emissions were originating and who was causing the problem which was endangering them.

In a recent World Bank report it was pointed out that for large water investments, governments must encourage stakeholder participation and work toward a national consensus.

The people with environmental concerns or exposed to secondary economic impacts should be heard, as well as water users from other sectors. This will cause some delays during the approval process but may prevent costly delays later.

Although the importance of farmer involvement at all stages of irrigation project formulation and development is known, governmental organizations do not always ensure that it is done. The FAO Consultation on Irrigation in Africa (FAO 1986), concluded that "farmers' involvement in all stages of irrigation development and management, and devolution of management responsibilities to farmer water-users' associations are indispensable to achieve successful development".

Through the implementation of pilot swamp development schemes in Benin, FAO has developed and tested a participatory methodology, in which local communities are considered as full partners and make the major decisions in a negotiation process with local authorities (FAO 1992a). The communities, organized into associations, are responsible for scheme planning, operation and even marketing of products. The project prepares several alternatives for consideration of the association which makes the decision. The inputs to be provided by various partners are negotiated and a development contract is signed. Monitoring and evaluation of the process is provided by members of the association to ensure that there is two-way communication to improve the techniques of working with people.

Representatives of the local communities assisted by the project participated in a national small-scale irrigation development strategy workshop in 1991. Their recommendations, based on their own evaluation of their experience with the project, were incorporated in the strategy which was later adopted at national level.

In Burkina Faso, FAO uses a similar approach to rural development (FAO 1987). The project team works with villagers to assess the situation and identify development problems. Priorities are defined together, and alternative courses of action considered. The choice of development activities which will be performed is the basis of a contract between the village and the project. After completion of the project activity, an assessment of results is carried out by the team and villagers. This type of approach tends to become the norm rather than the exception in rural development projects under different names ("gestion de terroir", "integrated", community land management, watershed management projects...), and usually provides a satisfactory framework for (local) public participation.

Bagadion (1986) reported that lack of participation of the farmers during project planning and construction usually results in the siting of canals and structures which do not correspond with their perceived needs, and thus the non-use of those facilities. Problems which often occur when participation is lacking include inequitable distribution of water, wastage of water at the farm level, and poor maintenance of the system. He further reported that government irrigation agencies tend to resist the idea of farmer participation because of anticipated delays. Review of projects in the Philippines found that properly planned and implemented farmers' participation, while difficult at first, facilitates many aspects of implementation and does not need to delay the project. It is often necessary to provide training and reorientation for the government staff working with farmer groups.

In the Philippines, an Irrigation Community Organizer (ICO) was introduced into the village to assist the farmers. The ICO helped the community to identify their problems and seek solutions to resolve them. This grass-roots approach was well received, as the planning and implementing of solutions was seen by the villagers as their solution, for which they felt ownership and responsibility for its success. The farmers would participate in all phases of development and rehabilitation. A formal Irrigation Association (IA) would be created to continue operation and maintenance after the National Irrigation Administration (NIA) withdrew. A formal contract is involved between NIA and the IA. The key to the programme is the involvement and confidence of the leaders of the village and the people.

Non-governmental Organizations are another group which strongly supports participation on the part of the rural community. NGOs encourage self reliance in rural communities. This grass-roots approach has been well received by those they aim to serve. FAO reports a number of examples of cooperation among members of the community in various countries and types of projects (FAO 1989).

Although there are many success stories of participation, problems have been encountered. In Africa, for example there have been problems in moving from popular participation to a workable arrangement for project implementation. In practice, social organization and custom may discourage participation; government staff or a ruling elite may be opposed; and contractual relationships, land tenure or gender roles may divide the community.

The tendency is to start with pilot exercises to refine the process prior to a large investment. Many rapid and participatory rural appraisal methods, all aimed at participatory assessment, monitoring and evaluation have been developed and are widely used within FAO. They are multi-disciplinary in nature and have an important sociology/ anthropology component. Unfortunately, however attractive and effective these methods are, they can be hampered by a relatively high planning/investment cost ratio and a scarcity of professionals and technicians who can implement them. There may also be concern that excessive emphasis on the process of these methods could divert attention from objective assessment of technical results. Typically, in environment/natural resources-related projects, a participatory approach to development activities must ensure technical and environmental feasibility and give rise to programmes which are cost-effective.

PUBLIC PARTICIPATION IN MANAGING IRRIGATION SYSTEMS

While participation of the public in general is particularly important at the planning stage, since at that time public opinion can change the course of a project, once the project is operational its role becomes less important. The participation of the more direct beneficiaries, namely the farmers, then emerges as a key to the success of the project.

The history of irrigation development testifies to the fact that most of the ancient systems were developed by groups of farmers anxious to use a valuable resource: water. Management of the system by the farmers was a natural consequence. However, at some stage of this process, the magnitude of the effort to store and distribute water was beyond the capacity of the private groups, and governments started to take up the responsibility for building the systems. Here the dilemma of farmer participation starts. Several options are open to governments : (1) for government officials to continue to manage the systems after completion; (2) to turn systems over to the farmers to manage them; and (3) to manage the systems jointly, meaning that some parts of the physical system (generally the larger canals) are managed by civil servants while the smaller ones are the farmers' responsibility.

Most governments have favoured the first option, particularly in the developing world, but this is precisely the one that is less conducive to the participation of the beneficiaries. The literature on management of irrigation systems is full of cases where the performance of such systems has been much below expectations and a recurrent reason for this is the low level of involvement of the beneficiaries. This is often evidenced by the inadequate cost recovery to meet the expenditures of the system, which leads to a chain of negative consequences, including poor maintenance, unreliable water distribution, and lack of confidence in the project staff.

On the other hand, if one analyses systems that were developed by the farmers and managed by them, the picture becomes positive and there are numerous successes. Examples of such systems are reported in South Korea, Nepal, India, Indonesia, Spain, Italy, USA, Argentina and many others.

The conclusion that emerges from the above is that there is high correlation between farmer participation in the management of irrigation systems and their sustainability. Consequently many countries have, in recent years, embarked on programmes that tend to reduce the government role in the management of irrigation systems and to expand that of the farmers by transferring to them part, or the whole responsibility for managing the physical systems. Unfortunately, this is a recent phenomenon and there is little documentation on the processes and the results obtained (Vermillion 1991).

Programmes of transferring the responsibility of management to the farmers are often introduced to reduce government expenditures, as part of major reforms to the economy. There is the expectation that most of the costs related to the operation and maintenance of the systems will be borne by the beneficiaries and that considerable savings will be made as a result of these changes, for example savings from the salaries of the officials who worked in the institutions responsible for operation and maintenance. There is also the assumption that a more direct involvement of the beneficiaries will result in greater accountability of those directly responsible for day-to-day management. There is the hope that better services will be provided and that this will lead to increased crop productivity and sustainability of the systems.

Governments have followed two different strategies to hand over irrigation systems to farmers. Some have favoured the quick establishment of water users' associations (WUA) and a rapid transfer of responsibilities to them. This approach has been followed in some few countries but with little success. Most countries are in favour of a phased handing over, accompanied by training programmes for the leaders of the water users' organizations. Both approaches have their pros and cons, but the general belief is that a phased programme has better chance of success and provides more opportunities to change course if required.

Although these transfer programmes have mostly been initiated in recent years, already some lessons are being learned and some issues identified that call for initial attention and decisions:

- A transfer programme needs strong political support at the highest political level of the country. The public institutions responsible for the management of irrigation systems are likely to resist these changes and only decisions at high political level can overcome such resistance. Furthermore changes to the water laws are often required and there should be political will for such changes.

- Farmers must understand what the transfer programme means: their roles and responsibilities, how to organize, clear rules and regulations for the operation of the system, financial implications etc. To convey all this information to large numbers of farmers is not a simple task. A major effort in communication is required, needing careful planning and allocation of resources.

- Transfer programmes imply that one or several government institutions will see staff drastically reduced or will have to assume different responsibilities. In either case a plan is required and financial resources may be needed for the payment of indemnifications and accrued benefits. Consultations with the concerned staff are of great importance in these situations.

- Farmers are not likely to accept the transfer of irrigation systems that have been poorly maintained and are in need of major rehabilitation. Therefore it is wise to undertake the rehabilitation works prior to the transfer programme. In such cases, farmers must commit themselves to keep the system as received, which may imply substantial financial contributions through irrigation service charges.

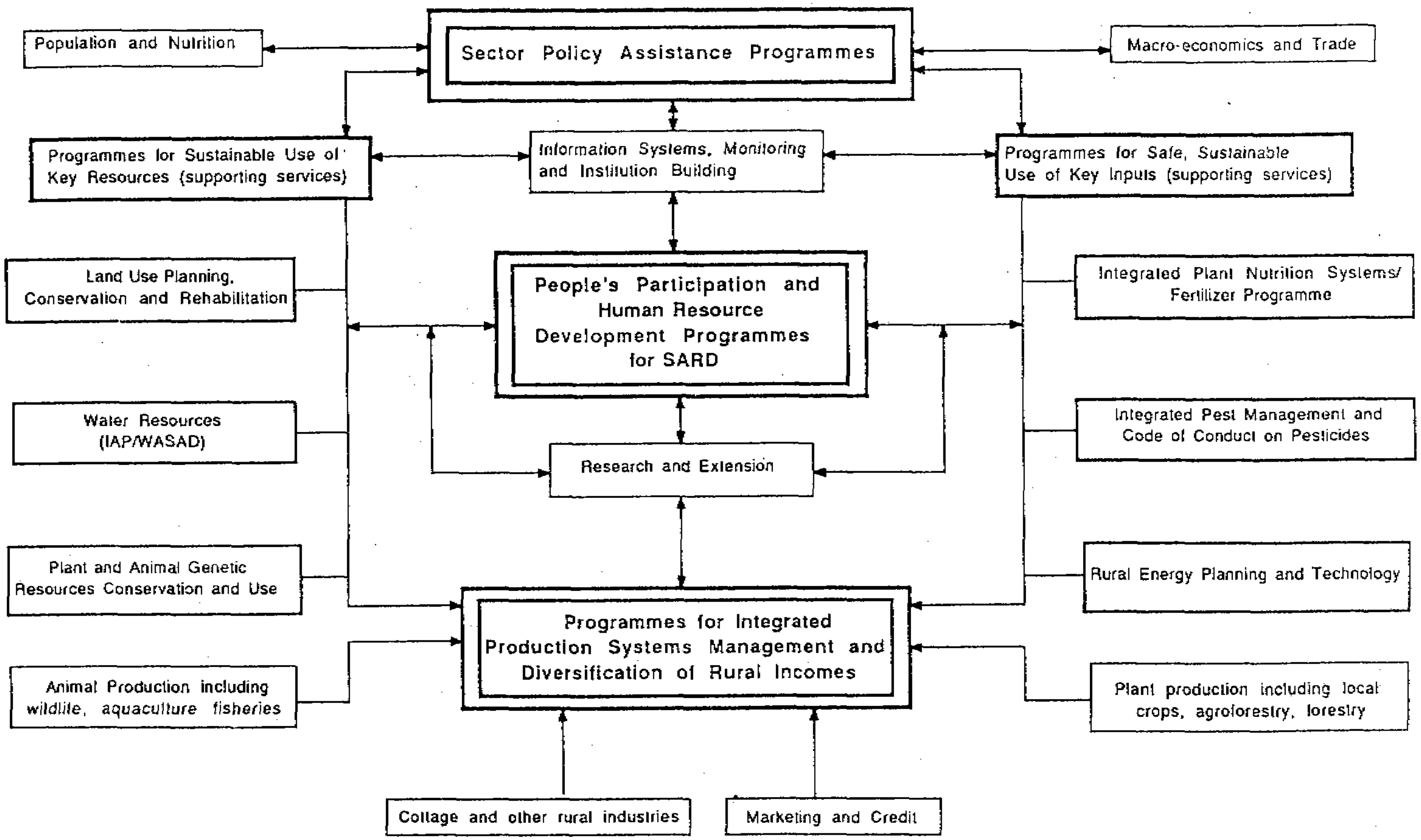
- Training of the farmers and the technical staff that will have responsibility for the management of the system is also an important consideration. Government must take some initiative in this matter and bear some of the costs. Without this support farmers will experience considerable difficulty in managing the systems during the initial years.

- The ownership of the physical systems is a potential area of conflict. Governments take different stands in this matter. Some prefer to remain the owners of the systems and pass them to the farmers on a sort of indefinite lease, and therefore investment costs are not recovered. Others favour the transfer of ownership and would require the payback of investment costs or a part of them. Also if there are problems with land ownership these must be resolved prior to the transfer, since such problems are likely to affect the cohesion of the WUA.

- WUA must be legalized and their rights, obligations and attributions must be clearly spelled out and integrated in the water codes or regulations of the country.

- While many governments are in favour of the transfer of irrigation systems, there are strong reservations about transferring the dams or the structures that store the water. In many instances water is used for several purposes, and only governments — as representatives of the general public — can manage the resource for the benefit of all possible users. There are however exceptions, and some countries (USA, Spain) have transferred even main structures to the WUAs or to the private sector, where they are being properly managed.

FIGURE 1
International Cooperative Programme Framework for Sustainable Agriculture and Rural Development (ICPF/SARD)



N.B. Double bold lines indicate programme and project groupings of an integrated, multi-disciplinary nature.
Bold lines indicate major programme and project groupings of a specialized nature; related activities are indicated with thinner lines.

The transfer of irrigation systems is clearly not simple, and has to be well thought out and carefully planned. This is why many governments are approaching the problem in a step by step manner and initially transferring only the minor canals (tertiary and below). Depending on the results obtained, the responsibility for managing larger canals will be added.

It is of utmost importance that farmers be involved, from the planning stage of the irrigation system, in all aspects that may have consequences in its future management. During the construction phase, efforts should be made to promote the establishment of the WUAs and to help farmers to understand the technical aspects of management of the system and to take an increased responsibility in it. This tutoring period may be short (one or two years), but could require longer if farmers have limited experience in irrigation and the associations have little cohesion.

Interactions between irrigation systems and the surrounding environment

Irrigation systems generate intensive agriculture and tend to become social and physical environments with different characteristics from those of the surrounding rainfed areas. Often the irrigation areas attract people from both nearby and remote areas, on expectation of employment and a better livelihood which unfortunately may not be fulfilled. This is often the result of faulty information publicized through the media. The public must be informed of what is happening in their area, but overoptimistic statements about the potential that can be generated may create unnecessary problems.

Irrigation systems are usually developed where a rural community already exists, but rarely are the needs of these villagers taken into consideration. A small part of the irrigation water can be used to improve the quality of life of the local people, and so generate positive effects. For instance, with proper water treatment and management, village water supplies can be improved, or recreational areas established. On the other hand the interaction of villages and towns with the irrigation systems may cause pollution in canals, resulting in serious problems in system maintenance or to the crops. There is a need for dialogue between the beneficiaries of the irrigation systems and others in the affected rural environment. Information exchange about each other's needs is the first requirement but institutional mechanisms are also required to effect solutions.

IAP-WASAD

The role of the public in promoting sustainable development is widely accepted. The FAO strategy document on Sustainable Agriculture and Rural Development (FAO/Netherlands 1991) emphasizes the active involvement of rural communities, collectively and individually, in all phases of rural development. Promotion of a "bottom-up" approach by developing more decision-making authority and responsibility down to the local level; providing incentives; and enhancing the status and management capacity of local communities, including that of women was stressed in the FAO's SARD strategy. A conceptual framework of this strategy is illustrated in Figure 1.

One of the four basic principles for sustainable water management adopted by the 1992 International Conference on Water and the Environment (ICWE), was that of public participation. This principle states that water development and management should be based on a participatory approach involving users, planners and policy-makers at all levels. The conference recommended that decisions will need to be taken at the lowest appropriate level, with full public consultation and involvement of the users in the planning and implementation of water projects.

The importance of public participation for sustainable development is amply reflected in the FAO International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD), FAO (1990). The objective of the IAP-WASAD is to assist developing countries in planning, developing and managing water resources on an integrated basis to meet the present and future needs for agricultural production. IAP-WASAD emphasizes the importance of involvement of the farming community and the private sector for sustainable water use in agriculture. The following recommendations of the programme are relevant in this regard:

- ensure participatory approaches in water programmes by involving all members of the community, both farming and non-farming members;
- enhance the capability of farmers in the implementation, operation and maintenance of water programmes; and
- increase local capability for integrated water resources planning and management, with special emphasis on linking public technical agencies to rural development institutions and local community organizations.

LESSONS FROM IAP-WASAD COUNTRY MISSIONS

FAO in collaboration with relevant UN organizations and bilateral donor governments carried out six country and lake-basin missions (Egypt, Indonesia, Lake Chad Basin, Mexico, Tanzania and Turkey) under the framework of the IAP-WASAD. The objectives of these missions were to identify issues relating to water management for sustainable agricultural development and to formulate costed and targeted national or basin action programmes.

The following could be deduced from these missions with regard to public participation (FAO 1991b, c, d, e and FAO 1992b) in irrigation policies, planning, development and management:

- In all countries, national irrigation planning is a "top-down" exercise, with little public participation in the decision making process. National agricultural and irrigation development policies are developed by the relevant government ministries in accordance with social and economic development goals. If the public has participated in shaping such policies, it has been only indirectly, i.e. through the political process, to the extent that government constitutes elected members, who are representatives of the people.
- In water management at project level, the participation of beneficiaries is evident in all countries, but in varying degrees. Management of water beyond the tertiary level is often left to farmers, who may manage water collectively through water users' groups or may function individually.

In Egypt, in the Sakia area and in gravity-fed areas of Fayoum, informal water users' groups have been managing water at the farm level for hundreds of years, while other areas have had little or no experience with formal or informal water users' groups. Egypt has now formulated a legal framework for the establishment of WUA's under the Egyptian Irrigation and Drainage Law which states:

> "the mesqa (tertiary canals) hydrological unit is private by virtue of being located on private property. The WUA is legally a private organization. As private formal associations, WUAs will be involved in planning, operating, maintaining and monitoring their own mesqa."

In Mexico, the government is actively pursuing the transfer of 2.0 million ha of irrigation districts to WUAs. In the first phase, hydraulic structures up to secondary canals are to be transferred, and this will be followed by a total transfer of the system.

In Indonesia, village irrigation systems covering an area of about 850 000 ha are managed by farmers. There is a move to hand over the responsibility of operating and managing tertiary systems of large and formal irrigation projects to the farmers, but the creation of formal WUAs or similar farmer groups is still at the experimental stage.

In Turkey, WUAs are functional in a few selected irrigation schemes. The government encourages the formation of such groups in all irrigation projects and proposes to establish legislation for the creation of WUAs and to provide incentives for them.

It has become evident from the country missions that people's participation is more evident in soil and water conservation and watershed management activities as compared to irrigation and drainage activities. In fact, many governments promote community and people's participation in such activities.

In Turkey, a World Bank funded watershed rehabilitation project is being planned for implementation. There was broad agreement with a participatory approach, whereby the local population and the government agencies will work together to identify problems and plan and implement solutions through integrated activities on a micro-catchment basis. The following activities amply demonstrate the participatory approaches to be adopted by the project:

- An initial contact and confirmation of local interest in soil and water conservation activities;

- Using a "farmer-centered-problem census, problem solving" approach, sessions would be conducted with local populations to elicit a census of the real and perceived problems of individual households and of the village as a whole; and

- Evaluation and implementation of the community's proposed solutions to the problems.

The IAP-WASAD has included, in its national action programmes, technical assistance to promote people's participation in all possible water management activities:

In Egypt, Indonesia, Mexico and Turkey, assistance is proposed to: strengthen legislation for WUAs; provide direct assistance to the creation and functioning of WUA's ; and train participating farmers in organizational and management skills.

In Mexico, a technical assistance programme is proposed for support to the transfer of operation and maintenance activities to irrigation districts and the modernization of irrigation infrastructure and operation and maintenance techniques.

In Indonesia, direct support to farmer groups is proposed for operation and maintenance of irrigation systems beyond tertiary level, crop diversification, and soil and water conservation in rainfed agricultural areas.

In Tanzania, the need to promote the role of women in irrigation and agricultural activities is emphasized. The Action Programme states the following in this regard: "women's productivity needs to be improved, both in the production of food as well as in their other household chores. For agriculture, this requires improved technologies that increase output and the productivity of labour through for example, better land preparation, irrigation and weed control techniques".

CONCLUSION AND RECOMMENDATIONS

Public participation and involvement in decisions which affect their lives is considered essential by many governments today. Water resources are used by all people, but governments tend to distribute responsibility for planning and managing their use among many organizations. In the United States, at present, there are at least 13 congressional committees, eight cabinet level departments, six independent agencies, and two White House offices with responsibilities related to water resources issues. Similar situations exist in other national governments. Coordination is often very difficult under such circumstances. Sometimes the same water is being assigned or programmed for different uses by "responsible" organizations. Conflicts exist and the public should be given a voice in their resolution.

Recent changes in government attitudes and increased concern about the environment have caused the public to express greater interest in having their views heard by decision makers. The June 1992 United Nations Conference on the Environment and Development held in Rio de Janeiro has focused considerable attention on the need for a sharing of responsibility for the wise use of limited resources.

FAO has developed a Plan of Action for People's Participation, which could serve as a framework for public participation in all rural activities, including those related to Irrigation and Drainage programmes.

FAO's experience has shown that farmers' involvement in all stages of irrigation development and management and the devolution of management responsibilities to farmer water users' associations are indispensable to achieve sustainable development. A number of national government and non-governmental organizations have taken bold steps to induce public participation in irrigation and drainage programmes and many have plans to follow.

Country and lake-basin programming missions carried out under the framework of FAO's International Action Programme on Water and Sustainable Agricultural Development indicate that the concept of transferring the responsibility for managing tertiary units of irrigation and drainage systems to farmer groups is accepted by the governments in principle. Transfer of responsibility will have to be well planned and executed within a phased programme that will enable the establishment of required policy and legislative changes; the training of farmers; and the strengthening of farmer organizations. The transformation of operational and administration-oriented government agencies to perform advisory and monitoring functions needs time and requires resources.

Public participation is the key to sustainable development. As we march towards the 21st Century, public participation is likely to increase. It is incumbent on all of us to promote this change into a dynamic and constructive process in which people take initiatives and take action stimulated by their own thinking and deliberation.

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Educational approaches to building awareness and action in rural communities for integrated water management

Imagine a situation where women and men farmers arrive home after a few hours at their local community centre, having attended a session on water management with an agricultural extension agent, and their children arrive home having studied the same topics in school. Both parents and children learned about integrated rural water management in their local area through participatory activities such as the sorting of pictures into different piles, the ordering of cards containing statements from general to specific, by moving figures on a flannel board, and drawing sketches of their community. No one lectured to them about the concepts or told them what they should and should not do. The children also brought home a colourful magazine with stories, games, puzzles, contests, and cartoons, all about water management. Over the evening meal, parents and children talk about what happened that day.

Listening to the radio that evening, they heard messages about integrated rural water management. More was to happen over the following days and months to involve adults and children of the community in determining what they can do about better use and conservation of water. A certain synergism occurred at home and in the community at large because both adults and children were exposed to the same ideas at approximately the same time and in similar ways.

Although this sounds very idealistic, collaboration among different government ministries and NGOs is bringing about such educational synergism at the local level. This, plus the use of innovative approaches to awareness-creation and education, can enable communities to understand the concept and to determine what actions they can take with and without external assistance.

Principle 1 of the Rio Declaration on Environment and Development is clear:

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Attaining this goal of sustainable development requires far more than laws, regulations and enforcements, more than scientific studies on ecosystems and more than institutional

DISCUSSION PAPER 12

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plans of action. Integrated efforts by all sectors, organizations, communities, families and individuals are required to make socio-economic development sustainable, including that of integrated rural water management. Individuals, from the highest government ministers to farmers and school children, ordinary women and men, all need to be a part of the plan and part of the solution. Leaders in a society have the special responsibility to initiate a process whereby ordinary citizens can become aware, knowledgeable and involved in protecting the environment.

This paper concerns the educational approaches to building awareness and action, in rural communities, for integrated water management. It reviews what communities can be expected to do and then describes the communications and education support methods that can be applied to bring about effective community participation.

WHAT COMMUNITIES CAN BE EXPECTED TO DO

Communities can be expected to do the following things (with outside assistance) to help bring about integrated rural water management:

- assess the local water situation
- define local water management problems affecting the community
- suggest actions for improvements and prioritize them
- make an action plan for community involvement in integrated water management
- make decisions about who will do what in the action plan
- share responsibility for overseeing the actions and improvements
- evaluate and modify the management scheme

Experience from the rural water supply sector shows that communities can be effectively involved in the following specific areas of water management:

- planning of community water supplies and their operation and maintenance
- management of domestic and agricultural wastewater
- maintenance of storm water drainage
- vector control related to water (insects, snails)
- prevention of water pollution from various sources.

The degree of community and individual involvement and commitment is dependent upon at least two primary factors: the degree of understanding of the problem or concept, and the perceived advantages to the primary economic unit (normally the individual or the family).

In order for individuals to understand the concept and the advantages of community and individual participation in integrated rural water management, good communications and education about the topic are essential.

COMMUNICATION/EDUCATION SUPPORT FOR INTEGRATED RURAL WATER MANAGEMENT

Communication/education support for integrated rural water management can be roughly divided into two categories:

- those activities that simply raise awareness and prepare individuals to accept new ideas
- those activities that educate individuals on a deeper level and enable communities to take responsible decisions.

Public awareness campaigns cannot be expected to bring about individual or collective behavioural change and should not be relied upon as a substitute for community participation in planning and management. Such campaigns are instrumental in creating an atmosphere of public support for new ideas. Getting active community involvement requires different methods from those designed to raise awareness.

Raising awareness

In most countries there are a various of **channels of communication** that can be utilized in raising awareness and providing some understanding. These include:

- the public and private educational system
- adult functional literacy programmes
- non-governmental organizations
- government extension programmes, especially Agricultural Extension
- religious leaders
- community leaders and respected persons
- commercial publications such as newspapers, children's comics, photo-novellas, women's and men's magazines
- radio and television

As many channels of communication as possible should be used simultaneously to form a net of messages into which nearly every individual could be caught.

The **public and private educational system** reaches large numbers of school children at very little additional cost. Integrated rural water management can be worked into existing curricula in science without major curriculum reform. Informal materials in the form of cartoon magazines, puzzles and games can be developed and distributed to schools with teacher guides. Ministries of Education review and revise curricula generally every five years, and at this time integrated rural water management can be placed into the formal curriculum.

Adult functional literacy programmes have been used as informational vehicles for family planning and health education in many countries. Often adult literacy programmes do not have enough adult-oriented reading materials and frequently welcome new materials from different programmes. Coordinating with adult literacy programmes is a way to obtain a wide coverage of adults at minimum cost.

Many **non-governmental organizations** reach wide audiences with literature and community activities, such as Scouts' and women's organizations. These organizations usually seek good causes to promote, and many NGOs are concerned with environmental issues. Coordinating with NGOs is another "minimal cost" method of promoting understanding of integrated water management.

Existing **government extension programmes** can be excellent vehicles for particular environmental messages. Agricultural extension is a logical vehicle for educating adult farmers about water management. What remains is to train the extension agents themselves in effective participatory learning methods and provide them with learning/teaching materials.

Educating Communities Through Schools in Burkina Faso

In Burkina Faso, EAST (Eau, Agricole, et Santé en milieu Tropical), a French NGO, is spreading water, sanitation and hygiene messages through the primary school system that reaches into the community at large. First, primary school water supplies and sanitation facilities are improved. As these schools are located in the centre of the villages, the improved water point serves the entire community. A kit of essential drugs is provided and a revolving fund for keeping the drugs supplied is put into place. Teachers are trained in water management and hygiene education, using participatory methods, and these methods in turn are used in the classroom with the children.

The next phase of this project reaches into the community to the families and friends of the children, to improve water supplies, sanitation and hygienic practices. The key to success of this project is the combination of physical improvements and participatory methods of learning. Improvements have been highly sustainable over the last six years and the Government of Burkina Faso is now taking over the project in two provinces. EAST, with support from WHO and SIDA, is now moving into Benin with this innovative approach.

Reaching the public through **religious leaders and institutions** has many advantages in certain parts of the world, and generally these institutions are more than willing to cooperate with improving the environment. Special training can be offered to religious leaders, with suggestions as to how they can educate people at the local level.

Disseminating messages through **existing commercial publications** is probably the least costly and one of the more effective ways to raise public awareness, if such publications are already popular and widespread. Commercial publishers should be permitted to present material on water management in their own way using their own graphic artists. Since such publishers already have a market, we can assume that they know how to appeal to local readers, and publishers are often eager for news-worthy material. It would be necessary to produce information packets for distribution to publishers. A number of countries disseminate health and environment messages through popular children's cartoon magazines (see box on the "Mazingira approach") and in Latin America the "photo-novella" is a popular medium for health and environment education.

Radio and television are becoming increasing available world-wide. Listening and viewing practices of adults and children have to be carefully studied and messages have to be pre-tested on a variety of audiences. The disadvantage of producing programmes for radio and television is that they are generally expensive to produce. In countries with many languages or dialects, messages must be made for different groups and regions.

Participatory learning methods

Awareness is the first step toward education and the eventual participation of communities in integrated water management. To develop a deeper understanding at the community level, participatory discovery-oriented learning methods need to be used.

Participatory methods are used to foster group discussions in communities and in the school classroom. They are generally regarded as being superior in bringing about popular participation in discussion and follow-up actions, primarily because of the use of graphic

The Mazingira Approach

One creative approach to mass education about the environment has been developed by the Mazingira Institute in Nairobi, Kenya. The Institute, which means "environment" in Swahili, produces children's cartoon magazines with games, puzzles, stories, and contests that can be used in the classroom and taken home for sharing with other family members. The magazine is written for a class 5 reading level, and as many adults were not able to continue past class 5, the reading level has been found appropriate for most of the literate population of Kenya.

This kind of teaching material has the advantage of being highly flexible. Messages are changed from year to year to meet changes in our knowledge. Also, these magazines are designed to be used in a variety of subjects and to attract children to reading them outside the classroom. Such magazines usually do not require a formal curriculum endorsement from the Ministry of Education, as would expensively printed textbooks, and thus the content can be decided upon and printed quickly. In addition to providing each elementary school in Kenya with ten copies of the magazine, the magazines are also sold in local newsstands for the community at large.

Recently the Mazingira Institute produced a cartoon booklet, teaching poster and teacher's guide on dairy cows and beef cattle. Agricultural extension agents encountered the magazine in the field and requested the Ministry of Agriculture to provide them with copies to give to farmers and teacher guides giving tips for holding discussions. It was felt that a reading level appropriate for grade 5 children is also appropriate for farmers, and the subject matter is of interest and relevance for persons of all ages. Since that time Mazingira has produced a magazine for school children on dental care which is now distributed by dentists and health centers, and a magazine for school children on immunization which is passed on to mothers through immunization clinics. The lesson here is obvious, that what we need to know at age 9 we also need to know at 90 and that people of all ages enjoy learning through informal materials.

WHO and UNICEF are jointly sponsoring research in Burundi on children's cartoon magazines as a vehicle for health messages. This two-year project will determine if a magazine of this type can be launched in a culture with few printed materials and high rates of illiteracy. Distributed through the school system, the Catholic Church and other NGOs, its pass-on value to out-of-school youth and family members will be assessed, as well as its effectiveness in imparting knowledge and raising awareness.

materials developed for the local culture, and the enjoyment community members derive from participating in the learning/discussion activities.

These learning materials and activities are particularly useful for discovery-learning among illiterate adults, but the materials are not childish and are equally effective for use with literate adults and children.

Participatory methods and accompanying graphic materials are not intended as teaching tools to change attitudes and behaviours so much as tools to help people "to develop the outlook, the competence, the self-confidence and the commitment which will ensure a sustained and responsible community effort" (Srinivasan 1990). This approach can help people to understand for themselves and to have the desire to create their own actions and to pass this knowledge to the next generation.

A participatory method being promoted in the community water supply and sanitation sector is the SARAR methodology. The approach was adapted by the UNDP/PROWWESS Project (PROWWESS stands for the promotion of women in water and environmental sanitation services) to achieve involvement of women in community decision-making, and a manual for training trainers in participatory techniques **Tools for Community Participation** was produced in 1990. The approach strives to build Self-esteem, Associative strengths, Resourcefulness, Action-planning, and Responsibility among community members, especially women. The manual and the course on the methodology remain in high demand. The materials produced as a result of the training course are relevant to local cultures.

When community development workers, school teachers or other leaders possess the participatory skills and the relevant graphic materials to work with confidence in the field, they can go beyond imparting knowledge to community members, which may be their limit when left only with a field manual, a flip-chart or a radio cassette.

COLLABORATION FOR EDUCATION AND COMMUNITY PARTICIPATION

In the ideal situation, ministries concerned with integrated rural water management (the Ministry of Agriculture, the Ministry of Health, the Ministry of Water Resources and the Ministry of Education, for example) would decide to collaborate on coordinating approaches to community education.

The educational activities might begin with a public awareness campaign using as many channels of communication as possible. This would be followed with training in participatory methods for agricultural extension agents, sanitary engineers and school teachers. Enjoyable learning materials would be produced for school children, and the children would be encouraged to take home inexpensively produced magazines to share with their parents.

Extension agents, teachers and other community leaders would facilitate participatory decision-making at the community level while supported by a public awareness campaign (such as radio) and school educational activities. Integrated educational activities can lead to meaningful community involvement in integrated rural water management.

Any number of UN organizations including WHO possess expertise in communications and education that can be applied to integrated rural water management. Countries should be encouraged to examine all possible channels of communication, to avoid reliance upon passive methods alone, and to venture into the more innovative methods, such as cartoons, photo-novellas and participatory methods, that are proving to be so effective in community water supply and sanitation.

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Building in-country capacity: experience of the UNDP-World Bank Water and Sanitation Program

WATER AND SANITATION SECTOR STRATEGIES

Prior research and promotional work on water and sanitation technologies and testing of delivery systems have developed to the point where large-scale investments are being made in the sector. A range of modalities and options exist which are being adapted to country circumstances. The question of institutional development for sustainable delivery of services has now moved to centre stage.

The strategy of the UNDP-World Bank Water and Sanitation Program emphasizes four inter-related themes in response to this challenge:

- Investment Support
- Structured Learning
- Capacity Building
- Disseminating Lessons

These themes find common ground in supporting in-country processes in support of investment projects, in emphasizing learning by local professionals and institutions and in encouraging local synthesis of experience and the application of activities from this synthesis. Special emphasis is placed upon the establishment of local learning processes with the primary objective of enhancing local capacities for sustainable development in particular localities.

THE CHALLENGE OF CAPACITY BUILDING

Lack of in-country capacity has been a major cause of poor performance in increasing the access of the poor to water and sanitation services. The major constraints to increasing capacity are : inefficient and ill-defined policies, disfunction of organizational systems, constraints on local-level decision-makers, and shortages in managerial and technical skills.

CASE STUDY 8

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Building country capacity to absorb an increased level of investments, and for sustained service delivery, implies activities in several inter-related areas.

- **Policies.** The creation of a supportive or "enabling" policy environment and legal framework facilitates the efficient use of resources in the sector. Capacity building involves improving the "rules" governing the sector as well as the regulations and practices which define the environment within which sound investments are made and sector development occurs.

- **Institutions.** The search for efficient and effective mechanisms between public, private and community institutions in the regulation, promotion, delivery, maintenance and payment of services is a central concern of the sector. Improved organization and management of sector institutions can facilitate achieving institutional objectives. The improvement of management techniques includes leadership development, responsive personnel policies, career planing and participatory techniques in planning and decision-making.

- **People.** Strengthening the managerial and technical capabilities of people involved in the sector is required at all levels. Human resource development (HRD) comprises staff development (through formal and informal training and other techniques of skill enhancement), increasing the capacity of local-level decision-makers, providing opportunities for greater women's involvement in the sector, facilitating community management, technical assistance, regional cooperative learning and strengthening professional associations.

Capacity building is as broad a concept as that of development itself. Much activity can be undertaken with little achievement. Effective strategies need to be:

- **Targeted** — towards the achievement of specific objectives.
- **Multi-facetted** — to contribute to the interaction between policies, institutions and people in single localities.
- **Long-term** — since the challenges of institution-building and skill development require sustained support and commitment.

PROGRAM CAPACITY BUILDING APPROACHES

The UNDP-World Bank Water and Sanitation Program has experience of, or access to, a range of approaches and tools for building capacity for use in different contexts. These include:

- **Policy Development**
- **Development of Country Sector Networks**
- **Identification and Promotion of Agents of Change**
- **Promotion of Learning and Dissemination of Information**

The following section summarizes these tools, giving examples of their application in different contexts.

Policy Development

The development of a sound and sustainable policy framework fosters sector development and strengthens key institutions. The main items of this framework are:

- **Institutional arrangements, including coordination and regulatory arrangements**
- **Financial arrangements**
- **Technical options**

Assistance to governments and in-country agencies in sector policy development and programme design remains the cornerstone of the work of the Program's Regional Water and Sanitation Groups (RWSG). Support to country sector agencies in policy development continues in over 20 countries, including China, Indonesia, Philippines, Pakistan and Zimbabwe. Typically, support to the government in project development, policy reform, training and HRD has assisted to provide a framework for increased investment in the sector. Policy development has often, as in the case of Uganda, resulted in formal Sector Strategy and Action Plans; in other countries Program assistance has promoted in-country policy, learning and development through informal means. The Program's policy development support has often been complementary to the work of the Bank Operations Division, building foundations through pilot projects, studies, technical assistance and HRD, prior to or in the formative stages of major investments.

Development of Country Sector Networks

Promotion of local institutions as foci of local learning, training, promotion and dissemination of information is a powerful capacity building approach. Local institutions support sectoral development in a more sustainable manner than external institutions, have greater local ownership of approaches and are more tuned to local requirements. Influential institutions in the sector may be found in a variety of locations in different circumstances: within governments, or local governmental authorities; within tertiary educational institutions; among non-governmental organizations (NGO); or in the private sector. Identification of institutional locations for effective promotion of the sector is an important strategic consideration. Different institutions have different areas of influence and draw on different learning experiences.

The promotion of a network of sector institutions within countries provides a flexible approach, building on natural affiliations between institutions, through which differing components of the sector can be addressed by different partners in a sustainable and efficient manner. The development of a more formal strategy, often with the help of an external catalyst, can further facilitate development of a country network.

In the case of Brazil, the Program in association with the Bank and with the active support of a range of Brazilian institutions, has assisted to catalyze a pluralistic, structured learning process among Brazilian institutions. In other cases, such as the National Irrigation Administration in the Philippines, the Small Enterprise Practitioners in Thailand and the NGO Forum in Bangladesh, national linkages of local institutions or learning groups have, through a process of consultation or exchange of experience, greatly extended capacity.

The International Training Network for Water and Waste Management (ITN), coordinated by the Program, has experience from several countries in enhancing in-country capacity through the development of national networks of sector institutions. National training networks drawn from government, the tertiary educational establishment and non-governmental sector. The nature of inter-institutional linkages and areas of priority concern of individual networks varies according to local demand.

In the Philippines, the national centre of the Philippines branch of the ITN, the Local Water Utilities Administration (LWUA), coordinates a network of 18 participating institutions. A core of common ground has been established, based on local experience and external learning. Agreement has been reached among participating institutions on areas of sector specialization and strategies for sector promotion. The Philippines ITN is able to promote skill enhancement in the sector, reaching people and institutions in a range of different circumstances. The network is linked through its board to the authority coordinating the sector and the major investments in the country, such as the Bank-assisted First Water Supply, Sewerage and Sanitation Services Project (FW4SP).

In the case of Zimbabwe, the national ITN centre, the Training Centre for Water and Sanitation (TCWS) plays a varied role in the sector. The centre assists government in specialized training initiatives and advice on training and education aspects of sector development; it liaises with local national training institutions, training trainers; and it collaborates with local sector research laboratories (such as the Blair Research Laboratory) in disseminating information on local state-of-the-art approaches. The centre is also a local partner for international training initiatives, with partners such as CEFIGRE and a regional centre, attracting pupils and regional linkages with a range of sector agencies in Southern Africa. The centre was a natural partner for a recent Bank-assisted sector review which drew together contributions from the lead actors in the sector and will provide the basis for a major rural infrastructure initiative in the country.

The India Training Network for Water Supply and Sanitation, a partner of the ITN, is an example of a network in which complementarity of institutions has been consciously built into the network design. Technology-oriented institutions are twinned in the network. Ten network institutions, representing a wide geographic coverage, are linked across the country. The network is coordinated by a central cell within the government and owned, executed and mainly funded by the Government of India.

An integral component of the Program, PROWWESS (The Promotion of Women in Water and Environmental Sanitation Services) has developed a global network, drawing special attention to the challenges of promotion of the role of women in the sector, in particular at the community level, through participatory management approaches. PROWWESS operates at various levels, extending capacity in the sector, extending participatory skills and enriching human resource development by drawing attention to gender issues. In East Africa, for example, promotion of inter-institution linkages and training of trainers with sector experience in participatory training techniques, has created a network of PROWWESS-affiliated NGOs exchanging experiences of sector work and building effective participatory approaches.

Considerations in establishing effective local sector networks include:

- sustaining creative linkages between different interest groups within the sector and establishing linkages to emerging sector institutions;
- creating financial sustainability of networks and establishing sources of seed money to stimulate partner organizations;
- establishing effective mechanisms for coordination;
- establishing a dialogue between network partners and policy-makers.

Agents of Change

Strengthening national institutions is perhaps the most important long-term initiative, for reasons of sustainability. Significant advances in the sector and key innovations for strengthening national approaches often come from key individuals. The Program will continue to act as a conduit of expression for the most innovative developing country in the sector and to support these local "agents of change" in a variety of ways.

The establishment of the RWSGs presents an important and unique opportunity for capacity building and the encouragement of excellence among national staff. The Program has encouraged staffing policies which promote exchange of experience with gifted and innovative individuals in developing countries. RWSG and Program staff are increasingly drawn from developing countries, strengthening regional leadership of the sector and providing incumbents with excellent regional experience. The use of national counterparts to international staff further increases the training function of RWSGs.

In East Africa, African capacity building initiatives are being supported by involvement of leading national officers in regional RWSG meetings. Key national sector personnel advise on RWSG operations, both strengthening direct accountability for national operations and strengthening the comparative experience of national officers.

Increasing concern is being placed by the Program upon identifying local agents of change, who can play a pivotal role in encapsulating local experience, producing and testing out new approaches. Programmes in countries of focus will actively seek linkages with key sector proponents "who can make a difference" to national initiatives.

Learning and Dissemination

The promotion of learning and dissemination of lessons at the local, country, regional and global levels is a fundamental prerequisite for capacity building and development of a sector leadership.

The Program is seeking out circumstances which can provide solutions to generic problems and undertake rigorous applied research to advance global understanding of the sector and to finding better solutions. The Program's research agenda has been broadened both in its range and depth. The research programme is now extending the analysis of financial and institutional options, to determine better the role and function of governments, local authorities, private organizations and users in seeking efficient and sustainable methods of extending access to services.

The depth of this analysis is also being extended. The policy research and learning process necessitates investigation and learning at several levels. National learning networks build and disseminate knowledge from local "best practice" experience. As described above, this process is acknowledged as a necessary approach to sector development. The Program's mandate also demands asking questions across country and regional experiences and disseminating lessons derived from this research.

CONCLUSION

The vision sustaining these approaches is to create within developing countries the ability to manage sustainable national programmes which extend access to the unserved. The endpoint of these initiatives will have been reached when:

- Key sector leaders are fully aware of the major policy choices facing them, and their implications, and they have developed policy frames which encourage efficient and equitable national programmes directed at extending access to unserved populations.

- Institutions and legislative frameworks are in place which facilitate sustainable growth, enabling services to be extended by market-like mechanisms.

- Countries establish national forums and networks for policy debate, programme coordination, learning, information dissemination and training in the sector.

- Regional and global networks are established which foster learning, information exchange and training among national agencies.

- Key institutions are equitably staffed by personnel with appropriate management and technical skills.

- Users, in particular women, have ownership or appropriate levels of consumer voice affecting the management of services.

Capacity building for agricultural water management in Egypt

THE GLOBAL WATER CRISIS

Many arid and semi-arid countries are already facing water crisis; the problem is likely to become more serious and will continue well into the 21st century. During the next two decades, water will increasingly be considered as the critical resource for the survival of the arid and semi-arid countries, so much so that political tensions between certain neighbouring countries over the use of international rivers, lakes and aquifers may escalate to the point of war, even before we move into the 21^{st} century (Biswas 1991).

All the major issues facing the world are inter-related, and the dynamics of the future of mankind will be determined not by any individual issue but by the interactions of a multitude of issues. An increase in population needs more food, energy and other raw materials. Augmenting food and energy supplies necessitates sustainable water management. The common requirements in all practical responses to the solution of these major problems must include greater investments, more technology and expertise and intensified cooperation. The interrelationships are global in character, and hence they can best be understood and resolved within a global framework, and one which incorporates a wide variety of integrated regional and national responses.

INTERVENTION STRATEGIES

Supply Management versus Demand Management

The term 'water resources' refers specifically to the supply side. For many years it was thought that developing this resource would be the key to an adequate satisfaction of the needs. It has emerged however, that the demand side of the resource is equally important. Without effective demand management, national development goals cannot be achieved.

CASE STUDY 9

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Capacity building may focus for example on farmers operating an irrigation network, or it may take a broader, long-term approach, like strengthening educational institutions building a nation's capacity for the sector.

Capacity building is a strategic element in the sustainable development of water resources, their management and supply. A continuing process that has to permeate all activities.

The process of involving communities should be used as a mechanism to reverse the trend of supply-driven policies to demand-oriented ones. This should be compatible with the consideration of social dimensions (UNDP Delft 1991).

Capacity building has been identified as a requirement for the future. This paper will focus upon the demand management side in relation to capacity building, in order to optimize water resources utilization by the agricultural end-user.

National Needs Assessment: Drivers For Change

Limited land base coupled with an ever growing population at an annual birth rate of 2.7% are the main features affecting the food production/consumption gap in Egypt. Egypt's population will grow to about 70 million by the year 2000 and swell to 110 million by the year 2025. In the Nile Valley, the population density is about 1300 people per km^2. Even with an intensification rate of 200% which would increase the agricultural land base from 7.4 million feddans to 14 million under crops, production of food would satisfy only 50% of the requirement, for a population of 59 million.

To bridge the food gap and to fulfil a goal of self reliance, expanding the land base and optimizing agricultural outputs are urgently needed. Agricultural land has increased about 1.9 million feddans (1 feddan = 4200 m^2). However the net gain has been somewhat less due to urbanization. The *per caput* share of land declined from 0.5 acre in 1897 to close to 0.1 acre in 1990. The current land reclamation programme aims for the development of 2.8 million feddans.

Land is not the critical constraint to development in Egypt, but rather water resources to reclaim the vast land resources available. Egypt presently has about 1000 m^3 of water per person which approximates the reasonable threshold for development. This ratio is projected to decline to 350 m^3 per person by year 2025. Competition for water resources among all end-uses will clearly intensify. This underscores the urgent need for better use and management of the finite water resources available today, for the future development of Egypt.

WATER RESOURCES QUALITY AND CONSTRAINTS

Fresh water is a finite resource, essential for agriculture, industry and for human existence. Without fresh water of adequate quantity and quality, sustainable development is not possible. Three sources of water are available, excluding rainfed systems which represent only about 5% of the agricultural lands in Egypt.

The Nile system is the major source of water in Egypt and Sudan. The Nile basin is also important in recharging underground water sources. The main aquifers in Egypt are the Nubian sandstone and alluvial aquifers in the Nile Valley and Delta. Additional shallow aquifers exist but are characterized by marginal water quality, due to salinity. Agricultural drainage water and sewage wastewater represent the third category of water resources available (Tables 1 and 2). The construction of the old Aswan Dam, the AHD and major Nile barrages has led to greater control of the flow. As a consequence, the ability of the river to flush its bed of sediment and associated pollutants at periods of high flow has fallen significantly. There is a set of technical questions about the sustainability of the system, whether it is salinity, excess nutrients, heavy metal, waterlogging or pesticide residues (Table 3).

The water quality of the Nile above the reservoir, and that of the river from Aswan to Cairo is fairly good. The Delta is characterized by stagnant water, low flow, low dilution and assimilation of wastes, production of macrophytes and high growth of algae, high level of nutrients and high organic matter loads. Water quality monitoring in Egypt is recorded by the Nile Research Institute (NRI), Water Research Center (WRC), Environmental and Occupational Health Center, National Research Center, and the Agriculture Research Center (ARC), and its Central Agriculture Pesticides Laboratory (CAL).

Chemical pollution

Pollution may occur from different types of inputs: disposal of industrial waste on agricultural land, atmospheric fall out, use of sewage sludge or effluent, pesticide residues, intensive mineral fertilization. The last two cause by far the most severe damage.

Within the River Nile Protection and Development Project (RNDP), a joint study was carried out by the (NRI) and the (CAL) to monitor and analyse fifteen organochlorine pesticides residues in sediment and fish samples. Organochlorine pesticides are considered in this investigation because they are fat-soluble and not water soluble, which establishes their long persistence in the environment. Organochlorine pesticides, extensively used in Egypt since 1950, were prohibited in 1980. Samples taken from Lake Nasser showed a higher level of DDT residue than samples taken from other sites. This was attributed to the current use of this organochlorine in Sudan. No water samples analysed contained residues of organochlorine pesticides that exceeded the limit established by WHO for drinking water.

Fertilizer use has soared since the 1960s to compensate for the nutrients formerly supplied by the alluvial sediments now retained at the High Dam and, also, as a result of the subsidy policy evolved by the government to increase both cropping intensity and the expansion of areas under cultivation. According to Ministry of Agriculture and Land Reclamation statistics, fertilizer use during 1987-1988 amounted to 990,000 tons of nutrient equivalents, representing about 2.3 million tons of market product. This represents an average volume per feddan of 190 kg (80 kg if expressed in nutrient equivalent), a very high value compared to application rates worldwide, but quite understandable in view of the high crop intensity.

TABLE 1
Egypt's present and future water resources

Source	Quantity (10^9 m^3/year)	
	1990	2000
River Nile	55.5	57.5*
Groundwater	2.6	4.9
Agricultural drainage	4.7	7.0
Treated municipal sewage	0.2	1.1
Saving flow management	0.0	1.0
Deep groundwater	0.5	2.5
Total	63.5	74.0

* First stage of the Jonglei canal completed.

TABLE 2
Egypt's present and future water demands (10^9 m^3/year)

Use	1990	2000
Irrigation	49.7	59.9[1]
Municipal uses	3.1	3.1[2]
Industrial	4.6	6.1
Navigaton and regulation	1.8	0.3
Total	59.2	69.4

[1] Includes irrigation requirements for an additional 0.6 million ha to be reclaimed by the year 2000.
[2] Additional requirements for the year 2000 will be secured through reducing system losses to 20%.

TABLE 3
River Nile flow downstream of the Aswan High Dam (AHD) and the drainage water flowing to the sea

Year	River Nile flow below AHD (10^9 m^3)	Drainage water	
		Quantity (10^9 m^3)	Salinity (mmhos/cm)
1984-85	56.40	14.30	3.71
1985-86	55.52	14.07	3.72
1986-87	55.19	13.59	3.59
1987-88	52.86	12.27	4.12
1988-89	53.24	12.03	4.26

TABLE 4
Amount of pesticides used in tons during the period 1988 to 1992

Year	Pesticides	Fungicides	Herbicides	Total
1988	9943.37	4163.16	1723.40	15830.29
1989	9512.30	4733.58	1583.80	15831.68
1990	7344.65	3436.94	969.25	11750.84
1991	4948.35	2841.16	583.11	8372.62
1992	3852.42	1918.60	315.31	6086.33

Legislative framework

Law 48, which addresses the protection from pollution of the Nile River and related waterways, was enacted in 1982. However it has yet to be enforced, most likely because it did not include a realistic phasing of discharge reductions to meet the standards. To enable enforcement in the near future, temporary permits incorporating realistic phasing of reductions and penalties for discharge of pollutants would need to be considered.

Pesticide use in Egypt

The Ministry of Agriculture has strengthened laws and introduced new legislation, dealing specifically with the control and safe use of pesticide. Egypt has a stringent pesticide registration law that is principally based on biological efficacy studies, labelling, packaging, toxicological investigations, residue trials, and environmental safety. Through the regular meetings of The Codex Committee, the maximum residue limits are determined and recommended as being consistent both with good agricultural practice and with the acceptable daily intake proposed by WHO.

Use of modern pesticides has much improved pest control; but because of increasing pest resistance, and environmental pollution concerns, research workers are now concentrating more on integrated pest management (IPM), in which pesticides are used in conjunction with other methods i.e. pheromones, beneficial insects, detection and sampling methods, economic thresholds, plant resistance and cultural methods. Integrated pest management in cotton, citrus and tomato is now well developed in Egypt, while other pest management programmes are being verified for several other important crops.

In Egypt, due to their long persistence and the rapid development of resistance in agricultural pests against their toxic action, chlorinated insecticides were completely replaced in the late 1960s by less residual phosphate and carbamate products. Synthetic pyrethroids are also in use as well as a variety of insect growth regulators. These chemicals are safer and more compatible with the environment. Considering the stringent pesticides law controlling these chemicals and the continuous efforts devoted to implement IPM strategies in several major crops, the amount of pesticides used annually in Egypt has dramatically decreased. As shown in Table 4, the amount of pesticides used in 1988 was 15 830 tons, gradually decreasing to only 6086 tons in 1992. This shows clearly that the policy adopted by the Ministry of Agriculture for pesticide regulation, IPM teaching, research, implementation and extension has brought about a change in outlook and practices regarding the use of pesticides.

Reuse of Wastewater

During the last decade, wastewater reclamation, recycling and reuse in agriculture have received much attention around the world, especially in the arid and semi-arid regions.

Wastewater reuse in agriculture accomplishes several purposes: minimizing wastewater pollution, providing much needed nutrients and fertilizers to agricultural soil, increasing agricultural production, supplying a reliable and continuous flow of water at minimal transportation cost: and most importantly contributing to the huge quantities of agricultural water needed for landscaping, soil modification, animal husbandry and crop irrigation. It is generally accepted that wastewater use in agriculture is justified on agronomic and economic grounds, but care must be taken to minimize adverse health and environmental impacts.

About 3.1 thousand million cubic metres (10^9 m^3) of the Egyptian share of Nile water is allocated for city uses. A large portion of this amount enters the municipal wastewater network. Cairo produces 0.9 x 10^9 m^3 of wastewater; by the year 2000 it will go up to 1.7 x 10^9 m^3 and by 2010 it is expected to reach 1.93 x 10^9 m^3. By the year 2010 Alexandria will produce 2.2 x 10^9 m^3 of wastewater. The rest of the country, in contrast, is expected to produce up to 4.9 x 10^9 m^3. The disposal of such a vast amount of water is a serious environmental problem. Sewage treatment stations are being constructed in several locations near the major cities in order to purify the water before it is pumped to the waste sites (desert or large water bodies). Sludge is usually dried and prepared to be used as soil and fertilizer amendment.

Pilot research units were established near Cairo, Alexandria and Ismaelia in order to control the pollution and use the waste water.

UTILIZATION-OPTIMIZATION

Aquaculture

Nile fisheries are of the highest importance as a source of affordable protein for the population. About 1/3 of animal protein consumed in Egypt comes from fish. From 1982-1992, total fish production from all sources increased from 222 000 tons to 347 000 tons. Fish production in Egypt has historically come from various capture fishery sources (marine and fresh water). Water pollution, as well as overfishing are affecting the productivity of these natural resources. Lake Mariot and Lake Manzala are examples of lakes affected.

Fish consumption in Egypt is about 7/kg/caput/year which is still below the international average. Fish production from aquaculture has increased at a higher proportional rate than total fish supply. In 1977, only 8.3% of the total fishery production was supplied from aquaculture, while in 1988 12.7% of the total was from aquaculture (about 30 000 tons are produced annually through aquaculture). Egyptian aquaculture currently has more than 100 000 feddans, of which about 96% is private sector. This contrasts with 71% private ownership out of a total of 30,000 feddans in 1989.

The major type of aquaculture in Egypt is fish farming in earthen ponds using different levels of intensification. Most of the lands used in pond culture are saline or alkaline with poor drainage characteristics, and have little or no potential for agriculture development. The use of fresh water from the River Nile and from irrigation canals is prohibited for pond culture. Only drainage water is available for such aquaculture. About 12 000-15 000 m^3 of water are required for each feddan per year for filling, and to compensate for seepage and evaporation.

Cage culture is another means of aquaculture in Egypt. Cages are licensed in the River Nile and its branches. The number of cages has increased from eight in 1985 to about 2000 cages in 1992. Tilapia are the major fish being cultured in cages. Cage culture in marine waters is currently being attempted.

Integrated agriculture/aquaculture also represents a developing area of Egyptian aquaculture in the forms of rice-fish and animal-fish culture. Rice-fish culture was initiated in 1983 with 500 feddans in production. Currently, about 400 000 feddans are used for rice-fish culture. About 20 000 tons of fish are produced annually, with common carp the main fish species. Duck-fish as an integrated culture system is still in the preliminary stages.

Production of fish fry and fingerlings is needed for different aquaculture activities. To support fish culture activities, four fish hatcheries have been in operation since 1980. Additional hatcheries in Upper Egypt (five) and in Alexandria and Sinai are being constructed. The use of water directly from the supply canals is allowed in fish hatcheries. Water quality is an essential factor in successful fish culture. Water sources vary significantly depending on type of effluent utilized (sewage, heavy metal, suspended solids, pesticides). This requires careful monitoring and management.

To support aquaculture activities, the National Aquaculture Center at Abbassa was established. This expanded as the Central Laboratory for Aquaculture (CLA) to provide leadership in research, training and extension for applied aquaculture. Most of professional staff of CLA were trained overseas, mainly in the USA with USAID funding. About 70 research staff are currently employed by CLA which has joined the Agricultural Research Center (ARC). The physical facility includes a mix of well equipped wet and dry laboratories for research in nutrition, feed preparation, limnology, ecology and biology, fish disease, genetics and breeding, reproduction, physiology, fish culture systems, economics and extension,and fish processing.

On-farm Water Management

Irrigation systems improvement

The majority of the Egyptian agricultural lands depend on surface irrigation systems. Water delivery is based mainly on several extensive canal systems served by principal canals which offtake from the Nile and the branches to a number of main canals that branch in turn to form "mesquas". The mesquas are small canals that serve about 100 to 500 feddans and from which individual farmers take their water.

The mesquas system was developed to save water and improve water distribution efficiency. The water level in the mesquas is always 50 cm below ground level and farmers were forced to pump the water using the "sakias", an animal-driven water wheel. Most of the sakias have been replaced by mobile diesel-driven centrifugal pumps. Water is conveyed from the sakias or pumps to individual fields by small channels called " marwes", which typically serve 10 to 50 feddans. The disadvantage of this system is the lack of control of the amount or timing of irrigation delivery by farmers.

To improve this system, modifications were necessary for the physical features of the water conveyance system such as control structures, conveyance ditches, lifting devices, and pipelines. Improvement covers both operation and maintenance aspects. Several attempts to improve this system have been reported, including canal lining, mesqua offtake structures, drop structures, check structures, division boxes, outlets and turnouts. These modifications were reported to improve the surface irrigation efficiency by about 25%. Furthermore, the introduction of laser levelling for the land is essential to improve the uniformity of water in the field and to minimize the waste of water on the farm.

On-farm irrigation management starting from the mesquas and up to the individual fields is the responsibility of the Ministry of Agriculture and Land Reclamation. Programmes related to research, extension and training, aiming at the improvement of on-farm irrigation systems and the optimization of on-farm water management are currently executed by the Soil and Water Institute and the Agricultural Engineering Institute of the Agricultural Research Center in collaboration with other institutes.

Improving the Old Land Irrigation System:

The Egyptian share of Nile water is about 55.5 x 10^9 m^3 per year. The amount allocated for agriculture from this share is about 38 x 10^9 m^3 per year. The total irrigated area in Egypt is about 7.4 million feddans, out of which 1.3 million feddans are irrigated by advanced irrigation systems, i.e. drip and sprinkler, and 6.1 million by surface irrigation.

Irrigation efficiency for the surface irrigation can be as low as 50%, while the advanced technology improves efficiency to 70% for sprinkler and 90% for drip irrigation systems.

In order to expand agricultural lands through land reclamation programmes, the major constraint that has to be solved is that of fresh water availability. The Land Master Plan for Egypt has identified priority areas of 3.4 million feddans that can be reclaimed if water can be made available. It is evident that improving irrigation efficiency in the "old lands" is a major way to secure water resources for the land reclamation programme. If the irrigation efficiency of 50% of the old land is raised to an average of 80% by improving canal systems and on-farm water application, this will save as much as 3000 m^3 per feddan per year, with a total of about 18 x 10^9 m^3 per year. This water saving can support a land reclamation programme for an additional three million feddans (6000 m^3 of water/feddan/year).

Protected Agriculture

Protected cultivation is one of the major elements of agricultural intensification. Production under plasticulture is characterized by high production per unit area and per cubic meter of water applied. The production of different crops under plastic has increased three to eight-fold in comparison with the open field. The water use efficiency for tomato under plastic houses for example, is 15 kg fruit/m^3 water, while it is only 1.6 kg fruit/m^3 water in the open field.

Protected cultivation is a tool for proper crop management that maintains a cleaner and less polluted soil and atmosphere. Biological pest and disease control systems can be applied in greenhouses effectively and this will minimize the chemical applications of pesticides. In addition, organic farming is more profitable when confined under plastic or glass as compared to the open field.

Farmers have acquired technical know-how related to these techniques, due to intensive effort by the agricultural research system to produce technological packages for protected cultivation and low plastic tunnels, with emphasis on research, development and extension units spread in different locations within the suitable agroclimatic zone. The area under plastic increased 7.5-fold in the last seven years, from 2000 greenhouses in 1987 to 15 000 in 1992.

Low plastic tunnels are even less expensive compared to greenhouses, and are quite suitable for some crops like tomato, cantaloupe and strawberry. The area under low plastic tunnels in Egypt increased from essentially zero in 1985 to about 25 000 feddans in 1992.

Hydroponic systems under plastic to optimize water use efficiency and fertilizer utilization were evaluated at several research and development sites. A technology package was developed from these cumulative efforts over the last seven years, for introduction of modified nutrient film and sandponics techniques to growers in the Sinai and the Red Sea where water resources are very limited. The basic idea of the modified nutrient film technology (NFT) is to prepare the soil bed in a slope, and lay a polyethylene gully over it. Nutrient solution is circulated from the catchment tank at the lowest end to the highest point of the slope and then by gravity through the gully back to the tank. Evapotranspiration in this system occurs only via the plants and this resulted in 100% water use efficiency compared to 85% for well-designed drip irrigated plasticulture and 40-60% for open field cultivation.

Recirculated sand culture is one of the substrate-based hydroponic systems that can efficiently use natural materials in a modern cantaloupe, cucumber, and pepper cultivation. Like the NFT system, the sand culture is prepared by excavating rows in problematic soils, lining them with polyethylene sheets before filling with "clean" sand. The nutrient application is accomplished using drip systems. The excess water in the system is collected in a tank, modified every day by adding water and concentrated nutrients up to the desired level and re-used for the cultivation as irrigation water in a closed system. The adoption of such techniques in the Red Sea area and Sinai can provide fresh vegetables for local consumption, for tourism, industrial, and civil demands, which reduces the pressure on transportation of fresh commodities from the Nile valley to these areas.

Soil-conditioner application, both in the form of organic matter or synthetic polymers, improves the water-holding capacity of the sandy soil substantially. One unit of soil conditioning material can hold water up to 200 times its weight, and make it available for plant roots in sandy soils. Several types of soil conditioners have been subjected to experimentation in the last 5 years. The influence of soil conditioning and soil moisture availability on plant growth is promising, especially in woody-tree nurseries and the protected cultivation of vegetables. The idea of manufacturing these materials in Egypt is being considered.

Human infrastructure was a target of several research and development programmes. Training programmes for protected cultivation were made available for growers and university graduates. The numbers of trainees exceeded 1600 in five years. These were considered as a core for the development of plastic-house farming in Egypt and also in some other arab countries.

Improving crop efficiency traits

The need to conserve water resources leads to management practices which promote greater water use efficiencies. One option available is to advocate and promote the farmers' selection of crops which produce more per unit of water. This is a topic which has been broadly developed and wide cropping options are available to farmers. Management control practices with such non-traditional crops must be translated through extension activities to the grower.

An additional strategy is to select cultivars within traditional crops which have considerably shorter development time (i.e the time interval from sowing to harvest) and which could save one or two irrigations thus minimizing consumption of water. This strategy has the additional advantage of allowing new cropping strategies, and providing multiple cropping on limited arable land. New marketing opportunities would then be available to the grower. Diversification of farm products may make the farmer less vulnerable to downward pricing fluctuation for a given commodity.

This strategy also requires the farmer to gain new cultural-management expertise. An added benefit of early-maturity varieties comes from the fact that the crops' vulnerability period to pathogens and pests is also reduced; requiring potentially lower pesticide inputs. Over the longer term, better cropping rotations may be developed; beneficially reducing soil-borne pathogens below economic thresholds. It is therefore not surprising that early maturing is one of the most sought after traits in crop improvement programmes.

Using Modern Technology in Crop Production

The ARC in Egypt is using three high-technology systems to enhance agricultural development. The first system is genetic engineering, to harness advances in biotechnology to support agriculture. The second system uses expert systems as a tool to optimize productivity by improving crop management capabilities. The third system uses Landsat technology for proper management of natural resources (El-Beltagy 1992).

Tolerance to adverse environmental conditions

A major domain for genetic engineering is the study of salt- and drought-tolerance, which are considered among the most serious problems in developing countries. The production of salt-tolerant strains of plants for salinized areas could be achieved by adopting non-conventional means of plant breeding. Partnerships of traditional plant breeding methodologies and contemporary molecular genetic engineering technologies have been established through the Agricultural Genetic Engineering Research Institute and ARC-University breeders, to alter crops' genetic make-up to be better adapted to water-restricted environments. This includes various water-related characteristics of the plant, i.e drought, temperature extremes, desiccation, salinity and waterlogging tolerance as heritable features. The goal is to manipulate components of the plant which condition higher productively per unit area and/ or to promote higher yield per unit of water. Adapting crops to more marginal environments represents another tool to maximize management/utilization of available water resources; whether this can be achieved without major sacrifices in yield potential remains open to conjecture.

Computer expert systems

The use of computer expert systems in agricultural extension can increase the yield and improve the quality of agricultural products. Further, they can optimize the use of water and land resources for crop production, through agro-management decisions in irrigation, nutrition, fertilization, weed control, herbicide application, insect control, and pesticide application. By using an expert system, workers can raise their performance to an expert level, hence improving their efficiency and effectiveness.

Landsat Technology and Agriculture

Landsat imagery is becoming extensively used in agriculture, land-use planning, and environmental monitoring. This will continue to increase as the technology advances and users gain experience with this relatively new tool. The Landsat system not only gathers the data, but also puts them into digital form for computer analysis. This provides precise monitoring of:

- Settlement and urban encroachment on fertile agriculture lands.
- Crop area estimation for individual crops.
- Early detection of plant diseases, water stress and nutrient deficiency.

Geographic Information System (GIS) is the fundamental technology for merging various independent spatial data (maps) into a form that represents information. Within the ARC in Egypt, institutions and laboratories conducting research on genetic engineering, using expert computer systems and Landsat technology, in agriculture, could not only serve the goals and objectives of the agricultural development plan for Egypt, but could also make savings regionally via joint research programmes and training.

LINKAGES AND HUMAN RESOURCES DEVELOPMENT

The key to success in land reclamation and desert development is the introduction of an appropriate advanced agromanagement technological package including crop selection, on-farm irrigation management, fertigation technique, and integrated pest management including chemigation, etc.

His Excellency Prof Dr. Youssuf Wally has formed regional committees for research, training and extension based upon agroclimatic zones. These committees formulated policies for enhancing the delivery of technological packages for major crops, including the design and implementation of appropriate training programmes for subject-matter specialists and end users.

More than 1600 agricultural engineers were trained in different topics related to modern irrigation, fertigation and IPM. A network of research and development units formed the nucleus for adaptive research and demonstration needs for agricultural desert development. Special emphasis was placed on creating a cadre of agricultural specialists for on-farm irrigation management.

Two FAO-executed projects are participating in fulfilling these objectives in Egypt. The first one, the Protected Cultivation Project (EGY/86/014), formulated several intensive training courses for hands-on know-how and theoretical background of modern irrigation techniques (particulary drip irrigation). The second is the Computer Expert System for Improved Crop Management (EGY/87/024); efforts have been made through the project to meld state-of-the-art human experience with computers, to transform modern irrigation techniques and fertigation into a knowledge-based system readily available to subject-matter specialists for diagnosing and advising on problems related to crop management. In addition, the Computer Expert System has been validated as a feasible tool in education and research.

Capacity building includes not only training and education and technology transfer, but also research-institution building, institutional development, and human resources development.

The importance of human resources development is stated in the Water and Sanitation for Health report. A dedicated, well trained person will always find a way to get a job done, whatever the institutional setting. On the other hand, a good institutional structure, however well defined, may have no impact if the people working within the structure do not have the capability to implement the programme (WASH 1990).

Human resource development related to water-use needs includes the ARC, WRC, Desert Research Center (DRC), National Research Center (NRC) and university efforts to optimize research inputs related to water resource management. The funding of these activities is provided by the Egyptian Government and several donors (USA, Europe and Canada).

Achieving Water Resource Management

While the International drinking water supply and sanitation decade of the 1980s, initiated by the Mar del Plata Action plan in 1977, made major strides toward meeting community water and sanitation needs, it fell short of its goal of service for all by 1990. Also, recommendations of the Action Plan concerning water resources generally, and agricultural irrigation in particular, were not adequately addressed. Of all the shortcomings in implementing the Mar del Plata Action Plan, the failure to address the water resources issues of the developing world is the most threatening.

The New Delhi Statement prepared at the Global Consultation on Safe Water and Sanitation for the 1990s, stressed capacity building as one of its major elements. A UNDP symposium "A Strategy for Water Resources Capacity Building", held in Delft (1991) — the Delft Declaration — was transmitted to the 1992 Dublin Conference on Water and Environment and subsequently to the UN Conference on Environment and Development in Rio de Janeiro. These valuable and constructive global efforts to achieve appropriate water resource management strategies will succeed only when there is a political will at the international, regional and national levels to carry out the necessary actions.

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Water management in irrigated agriculture in Mexico

The evolution of agriculture in Mexico, from the perspective of its natural resources, has been limited by the lack of the combination of water availability and suitable lands. It has been necessary to unite these two factors by means of the construction of hydro-agricultural infrastructure works to prepare farm lands and for water control and storage.

The nation covers an area of 196.4 million hectares. The average annual available runoff amounts to 410,000 million cubic meters. However, the climate makes irrigation practically indispensable in most of the cropped areas. On the basis of the Lowry and Johnson, Oribe classification, 62.8% of the national territory corresponds to arid climates, with a precipitation of less than 400 mm, where irrigation is indispensable; in 31.2% of the lands, irrigation is necessary with precipitations of 400-600 mm; in 4.5%, irrigation is recommendable and in only 1.5% irrigation is not necessary.

Aridity therefore constitutes the main limiting factor for agricultural activities, although these are also affected negatively by the country's orographic characteristics, as Mexico is one of the most mountainous countries in the world. This causes great contrasts and irregularities in the climate and the predominance of steeply sloped lands that severely limits their extent and quality for agricultural uses.

Taking into account the above factors, water availability for irrigation and the feasibility of implementing future developments, the Secretariat of Agriculture and Hydraulic Resources estimated in 1975 that the total irrigable area in Mexico amounts to 11 million hectares, of which 7 million hectares would utilize surface water, 2 million underground water and 3 million hectares required the construction of drainage systems.

On the basis of the Irrigation Law of 9 January 1926, the National Irrigation Commission (CNI) was created, under which the construction and organization of the National Irrigation Systems was begun. After 1935, these were denominated as Irrigation Districts.

CASE STUDY 10

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TABLE 1
Harvested area and production of main crops (irrigated and rainfed)

YEAR	MAIZE		BEANS		SORGHUM		WHEAT	
	AREA (THOUS HA)	TONS (THOUS)	AREA (THOUS HA)	TONS (THOUS)	AREA (THOUS HA)	TONS (THOUS)	AREA (THOUS HA)	TONS (THOUS)
1980	6 766	12 374	1 551	935	1 543	4 689	724	2 785
1981	7 669	14 550	1 991	1 331	1 684	6 086	860	3 193
1982	5 824	10 767	1 605	980	1 434	4 718	1 009	4 391
1983	7 421	13 188	1 958	1 286	1 528	4 867	857	3 463
1984	6 893	12 788	1 679	931	1 636	5 038	1 034	4 505
1985	7 590	14 103	1 782	912	1 862	6 597	1 217	5 214
1986	6 417	11 721	1 820	1 085	1 533	4 833	1 201	4 770
1987	6 801	11 607	1 787	1 024	1 853	6 298	988	4 415
1988	6 506	10 600	1 947	857	1 800	5 895	912	3 665
1989	6 468	10 945	1 313	586	1 620	5 004	1 145	4 374
1990	7 339	14 635	2 094	1 287	1 820	4 978	933	3 931
1991	6 947	14 252	1 989	1 379	1 381	4 308	984	4 061
1992*	7 068	13 630	1 519	858	1 452	5 297	892	3 583
AVERAGE	***7 476***	***13 763***	***1 920***	***1 121***	***1 762***	***5 717***	***1 063***	***4 363***

* Estimated figures on the basis of the progress up to date of the Autumm-Winter 1991/1992 cycle, registered in the month of August.

Source: Secretariat of Agriculture and Hydraulic Resources, 1992.

During the 1960s, it was seen that most of the Irrigation Districts showed considerable deterioration because of soil salinization caused by, among other factors, deficiencies in the drainage systems. In order to correct these problems, in recent years, a Programme for the Rehabilitation of the Irrigation Districts has been begun, with funding from the World Bank and with producer participation. Towards the middle of the 1960s, the National Plan for Farm-Level Improvement (PLAMEPA) was put into action, also backed by external funding. The main objective of this Plan was to improve the operation of the districts, reduce conveyance losses and give technical support to the producers for increasing the efficiency of water use, as well as the expansion of harvested areas. As a result of these activities the annual production growth rate exceeded 5%.

At present, of the 20 million cropped hectares nation-wide, 6.3 million are under irrigation. It is interesting to note that the production value of these areas is approximately 50% of the total harvested crop value, which implies that the productivity of these areas is 2.5 times greater than that corresponding to the rainfed areas. The main crops are: maize, with a harvested area of more than 7 million hectares and a production of 14 million tons; beans, with 2 million hectares and 1.1 million tons; sorghum, with 1.8 million hectares and 5.7 million tons, and wheat, with 1 million hectares and a production of 4.4 million tons (Table 1). Of this production, the areas under irrigation are: 25% for maize, 29% for beans, 47% for sorghum and 94% for wheat.

The production value for these main crops exceeds 5.6 thousand million US dollars. There are 79 Irrigation Districts, with an irrigated area of 3.5 million hectares. The rest of the irrigated land is made up of 27 000 small irrigation units, distributed nationwide, with a total area of 2.8 million hectares.

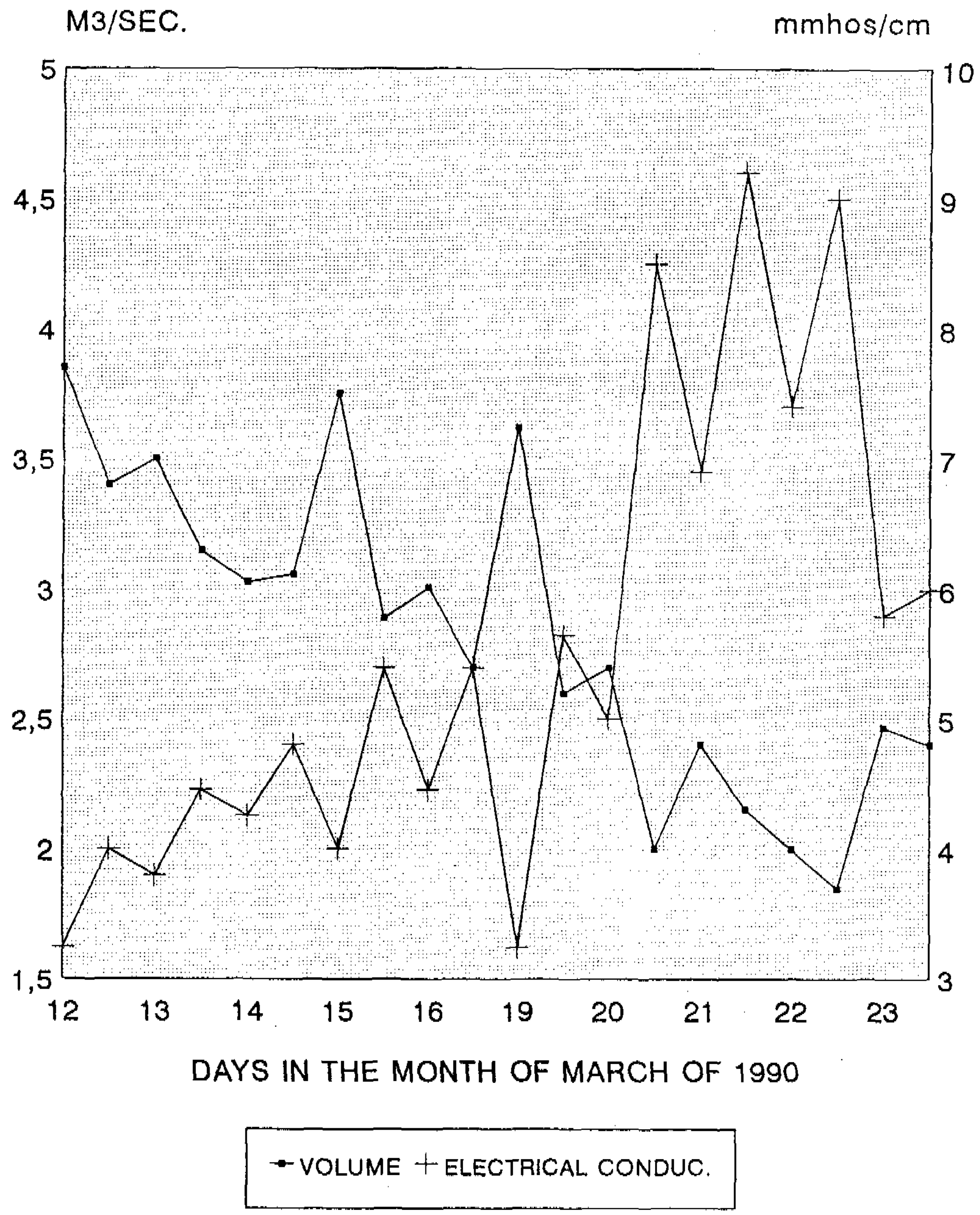
PRESENT CHALLENGES

At the beginning of the decade of the 1980s, the National Irrigation Districts and Units have undergone a deterioration of their infrastructure and productivity, which has resulted in a considerable drop in crop yields. This situation was brought about by a decrease of funding resources and deficient administration, caused by a severe economic crisis, not only on a national but also international level, that was reflected by reduced participation of the users in the costs of operation, conservation and administration as well as a decrease of subsidies from the Federal Government.

Conveyance efficiency, that in 1977 had reached 65%, has dropped to 57%. This reduction means that conveyance losses have increased by some 2800 million m^3 annually, which represent sufficient water to irrigate some 300 000 hectares. Likewise, cropped areas have also diminished by 20% and crop yields are tending to diminish due fundamentally to the expansion into areas with drainage and salinity problems that already affect more than 500 000 hectares. As a consequence of the above, the growth rate of the Irrigation District production has fallen to 0.5%, that is, only one tenth of the rate corresponding to the decade of the 1970s (Robles 1992).

In gauging carried out in the Northwest Irrigation Districts in the lateral and sublateral canals and the branches, and in the discharges into drains of excess water at farm level, it was estimated that, on the average, 22% of the irrigation water from the canals was wasted,

FIGURE 1
Volume and electrical conductivity gauged in the collecting ditch 'Guayparime', Irrigation District 075 Rio Fuerte, Sinaloa, Mexico



mainly due to poor operation practices by the personnel that operate the Districts and lack of care by the users.

This was demonstrated at the beginning of the agricultural cycle of 1989-1990, when a monitoring system was established at control points of the collecting drains. Figure 1 shows the variations in water volume and quality caused by not practising night irrigation and by inadequate hydraulic infrastructure, such as storage, that would allow greater flexibility in the operation and distribution of water.

Since large volumes of water are lost as a consequence of poor operation of the distribution network, production and productivity levels of the Districts are limited. Second crop cycles are restricted, the established crops do not receive timely attention and delays occur in cropping at optimum dates.

In general, the challenges facing the Irrigation Districts can be summed up as:

- Deterioration of the hydraulic infrastructure.
- Low water conveyance efficiency in canals.
- Inappropriate expansion of irrigation into areas with elevations close to sea level.
- Deficient drainage of farm lands.
- Salinity
- Land levelling requirements on farm lands.
- Insufficient charges for irrigation services.
- Poor participation of water users in district administration.

CORRECTIVE MEASURES

In order to correct these problems in the Irrigation Districts of the Northwest, the implementation of Modernization Projects was begun in 1987. These consist of an improvement process for irrigation systems in order to reach levels of development that will exceed those of the original design. In short, a modernization to achieve new and higher levels of efficiency (CNA 1989; 1992). Many of the Irrigation Districts and Units are included in this programme, summarized in Box 1.

The Modernization Programme is aimed at:

- An increase in the efficiency of the conveyance, distribution and application of irrigation water, assuring a water supply in the required quantities, at the right time.

- Increased crop yields, through the implementation of land-levelling operations, improvement of irrigation techniques and the agricultural know-how of the producers.

- Establishment of a system for water delivery to the producers, on the basis of volumetric water duty.

- Reclamation and/or improvement of soils with drainage or salinity problems.

MODERNIZATION PROGRAMME OF THE IRRIGATION SYSTEMS IN MEXICO

A. MODERNIZATION OF DISTRICT MANAGEMENT

- TRANSFER OF THE IRRIGATION DISTRICTS TO THE USERS
- IMPROVEMENT OF WATER OPERATION AND DISTRIBUTION
- TECHNICAL ASSISTANCE IN IRRIGATION AND TRAINING

B. IMPROVEMENT OF CONVEYANCE EFFICIENCY

- IMPROVEMENT AND CONSTRUCTION OF COMPLEMENTARY WORKS
- GAUGING IN THE DISTRIBUTION AND DRAINAGE NETWORK
- AUTOMATIZATION OF THE MAIN CANAL NETWORK
- OPTIMUM CONSERVATION OF THE DISTRIBUTION AND DRAINAGE NETWORK

C. IMPROVEMENT OF ON-FARM EFFICIENCY

- LAND LEVELLING
- RECUPERATION OF SALINE SOILS
- IRRIGATION PROJECTS AND ALIGNMENTS
- VOLUMETRIC WATER DUTY (m^3/sec)

- Improvements to the existing hydraulic infrastructure, using both surface and underground water.
- Greater participation by farmer-producers in the administration of the Irrigation Districts, by means of the "Transfer Programme".
- Promotion of public and private participation in the funding of hydro-agricultural infrastructure works.

The Modernization Programme is made up mainly of the following three components:

Modernization of District Administration:

This component includes the transfer of the operation, conservation, and administration to the users. Once they are organized in irrigation modules or civil associations, they will be assigned water and given permission to use the hydro-agricultural infrastructure of each module, taking the necessary measures to achieve financial self-sufficiency; the installation of computer programs and systems for the administrative work and agricultural and hydrometric statistics; water administration on the basis of a systemization of gauging during the distribution process; computer programs in order to control irrigation programming, timely and precise distribution to the users; control of the list of registered users, with volumetric water duty assigned to each one; a redefinition of the policies for the operation of surface and underground supply sources, in order to encourage the use of both sources; and training programmes for the technicians that operate the irrigation systems still under the responsibility of the government (National Water Commission), as well as the availability of technicians who will attend the producers under the Transfer Programme.

In order to improve operating conditions, and to offer a more timely and efficient irrigation service to the producers, steps have been taken to:

- Use trained technical personnel for the distribution and irrigation service to users of the irrigation sections (previously done by ditch riders without special training).

- Establishment of water delivery to the user in terms of measured volumetric supplies, in m^3/sec, following the irrigation depths and frequencies recommended by the Irrigation and Drainage Engineering area of each District.

So that the technical personnel serving the producers carry out their functions with greater efficiency, the National Water Commission is organizing training workshops, theoretical and practical courses.

During the first stage, the trained persons will acquire the basic know-how that will allow them to participate in irrigation services. Later they will receive updating courses. Among other topics, they will study the different ways to gauge the canals and watercourses, using current meters and existing structures. (With the Modernization projects, simple structures will be installed that will permit the delivery of steady volumes to the users.)

There will also be the training of technicians in the formulation of irrigation plans and these will be elaborated on an Irrigation Section level, with the objective of establishing irrigation programming with better timing and flexibility.

The training of producers in order to promote more efficient water use at farm level is also foreseen.

Improvement of Conveyance Efficiency:

This second component is aimed at raising water conveyance and distribution efficiency in canals, to ensure timely delivery of the required volumes of water.

For the above, it is necessary to investigate and install, in the distribution network of the canals, modern structures for water gauging and control, as for example the so-called "duck bill weirs" to maintain constant levels of operation and constant volumes of water to the sub-lateral canals, branches and direct intakes. These actions would give greater flexibility of the infrastructure and would permit a more dynamic operation, minimizing the intervention of the human factor and reducing the response-times for adjustments of the volumes to be delivered.

Efforts are being made to reduce seepage losses in the canal network, by lining the critical lengths and improving the physical conditions of the distribution and drainage network, where there is a backlog of rehabilitation requirements.

Improvement of On-Farm Efficiency:

Actions are also focused on improving efficiency at the farm level. In order to achieve this, technical assistance programmes will be established for irrigation and drainage and land levelling, with the participation of the producers. Measures will also be taken for soil reclamation on areas that have deteriorated due to salinity. As a fundamental part of this process, the delivery systems will be modified to adapt them to a set water duty for each user.

CONCLUSIONS

The engineering design of the irrigated areas of Mexico corresponds to the "upstream" system of control in canals. Efficient operation of these systems, with respect to the control and gauging structures, depends on human intervention for the necessary adjustments and changes of the distribution programme and for water delivery to the users.

At present, it would be impossible to redesign and reconstruct the irrigation systems in Mexico. However, with actions such as the District Transfer, where greater producer participation is established, and other measures are focused on obtaining greater flexibility from the infrastructure, new levels of efficiency are being established.

An example of this is the implementation of a measured volumetric system of delivery, operated by trained technical personnel.

This represents a practical alternative in order to increase water use efficiency, during distribution and farm-level application. This system will allow a more flexible water management in the canals and a service to the users that satisfies the timing and volume requirements. It also implies an important saving of water that could be used to irrigate second cropping cycles, and to increase production and productivity.

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Health comic magazines in Burundi: a means of communication with children and their families

COMICS AND HEALTH

Recent years have seen the success of a number of children's magazines in both developing and developed countries. Those interested in health education have been impressed by the ability of magazines such as **Pied Crow** in Kenya, **Rainbow** in East Africa and **Action** in Southern Africa, to communicate with children in and out of school, and with adults of all ages. In Latin America, comics and fotonovellas play an important role in popular culture and the medium has been used extensively in health information.

The growing problem of AIDS has sparked off a number of initiatives to reach children and adults through comics and magazines. In Switzerland, Derib created **Jo** to reflect the reality of the lives and concerns of young people. In many other countries governments, NGOs and even individuals have recognized the potential of the comic magazine medium in dealing with difficult, embarrassing, but vital, health issues.

There has been much discussion of magazines (with comic strips, stories, games, puzzles, competitions) as a way of capturing children's imagination; of the relatively low cost of production; of the considerable "pass-on" value of the comic. It is recognized that children are a very effective channel of communication, in that health information passes through the child into the family. Equally the experience of the Mazingira Institute in Kenya suggests that magazines initially designed for children of approximately 10 to 12 years have a significant appeal for older, children, adolescents and adults. **The children's magazine then becomes a means of disseminating information, not just to children, but to the wider population and can play an important role in bringing about behaviour change in the community.**

WHO's Health Learning Materials (HLM) project in Nepal has developed **Hamro Sathi**, a quarterly magazine for children, centred around health and hygiene issues. Creation of the magazine was made possible by WHO's Community Water Supply and Sanitation unit. After preliminary testing by primary school teachers, 5000 copies of a first field test issue were published in Nepal and distributed in September 1992. Evaluation will take account of the

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comic's impact, not only on children's health and sanitation awareness, but also on the degree to which important health messages diffuse through the child into the wider audience of the family.

In Geneva, the HLM programme is currently preparing an in-depth review of existing and potential use of children's magazines in health education and promotion.

There are two questions related to this health communication medium which are of particular interest to WHO; first the lack of such children's magazines in francophone Africa; second the lack of comprehensive research into the effectiveness of the medium and of detailed evaluation of its usefulness especially in promoting the development of healthy behaviour and related skills in the community. **This project offers an important opportunity to remedy these two areas of weakness.**

PROJECT DESCRIPTION

WHO's **Adolescent Health Unit** (ADH), **Community Water Supply and Sanitation Unit** (CWS), **Global Programme on AIDS** (GPA), **Division of Maternal and Child Health** (MCH) and **Interregional Health Learning Materials Programme** (HLM) are together interested in putting children's magazines to work in spreading important health messages in francophone Africa. They want to obtain more detailed information about the value of children's magazines in health education and to gain comprehensive experience of the process of magazine creation.

At the same time, UNICEF in Burundi has already supported a project for the development of a comic book on AIDS. It has secured the services of an experienced Belgian group for the training of local artists in the creation of cartoon strips and animated films, and intends to sponsor a series of cartoon health messages based on **Facts for Life**.

This is the rationale for developing a test project for the creation of such a magazine in Burundi.

Why Burundi?

Any project to provide a French language children's health comic suitable for adaptation and distribution in several countries in francophone Africa must necessarily begin with trials in one socio-cultural context. Burundi presents certain specific population and educational characteristics which suggest that a comic could prove an effective health education medium.

- Whilst primary school education in Burundi is fairly comprehensive, only ten percent of children continue in education after primary school. The vast majority of older children and adolescents have therefore to be considered as "out-of-school youth" to whom the spreading of health messages is no easy matter.

- Because the population of Burundi is 95% rural and is very dispersed, many traditional health education media are ineffective. The problem of distribution of the magazine in rural areas will need to be solved with the help of the Bureau d'Enseignement Rural (BER) and a number of NGOs, youth groups and women's groups.

Burundi has recently declared its wish to join WHO's Health Learning Materials programme and is currently setting up a national HLM project. It is intended that the development of children's magazines will parallel the growth of the HLM project, bringing new skills to the production of HLM in Burundi. Should the project later be expanded to include other francophone countries, field testing of the magazines will be greatly facilitated through the HLM intercountry network now operating in nine francophone countries in Africa. A first step will be trials in the well developed HLM projects in Benin and Rwanda.

The Target Group

The experience of the Mazingira Institute in Kenya has shown that a magazine designed for the reading level of the 10-12 years old age group, will in fact be read and appreciated by older children, adolescents and adults. In Burundi, where only ten percent of children progress past primary education, levels of literacy can not be expected to increase significantly past the level achieved by age 12.

In creating a magazine to appeal to a wide audience, ranging from children of 10 years old to adolescents and even adults, differences in behaviour and attitudes between these groups must be accounted for. This is particularly true with respect to issues concerning sexual behaviour and attitudes.

The Magazine

Over a projected two-year time frame, six issues of the magazine will be produced. Each issue will focus on one major health topic, but also contain additional features addressing other health issues. In view of local health priorities, the first issues will deal with AIDS, STDs and topics of special relevance to community water supply and sanitation. One issue might, for example, have an AIDS topic as cover story, as well as spreads on ways of keeping water clean and on malaria and its prevention. Many of the messages conveyed will be based on the successful **Facts for Life** initiative.

Because the magazines are to be aimed at children both in and out of school and adults, they must be suitable for use both with or without a facilitator. It is anticipated that packs of magazines despatched to schools and youth groups will include a brief guide for teachers and facilitators on effective ways of incorporating the magazine into curricula, classes or activities.

A jigsaw puzzle, representing one of the illustrations from the magazine with a caption presenting a health education message, will also be included in the package. The puzzles, examples of which have already been developed by WHO's CWS and HLM units, could be valuable in reinforcing the magazine's messages through play. The effectiveness of jigsaw puzzles as a learning tool will be evaluated separately

Issues to be assessed

Feasibility of the approach

- Can health information and prevention skills be taught to children through comic magazines?

- Can we expect children to develop skills and attitudes through exposure to a series of magazines?

- Is it possible to promote magazines among children who have left school and may be living in remote rural areas where other sources of information are scarce?

Acceptability to children

- Will magazines of this type be accepted by children?

- Will children find magazines credible in conveying health messages?

Effectiveness for change

- Will children's magazines be successful in shaping and promoting desirable health beliefs, attitudes and skills?

- Will children exposed to such magazines be able and willing to pass on health messages to their siblings and families?

- How different is the effect of the magazine when used by one child in isolation or by children in a group setting assisted by a facilitator?

All the project partners are aware of the complexity of measuring behaviour change. It is hoped, however, that towards the end of the two year project period, after publication of a number of issues of the magazine, detailed evaluation of behaviour change will be possible.

Cost-effectiveness

- How much does it cost to reach a child through this means of communication?

- What are the problems, and what costs are incurred, in the distribution and promotion of these magazines?

- Is it feasible to sell these magazines to other organizations or directly to children? If so, what would be a reasonable price? Can suitable distribution outlets be found?

Sustainability

- Can the appropriate administrative structures be established to ensure a long term future for the magazine?

- Could a local NGO or other organization undertake the administration of the project?

- Will long term financial support be forthcoming?

Project Phases

Stage 1 : ***Project Planning and setting up appropriate Administrative Structures***

In Burundi the magazine will be created through close collaboration between WHO, UNICEF and those involved in health education in Burundi. A local project manager will be selected by the Bureau d'Enseignement Rural (BER) and UNICEF and funded by UNICEF, which will also cover all local costs. WHO will provide an Information, Education and Communication consultant, to work with the project manager to prepare a more detailed project plan, including refined estimates for the cost of the project - its implementation and evaluation. Project implementation will begin as soon as the plan has been approved by WHO and UNICEF.

Advisory Team : The UNICEF IEC specialist, together with the WHO consultant, the local project manager and other local IEC specialists will form an advisory team to plan and guide the development of the magazine.

The first task of the advisory team will be to prioritize local health issues to be presented in the magazines and to propose ways in which these issues can be addressed. As the magazine develops, the advisory team will continue to provide guidance on content, whilst the project manager monitors all aspects of the magazine's development.

Should the administration of the magazine finally pass into the hands of a local NGO or other organization, the managerial role of the project manager and the supervisory role of the advisory team will be vital to ensure a successful transition.

Stage 2 : ***Baseline Research***

Research is needed to collect information essential for project implementation and to provide a baseline for the evaluation. **Before the magazine can be designed, certain questions must be answered, including:**

- What do children and adults from different areas and different educational or socio-economic backgrounds already know or believe about the diseases and environmental conditions to be discussed in the comics?
- What is their behaviour in relation to these health problems?
- What is the local terminology for these diseases or conditions?
- What are the local treatments and are any of them efficacious?
- What levels of literacy and visual literacy can be expected of children from different areas and educational backgrounds?
- Do structures or groups exist through which out-of-school youth can be reached?

The Project Phases in Brief

Time frame: January 1993-December 1994

Stage 1. Planning and Setting Up Appropriate Administrative Structures
From January 1993-May 1993

To formulate a project document and create a structure to administer the project and supervise magazine content and development.

Stage 2. Baseline Research
March 1993-May 1993

To undertake the necessary baseline research in order to collect essential information about the target audience and the means of production of the magazine.

Stage 3. Training of Local Artists
December 1992-February 1993

To train a number of local graphic artists in Burundi in the techniques of preparing children's comic magazines to convey health messages.

Stage 4. Creating the Magazine
May 1993-December 1994

To design and prepare six issues of a children's comic in the two major languages of Burundi (Kirundi and French).

Stage 5. Promoting and Distributing the Magazine
May 1993-December 1994

To promote and distribute the magazines, creating links with other media including, in particular, radio programmes.

Stage 6. Evaluation

- **Monitoring of the process**
  From publication of first issue (mid-1993)

  In order to identify and remedy practical and conceptual problems.

- **Comprehensive evaluation of impact**

  To determine the acceptability and effectiveness of the magazines in health education in Burundi, in terms of the children's awareness and the degree to which the messages are passed to, and acted on by, their families.

Stage 3 : Training Local Artists

Support is being provided in the training of graphic artists by a Brussels group, **Atelier Graphoui**, who specialize in innovative ways of using print, comic strip and film media. Contact between WHO and Atelier Graphoui was initiated by the **Communauté francaise de Belgique**, an ally of WHO's HLM Programme and a supporter of many projects in the francophone network of countries.

UNICEF has already planned a project in conjunction with Atelier Graphoui and the Bureau d'Etudes des Programmes de l'Enseignement Secondaire (BEPES) in Bujumbura, to produce short animated films as well as comic-strips. An expert, engaged by UNICEF, will train a number of local staff in the development of comic strips in direct relation to **Facts for Life** messages. Atelier Graphoui will bring to this new project their knowledge of those techniques.

Stage 4 : Creating the Magazine

Successful design and preparation of the magazine requires the full participation of local children.

The project partners have many ideas about the types of materials which might be included in the magazines (comic-strips, stories, puzzles, quizzes, letters, competitions, colouring pages, etc.), however decisions about what subjects can be treated using humour, about design, layout, colour and format, about the use of different types of materials can be made only after assessment studies with groups of local children.

Children are the ideal source of stories and local humour. Use can made of the Narrative Research Method — allowing children to recount stories and jokes which reflect the issues and approaches relevant to their community. Those involved in the project will be able to draw on the extensive experience in this method of WHO's Adolescent Health unit.

Local humorous characters, such as animals preferred by children in Burundi, can be determined. All materials, both written and visual, should be pre-tested with small groups of children before inclusion in the magazine - this pre-testing will prevent eventual costly mistakes.

Creation of the magazine covers not only content and design issues but also the printing process. Initial research will have identified the most cost-effective and reliable printing facility. Now this part of the creation process must be supervised and quality controlled.

Stage 5 : Promotion and Distribution of the Magazine

These are two vital phases of the launch of the magazine. A comprehensive study of possible means of distribution must be made, examining innovative ways of getting the magazine through to the target audience, in particular to out-of-school youth.

Effective promotion is necessary in order to give the magazine high profile and create interest and demand amongst children and adolescents. Radio is a particularly effective method of communication in Burundi, reaching a high proportion of the population. It is important to establish a strong link with radio, in order both to draw attention to the magazine launch, and to reinforce those messages presented within the magazine.

Stage 6 : Evaluation

Monitoring of process

It is not envisaged that full evaluation can take place until at least four issues of the magazine have been produced and distributed. However, at a practical level, certain aspects of the production process and of the magazine content must be monitored immediately. Such review and monitoring should be a continual process.

A case in point is the comic created by the HLM project in Nepal with CWS support. The first issue was initially tested in draft by primary school teachers. The subsequent distribution of 5000 copies then served as a large scale field-test in schools. A similar approach might be used for the first issue of the Burundi comic, but with a much larger target audience of youth-out-of-school.

The success and cost-effectiveness of the printing process must be evaluated. Equally, it is important to examine whether wide distribution of the magazine was possible and whether copies distributed were kept by those who received them. Were the paper and print quality appropriate? Has a suitable time frame been allotted to the production of each issue? Is project funding realistic?

Pre-testing should have eliminated major problems in the understanding of, and reaction to, both visual and written materials. Continued monitoring is nevertheless important to be certain that the magazine is pitched at the correct level to ensure understanding and interest amongst children and adolescents of different ages and educational levels. Could new components be introduced to make the magazine more attractive and relevant to its target audience?

It is hoped that it will be possible to include competitions and a letter page in the magazine. These could prove not only a source of useful feedback about the magazine, but also about the issues which concern young people in Burundi and their attitudes and behaviour.

Monitoring will also seek to discover whether and in what ways the magazines are being used in schools and to obtain the reactions of teachers to the content and format of the magazine.

Comprehensive evaluation of impact

A detailed evaluation plan will be formulated within the project document.

Methods of Evaluation: The WHO-sponsored consultant will work with the various project partners, and particularly with the UNICEF IEC unit in Burundi and the local counterpart and the advisory team to select the best and most appropriate methods of evaluation. In order to obtain accurate data for analysis, methods of data collection including questionnaires, interviews and focus group discussions will be considered. The evaluation techniques to be employed will be detailed in the project proposal.

Subjects for Evaluation: Evaluation will concentrate on:

- The degree to which messages have been received by school children and out-of-school youth.

- The degree to which these messages have been relayed on to family members and the wider community.

In both cases evaluation will seek to ascertain:

- Whether the health messages have been **understood**.

- Whether these messages have been **remembered** - for how long and with what degree of accuracy?

- Whether the messages have been **acted upon** - has any change in behaviour taken place?

PROJECT SUSTAINABILITY IN THE LONG TERM

For a children's magazine to endure, as has **Pied Crow** for example, it requires the support of a stable organization, well implanted in the country and with plans for long-term involvement. In Kenya this has been provided by the international NGO, CARE.

Not only is reliable financial backing essential, but for the magazine to be able to develop, some interaction with its audience (correspondence, competitions, questionnaires etc.) is vital. This demands administrative stability — a fixed address, someone to process correspondence, contact with other organizations working in health information and education.

If this project to create a health comic, initially in Burundi and eventually in other francophone African countries, is to be successful, a long-term supporter must be found and a stable administrative structure must be established.

The experience gained in WHO's South East Asia Region, in the development of an adaptation kit for a 4-story comic book, could be of value, as adaptation will become increasingly important when the magazine is used in other countries, cultures and languages.

ESTIMATED BUDGET

The total cost of the project over a two-year period is estimated at approximately 100 000 US$. Upon approval of the project document this will be met jointly by UNICEF Burundi and the WHO project partners (ADH, CWS, GPA, HLM and MCH). In general UNICEF will provide for local costs and will share the printing costs. The WHO partners will meet other expenses, including the cost of engaging an IEC consultant for implementation and evaluation of the project, direct participation through visits to Burundi by WHO staff, and a share of the printing and other identified administrative costs.

PROJECT REPLICABILITY

Expansion of the project to include other francophone African countries will depend upon the results of detailed field testing in Burundi. If evaluation of the comic shows it to be an effective medium for carrying health messages, expansion of the project for field-testing and eventual implementation in other francophone African countries can be planned.

Linguistic and socio-cultural constraints may well prevent wholesale "exportation" of the comic. Guidelines on adaptation would be necessary, as well as provision for the sharing of skills in graphic art and the production of children's magazines.

WHO's HLM programme could prove an excellent channel for the "sharing" of a French language children's magazine in Africa. The programme has a well developed network of projects in francophone Africa with a network office in Benin and several years of experience in the exchange of skills and materials.

Promotion of environmental management for vector control through agricultural extension

The Medium-term Programme 1991-1995 of the WHO/FAO/UNEP/UNCHS Panel on Environmental Management for Vector Control (PEEM) distinguishes three programme areas: promotion, policy modification and technical cooperation; research and development; and, training of various target groups. Characteristic of the activities contained in all these areas is the inter-sectoral approach towards the prevention of adverse health impacts of land and water resources development. The training component tries to overcome the disciplinary limitations imposed by conventional tertiary education systems and to explore the effectiveness of new vehicles to transmit health-promotional messages to the community level.

For the successful promotion of environmental management at the country level three conditions are essential:

- a favourable policy framework which guarantees the consideration of health aspects at the early planning stages of water resources development projects;
- the capacity of sectoral professionals to maintain an inter-sectoral dialogue that will support the translation of these policies into action; and,
- mobilization of the community to participate in the application of environmental management measures, which, in the rural context, will be closely associated with certain agricultural practices.

These three conditions relate to three specific capacity building activities. Awareness creation of policy makers will facilitate the review and modification of sectoral policies. Training of middle level managers will strengthen their capacity to cooperate in an inter-sectoral manner to ensure the incorporation of health safeguards into new water resources development projects. Education of the community members will provide the basis for continuity in the application of environmental management, and contribute to the sustainability of the measures and the human health status achieved by them.

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Robert Bos, Secretary, Joint WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control (PEEM), World Health Organization, Geneva, Switzerland

In its programme area "Training of various target groups", PEEM has developed and implemented the following activities to meet the above objectives:

In 1992, a first trial course "Health opportunities in water resources development" was held in Darwendale, Zimbabwe, for a group of 28 middle level managers from the ministries of health, agriculture and water resources, and from the National Economic Planning Council. The course was organized jointly by PEEM and its collaborating centre the Danish Bilharziasis Laboratory, with the Blair Research Institute as a local counterpart. It contained various innovative components, which, after the course evaluation, are now under further elaboration in the preparations for the next course in Ghana. Due follow-up is given to the course in Zimbabwe.

During 1991 and 1992, PEEM organized three inter-regional workshops on the promotion of environmental management for vector control through agricultural extension programmes. Two-person teams from 25 countries participated, each team consisting of one health sector professional and one agricultural extension professional. The workshops resulted in action plans aimed at promoting this concept at the national level.

In this case study document, the trial course and the workshops are presented as examples of innovative capacity building approaches aimed to achieve integration of a health component in rural water resources development. The Darwendale course may provide a model for training professionals from the various water-using sectors in the inter-sectoral decision making that will be required for integrated rural water development. Agricultural extension may provide an appropriate tool to mobilize farmers for the application of new water management techniques at the local level.

THE DARWENDALE TRAINING COURSE

A brief description of the course

Preparations for the course started 1½ years in advance and the objectives were initially formulated to be:

- to introduce the participants to the concepts, techniques and approaches involved in the prevention or mitigation of vector-borne disease impacts of water resources development;
- to provide the participants with the knowledge and skills to include human health considerations in the planning and implementation of water resources development projects with a view to optimizing the health status in the project area; and,
- to encourage an inter-sectoral dialogue that will form the basis for improved inter-sectoral and inter-institutional collaboration.

For the modules that made up the first week of the course, these general objectives were translated into detailed learning objectives.

The profile of the target audience was initially the following:

- Planners and decision makers

  - from ministries of planning and finance
  - from relevant sectoral ministries
  - from regional development authorities and river basin authorities

- Representatives from local consulting engineering firms and managers of agricultural schemes.

In the final selection of participants, four criteria were applied: (1) there should be a proper balance in the representation of the various sectors; (2) participants should be in a position to influence the planning process of water resources development in Zimbabwe; (3) participants should have an appropriate educational background; and (4) participation of women should be encouraged.

The course structure combined conventional and innovative elements. During the first week, the emphasis was on knowledge transfer and the development of skills. Five modules were developed to address the crucial topics, and these were presented by one or more external resource persons. They included:

- An introduction to the concept of sustainable development and the place of human health in this context, with special reference to policies, planning and legislation
- Health risk appraisal, concepts and methodology
- Engineering and other approaches in environmental management
- Methods of economic evaluation as a basis to select options for interventions
- Strengthening of health services

During the second week, participants were given a formal assignment to carry out a full health-opportunity assessment of the Mupfure Irrigation Scheme, a smallholder project in Mashonaland Province, currently in the planning phase. In this assignment, the participants had to apply the knowledge and skills acquired on a real project, which strengthened the learning process and also served as an effectiveness assessment of the first week of the course. In addition, the outcome of their work would be of immediate value to the authorities in Zimbabwe.

Innovative elements of the course

Several innovative methods and approaches were tested in this course. The major aim of the course was to foster inter-sectoral cooperation, and the participants were therefore from the start of the course divided over small groups. Each group had five or six people, with representatives of all sectors present in each group. This **inter-sectoral group** work was facilitated by periods of **active learning**. Resource persons had the remit to combine formal presentations with group assignments and discussions. For day two (Health risk appraisal) a **problem-based learning module** had been developed. In the PBL sessions, the groups worked their way through specially prepared materials guided by a tutor and learning from each other. Another active learning element during the first week was the organization of a **debate**, in which the participants could reflect on the potential benefits and disadvantages of inter-sectoral collaboration.

The **assignment** in the second week was made to be as realistic as possible. Each participant received a formal letter of remit from the Commissioner of the National Economic Planning Commission, with terms of reference attached. As a member of an inter-sectoral group to carry out the assignment (the same groups were used as in week one) each participant had to contribute his or her share. Each group had access to a library of relevant information and a budget was provided that would allow hiring resource persons as consultants. Simulators representing politicians or pressure groups tried to disrupt the completion of the task. All groups prepared detailed reports which have subsequently been consolidated into one appraisal statement.

The course assessment also contained innovative elements such as the use of the nominal group process (NGP) to test the acceptability of the course and its various specific elements.

Course evaluation

Methods - Since this was a trial course, ample evaluation activities were included in the programme. The evaluation considered the acceptability, effectiveness and efficiency of the course, and the assessment was asked not only from the participants, but also from resource persons, tutors and simulators. In the context of this case study, only a brief account will be given of the results of the acceptability evaluation by the participants and of the effectiveness assessment.

The acceptability by the participants was evaluated three times: the PBL experience on day two was evaluated two days afterwards through the NGP; the entire first week was evaluated at the end, also through the NGP; and the entire course was evaluated on the last Friday by means of a questionnaire.

The effectiveness of the course was tested through an assessment of the task reports produced in week one, the contents and presentation of the assignment reports at the end of week two and a Modified Essay Questions exercise at the end of the course.

Conclusions

The outcome of the evaluation was reviewed at a meeting which also set the stage for the preparation of the second course and explored possibilities for a follow-up in Zimbabwe.

Aims and objectives - Several resource persons felt unclear about the precise aims and objectives of the course. The participants indicated unanimously that aims relating to inter-sectoral cooperation and health impact considerations had been met, yet it is not clear what has been achieved in actual operational competence. The aims and objectives should therefore be restated.

Target audience - The restatement of aims and objectives should lead to a redefinition of the target audience and the further development of criteria for participant selection.

Length of the course - participants expressed a sense of too much work pressure, while several resource persons felt they had not been made use of in the most efficient way. The length of the course should be reconsidered in the light of these comments, of the restated aims and objectives and of the cost implications.

Contents - It is desirable to reconsider the volume of information to be presented versus the prospect of achieving genuine understanding and operational abilities.

Format - The active learning in inter-sectoral groups and the problem-based learning day scored high with the participants. The resource persons acknowledged the convenience and efficiency of a modular approach in terms of their own time contribution, but several argued for a more integrated approach of cumulative learning, which would result from a closer coordination between the topics. This may be achieved by a problem-based learning format throughout the course (using one or two projects as the learning context), where plenary "resource" sessions can be anticipated **in response to needs** for expert information **identified by participants** in the course of completing their tasks.

Use of experts - Preference should be given to the recruitment of local experts who can respond flexibly to the expressed needs of participants.

Preparations for the next course

Based on the evaluation the preparations for the next course (which will be held in Ghana in January 1994) have started by reformulating the course objectives and redesigning its structure.

The overall objective now reads as follows:

> "Irrespective of his/her sectoral affiliation, after completing the course each participant will be able to contribute to the decision whether or not a health opportunity assessment is needed, assist in the formulation of terms of reference for a health opportunity assessment, determine the adequacy of the assessment report, including recommendations on health protective and promotional measures, and prepare for the inter-sectoral monitoring of the project."

The next course will be completely task-oriented and driven by student demand. Over the period of two weeks, the participants will be assigned four tasks, in the context of real water resources development projects. They will work in groups, except for daily plenary sessions in which questions that remain unresolved in the group work can be discussed with resource persons. The tasks will be the following:

First task

- An initial health examination at the project identification/prefeasibility stage requiring a rapid assessment (including site visit)

Output: a recommendation whether or not a full Health Opportunity Assessment is necessary.

Second task:

- The hazards related to community vulnerability and environmental factors are then translated into risks as perceived against the backdrop of health services capacity; risks are classified and terms of reference are formulated focusing on risks of sufficient importance. TOR also include health opportunity assessment.

Output: terms of reference (TOR)

Third task:

- An appraisal of a health impact assessment report, which will indicate whether or not the report conforms with the TOR and whether or not the report has a bias; whether the data and their interpretation are sufficient and credible to support the conclusions; and whether the recommended health protective and promotional measures are technically feasible, socially acceptable and represent the most cost-effective options?

Output: consolidated recommendations that can be submitted to the planning and finance authorities for use in the negotiations with external donors or financing agencies

Fourth task:

- Design the inter-sectoral organization, major logistics and resource sharing needed for the monitoring of the project during construction and subsequently.

Output: a plan that outlines the inter-sectoral organization and major logistics arrangement, and the text of a Memorandum of Understanding which governs the sharing of resources

In the new course, reliance on external expertise will be kept to a minimum. The materials produced to facilitate the tasks will be of a generic nature so as to allow replication of the course in other countries. An internal follow-up to the Ghana course will be planned in advance, and aims to achieve the policy and institutional change needed to make it possible for the participants to carry out the above tasks effectively.

WORKSHOPS ON THE PROMOTION OF ENVIRONMENTAL MANAGEMENT THROUGH AGRICULTURAL EXTENSION PROGRAMMES

Promotion of environmental management for disease vector control in stable rural areas, i.e. areas where no development projects are underway, is targeted at a population of farmers whose agricultural practices have an immediate effect on environmental health risk factors.

Irrigation management, cropping patterns, chemical inputs and integrated pest management (IPM) practices may all affect vector populations one way or the other. On Java, the application of different irrigation techniques is an important determinant in the distribution of the main malaria vector *Anopheles aconitus*. In Kenya, farmers working in the rice producing Mwea scheme show a high prevalence of schistosomiasis, whereas their counterparts in the Perkerra scheme, where vegetables are grown, do not. The main malaria vector in Central America, *Anopheles albimanus*, developed multiple resistance to insecticides because of the intense spraying in cotton fields, and this rendered the conventional control programme using house spraying with residual insecticides largely ineffective. Preliminary data from IPM studies and research on nutrient recycling in irrigated rice fields, carried out at the International Rice Research Institute, demonstrate the role of disease vectors, in their larval and adult stages, in this agro-ecosystem.

Farmers, therefore, have an important role to play in the application of environmental management measures for disease vector control. Under certain conditions, modified or newly introduced practices will contribute to a reduction of the transmission risks posed by vectors; they may also have agricultural benefits, which favours their acceptability by farmers. Indirectly, the reduced health risks will result in an increased quality of life for farmer communities.

The traditional health education system is, however, not suited for the delivery of environmental management messages. Not only is the training of health educators or primary health care workers focused on specific health services functions (nutrition, mother and child health, vaccination, domestic hygiene), but it is also unlikely that farmers will accept recommendations to change their agricultural practices from a health educator.

The agricultural extension system, which developed in the second half of the last century in the USA and Europe, aims to provide a two-way communication channel between agricultural researchers and farmers. Farmers receive information on how to apply new research findings in their every-day practice, researchers get feedback concerning the problems faced by farmers that need further investigation to arrive at feasible solutions.

At the eighth PEEM meeting, in Nairobi in 1988, the Panel reviewed education and training in support of environmental management, and recommended that the possibility of using agricultural extension as a vehicle for environmental management measures needed to be explored. In response to this, the PEEM Secretariat started collaboration with the Agricultural Education and Extension Service of FAO. Together they designed a series of three workshops to elaborate the topic and to work with country representatives from the health sector and agricultural extension organizations on action plans at the country level. The workshops were implemented with support from the Vector Biology and Control project (an Arlington-based consultants group sponsored by USAID) and from the International Development Research Centre (IDRC), Canada.

The workshops were organized on an inter-regional basis and took place in Alexandria, Egypt (September 1991), Bangkok, Thailand (October 1991) and Tegucigalpa, Honduras (October 1992).

Objectives, contents and structure of the workshops

The objectives of this series of workshops had been formulated as follows:

- to collect information on disease vector control programmes and agricultural extension programmes at the national level;
- to review the practical implications and assess the potential of incorporating an environmental management component for vector control into agricultural extension programmes;

- to stimulate an inter-sectoral dialogue between national participants representing health and agriculture sectors at the workshops, and to identify countries where research and demonstration projects can be initiated;
- to collect material that could form the basis for the preparation of a manual for the incorporation of environmental management into agricultural extension programmes;
- to formulate a number of proposals for pilot or demonstration projects, in interested countries, on the promotion of environmental management through agricultural extension programmes.

For each of the three workshops two participants from each selected country were invited: one from the health sector (usually managers of vector-borne disease control programmes) and one from the agriculture sector (usually the directors of agricultural extension programmes). Countries were selected on the basis of the local public health importance of agriculture-associated vector-borne diseases and the strength of their agricultural extension programmes. The following countries were represented:

Workshop 1	**Workshop 2**	**Workshop 3**
Egypt	China	Bolivia
Ethiopia	India	Brazil
Kenya	Indonesia	Colombia
Morocco	Malaysia	Costa Rica
Pakistan	Nepal	Cuba
Syria	Philippines	El Salvador
Tanzania	Sri Lanka	Honduras
Zimbabwe	Thailand	Mexico
		Nicaragua

In order to start the "bonding" process prior to the workshops, each country team was asked to prepare jointly a country report, highlighting issues pertaining to vector-borne disease control and to agricultural extension. These reports were used as background information during the workshops, and the programmes included sessions where the participants presented summaries of their reports.

The workshop programme further included: presentations on conceptual issues by a number of external resource persons; a debate on inter-sectoral collaboration (2nd and 3rd workshops); identification of constraints to the proposed incorporation of environmental management into agricultural extension (in small working groups, which considered institutional, technical and methodological issues); formulation of possible solutions to overcome these problems; and the development of an action plan for follow up at the country level.

The reports of the three workshops will be published shortly.

Outcome of the workshops

All participating teams produced valuable country reports containing important, updated information, both on the local health situation and the status of the agricultural extension programmes. At each workshop, constraints and possible solutions were clearly defined. Most importantly, each workshop resulted in feasible action plans, many of which are worth following up for implementation.

There were clear regional differences, described below by workshop.

Workshop 1 : African and Eastern Mediterranean Regions.

The countries represented at this workshop present a heterogeneous picture; on the whole, the situation analysis for all of them is the least favourable. In the African countries the awareness of the problem and the knowledge base are extremely limited. Agriculture/health linkages are, on the other hand, among the most complex with, in most countries, vector species succession during the cropping season and instability in the vector population dynamics, with various sibling species common features. Agricultural extension programmes and health services alike have to deal with major financial and human resource problems. In the countries of the Eastern Mediterranean, awareness and knowledge also are relatively low, but the agriculture/health linkages are less complex: in North Africa and West Asia confined to schistosomiasis in irrigated areas and in Pakistan to one-vector malaria problems in waterlogged areas. Agricultural extension programmes and health services are better developed.

Workshop 2: South East Asia and Western Pacific

The countries present at this workshop were more homogeneous. There was a high level of awareness of the problem and a strong knowledge base: research on the association between irrigation and vector-borne diseases has, in this predominantly rice producing part of the world, a long-standing history. In many instances linkages between agriculture and health are clear: malaria usually occurs in one- or two-vector systems with well defined breeding habits, Japanese encephalitis is intimately linked with irrigated rice production. Agricultural extension and health services are well developed and operational, and there is a strong move towards integrated pest management, the promotion of which is carried out through the extension services. This provides a clear opportunity for environmental management for vector control.

Workshop 3: the Americas

While the awareness and knowledge base are not of the same dimension as in SE Asia/Western Pacific, the organizational structures are without doubt the best, with effective operations. The nature and intensity of linkages between agricultural practices and vector-borne diseases is patchy, and in some part unclear because of the illegal nature of agriculture (coca). This was the only workshop where one country (Brazil) reported already to have integrated messages on malaria control in their extension work.

Follow-up of the workshops

The tangible outcome of the workshops consists of action plans for appropriate follow up at the country level. The proposed follow-up activities show a spectrum that reflects the situation analysis summarized above. They include, in order of sophistication and progress:

- organization of national awareness-creation workshops as a basis on which to proceed with the actual incorporation of an environmental management component into agricultural extension;
- research to strengthen the knowledge base which is currently considered too limited to provide convincing evidence to national authorities that environmental management should be promoted through agricultural extension;
- research for the further development of environmental management techniques that can be effectively applied by farmers as part of their regular activities;
- preparation of material and organization of courses to train agricultural extension workers in this new specialty;
- preparation of materials on environmental management that can be used by extensionists in their work with the communities;
- demonstration projects of the feasibility and effectiveness of including environmental management in the information package provided to the farmers, and to assess farmers' needs in this respect;
- expansion of on-going work in Brazil into appropriate areas of adjacent countries (TCDC).

Discussion Forum

The Water Supply and Sanitation Collaborative Council

BRIEF OVERVIEW: PROGRESS SINCE OSLO

The first Water Supply and Sanitation Collaborative Council Meeting took place in Oslo in September 1991. The members at that time were not aware of, and did not consider the capacity and the resources of the Secretariat when they decided on the setting up of seven Working Groups in addition to three initiatives already in hand. The Secretariat had therefore to develop a resource base, to be able to cope with the tasks in hand at the same time as establishing itself within WHO in a manner that it could be responsive to the spirit and needs of the Council.

It materialized also that the Secretariat had to be much more involved with the Working Groups than originally envisaged, to ensure common approaches, standard methods and consideration of cross-cutting issues. Additionally, the Coordinators of five of the seven Working Groups had to depend on others for resources (particularly funds) to discharge their responsibilities. Hence sponsoring arrangements had to be negotiated. For many reasons the resolution of such issues also became part of the Secretariat's tasks.

The Secretariat is thankful to the Swiss Development Corporation, WHO, UNDP, British ODA, Canadian CIDA, German BMZ, the Netherlands DGIS, and the Government of Italy for the financial assistance provided, without which it could not have operated. Discussions continue with the Governments of Belgium, the Netherlands and Japan for further assistance, and it is hoped that these will result in favourable responses towards meeting immediate needs. Other forms of assistance have been received from UNICEF; the Asian Development Bank; the UNDP/World Bank Water and Sanitation Programme; PAHO; USAID; the Ministry of Health, Lisbon, Portugal; and NORAD. It is hoped that other bilateral agencies will be forthcoming with help for the next term, which starts in September 1993. The Swiss Development Corporation and the Government of Germany have already made pledges in principle for this period.

DISCUSSION FORUM PAPER 1

Bryan Locke, Deputy to Executive Secretary, Water Supply and Sanitation Collaborative Council, World Health Organization, Geneva, Switzerland

The second meeting of the Water Supply and Sanitation Collaborative Council has been fixed for September 1993 in Rabat, Morocco. Information on its preparation is included towards the end of this report.

The major tasks which the Secretariat is concentrating on now, are:

- ensuring a balanced representation at Rabat between developing countries and external support agencies; water supply and sanitation, solid waste disposal and drainage; and increased participation from women, NGOs, and water resources specialists;
- finding financing for developing country participants; and
- having discussion papers prepared in time for the new issues to be taken up at the Meeting.

WORKING GROUPS

It will be recalled that the seven Working Groups as outlined in the Oslo Report are:

1. Country-Level Collaboration

Rationale: Improved country-level collaboration (CLC) remains a key objective of the WSSCC. The Global Forum identified a need to review current experience with CLC, including aspects of the case studies presented in Oslo, to seek success stories. The Working Group should aim to develop a framework and practical guidelines for ESAs, NGOs and developing countries' governments on ways to achieve better CLC. Ways are also needed to monitor the success of CLC and measure its benefits.

Objectives: To develop recommendations for improving Country-level Collaboration in water supply and sanitation.

Coordinator: Mr Brian Grover, Director, Water Sector, CIDA, Hull, Quebec, Canada.

Activities: Following the collection of information from members of the Council on the CLC situation in their countries, consultants engaged by CIDA made an analysis and prepared a synthesized report. They recommended the preparation of country-specific case studies. Ten case studies were prepared and considered at the WG/CLC meeting in Kandy, Sri Lanka, in February 1993. The conclusions with suggested guidelines are being prepared for endorsement for dissemination by the Rabat meeting.

2. Information, Education & Communication (IEC)

Rationale: The existing Core Group on IEC has prepared comprehensive proposals for national and global strategies to promote the sector. The Global Forum saw a need to develop implementation mechanisms and mobilize resources for communication strategies at all levels. The Working Group will take over the work of the Core Group and endeavour to convert the recommendations into IEC activities at the global level, and to mobilize support for country IEC strategies.

Objectives: To develop communication/promotion and other IEC strategies on behalf of the WSSCC, and to mobilize resources for implementation of approved strategies.

Coordinator: Mr Hans van Damme, Director, IRC International Water and Sanitation Centre, The Hague, The Netherlands.

Activities: An informal meeting of this Group took place in Dublin in January 1992. It was decided that approaches in specific countries should be attempted. Members from Guinea Bissau and Nigeria agreed to most country projects. The experience is expected to be earmarked for the Morocco meeting.

3. Information Management

Rationale: An earlier Collaborative Council TWG developed recommendations for technical information exchange and the management of project and sector information. The Working Group will seek ways of promoting more effective information management systems, building on existing informal information networks.

Objectives: To provide support, on behalf of the WSSCC, for developing countries seeking to introduce information management systems for the water supply and sanitation sector, and to develop recommendations for improving information exchange among countries.

Coordinator: Mr Han Heijnen, IRC International Water and Sanitation Centre, The Hague, The Netherlands.

Activities: The first meeting of the Group was held in Bangkok, 8-10 April 1992 and the second meeting is scheduled for April 1993 in Amman, Jordan. A draft strategy will be presented and considered, prior to submission to the Morocco meeting.

4. Applied Research

Rationale: The Council-sponsored Global Applied Research Network (GARNET) has expanded rapidly and there is a need for an advisory body to provide periodic monitoring and advice, and to help identify future applied research needs.

Objectives: To assess, on behalf of the WSSCC, the continuing development of GARNET; to provide support and advice to the Global Network Coordinator; and to identify research needs.

Coordinator: Mr Roland Schertenleib, International Reference Centre for Waste Disposal (IRCWD), Dübendorf, Switzerland.

Activities: Following a reduced group meeting 15-16 June 1992 to formulate the terms of reference and workplan for the Group, the first Working Group Meeting took place in Geneva in October 1992. The second meeting is scheduled for March 1993, where papers will be considered on (i) "Improvement of the Quality of Research Proposals, (ii) Problems and Issues related to Funding of Research; as well as (iii) a revised version of "The Process of Applied Research in WSS", and (iv) a review of GARNET (Global Applied Research Network).

5. Gender Issues in the WSS Sector

Rationale: The IDWSSD focus on the **role of women** has raised awareness of the need for gender approaches in WSS sector planning and implementation, but there is still a long way to go to achieve real progress. The Global Forum saw a need to develop gender planning approaches further, to provide guidance for improving project planning.

Objectives: To collect experiences on gender planning approaches, to assist in the evaluation of such experiences and the dissemination of resulting guidelines, and to assess the need for gender training in the sector.

Coordinator: To be decided by INSTRAW, PROWWESS and NORAD. Initial contacts to Ms Borjana Bulajich, INSTRAW, Santo Domingo, Dominican Republic.

Activities: At a September 1992 meeting of WSSCC Secretariat and the Coordinators of the Seven Working Groups, it was decided that members of the WG/Gender Issues would participate in the work of the other WGs to ensure that the gender issues are adequately addressed and that their products are gender-sensitive. The WG/G would prepare guidelines on an approach to Gender Issues in the WSS sector, and compile a Source Book on women having experience in the WSS sector. Coordination is being carried out by Wendy Wakeman and Bruce Gross of UNDP/World Bank WSS programme.

6. Urbanization

Rationale: The urgent needs of low-income urban communities featured prominently in the Global Forum discussions. Participants stressed the need to correct mistaken past assumptions that urban WSS was adequately catered for by ongoing programmes. There is a priority need for the development and application of new approaches, backed by increased investment in programmes to serve the urban poor.

Objectives: To assess, on behalf of the WSSCC, the most suitable ways of achieving sustainable progress in the provision of water and sanitation services to the urban poor.

Activities: A case group of WG/U took place in Geneva in November 1992. The WG/U meeting proper is scheduled to take place 25-28 April in Siena, Italy. A strategy outline will be considered along with worksheets used as a basis for preparing Guidelines and a work plan on priority activities to improve WSS accomplishments in the urban and especially peri-urban areas.

Coordinator: Mr Ivo Imparato, Ministry of Foreign Affairs, DGCS, Rome, Italy.

7. Operation & Maintenance

Rationale: Inadequate operation and maintenance has been a major factor in the lack of sustainability of past WSS systems. Correcting O&M shortcomings will be a crucial part of future strategies. The Global Forum agreed that the valuable work already undertaken by the WHO Working Group and Advisory Committee on O&M should be continued under the umbrella of a WSSCC Working Group.

Objectives: To assist the WSSCC in the preparation of guidelines and promotional messages which will help developing countries to improve the effectiveness of operation and maintenance in both urban and rural WSS programmes.

Coordinator: Mr José Hueb, Sanitary Engineer, CWS, Environmental Health Division, WHO, Geneva, Switzerland.

Activities: This ongoing Group will meet in June 1993 in Geneva to consider the preparation of guidelines on the management and training for the O&M session at the next Collaborative Council Meeting.

A meeting of the Coordinators of the seven current Working Groups was convened at IRC The Hague, The Netherlands in September 1992 to assess progress made in the year since Oslo, identify cross-cutting issues and interlinkages to ensure coordination and co-operation in these areas and also to focus on what each group would deliver at Rabat for the benefit of the sector.

The consensus at the meeting was that the Working Groups should focus on outputs of practical value to move each particular activity as far forward as possible and so would present to the members a "set of tools/strategies".

There has been very good collaboration between the Working Groups and the Secretariat. The Coordinators have shown great commitment and have made many sacrifices to keep activities moving. Each group has adopted a strategy to be responsive to the issue to be dealt with. All are expected to complete their tasks and have their reports ready by May 1993.

THE THREE OTHER INITIATIVES

The UNDP, the Government of Portugal and the Asian Development Bank, respectively (with assistance of others) have taken the responsibility for dealing with and are working on, the following initiatives:

- Small Island Nations - to address the issues and needs peculiar to such nations and which are not adequately addressed at larger fora.

- African Lusophone Countries - to deal with shortcomings in literature and information and education and training support in the portuguese language. An international meeting will be hosted by Portugal in Lisbon to draw up a workplan for interested parties to join forces in resolving such issues.

- Managing Water Resources to Meet Megacity Needs (in Asia) - to deal with related issues in the 12 megacities (10 million + population) expected to emerge by year 2000. A meeting to consider the situation will be hosted by the Asian Development Bank in Manila, Philippines, in August 1993 and will submit recommendations to the Council in September 1993.

PREPARATIONS FOR RABAT

The Conference theme "Making the Most of Resources" encompasses the need to obtain the most out of existing assets and in planning for future investments. The three keynote speeches are: (i) Making the most of Resources; (ii) Better use of Resources (the Moroccan experience); (iii) Coming down from the Earth Summit - practical reflections on Water and Energy Use.

The Rabat meeting has been structured to fulfil two purposes: First, to consider amending as necessary, then adopting and deciding on any future disposition of the current Working Group themes. It is expected that the current groups on Urbanization, Information Management, Operation and Maintenance, and IEC will continue some activity beyond Rabat in a format to be decided by the Council.

Secondly, Group sessions need to be held to allow for discussion of new issues in order to set the work programme for the next two-year period. Candidate topics include the following:

Freshwater and Wastes,
Institutional and Management Options (Urban and Rural, including
Community Management),
Environmental/Hygiene Education,
Promotion of Sanitation,
Political Advocacy,
Private Sector Participation,
Monitoring and Evaluation, and
Role of Professional Associations

Based on experience to date, a few tentative ground rules for Working Group activities have arisen:

Firstly, the Council should not take on more than seven groups in total in consideration of the actual physical and financial capacity. Secondly, funding and resources support for the Working Groups has been an issue this term. It is proposed that those who volunteer to coordinate a working group must also volunteer to provide or find the financial and other support for the activity.

CONCLUSION

The WSSCC is an unique arrangement that provides a very useful forum, at a low cost, and through a very small and agile permanent structure complemented by voluntary Working Groups. In fact, through the WSSCC the water sector is better equipped to identify key issues and find ways of addressing them, tapping the collective expertise of Collaborative Council membership. The mere fact of regularly bringing together practitioners from developing countries and the development community seems a meaningful achievement: some believe that it could perhaps be usefully replicated in other sectors.

IAP-WASAD: mechanism of coordination and implementation

The International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD) was formulated by FAO with the full cooperation of the UN Organizations under the umbrella of the UN Administrative Committee on Coordination - Intersecretariat Group on Water Resources (ACC-ISGWR). IAP-WASAD forms an integral component of the UN Strategy for the Implementation of the Mar del Plata Action Plan for the 1990s. It is also recognized by the UNCED Agenda 21 on the Protection of the Quality and Supply of Freshwater Resources, as the basic framework for action on water management for sustainable food production and rural development at national, regional and global levels.

The objective of IAP-WASAD is to assist developing countries in planning, developing and managing water resources at national and international levels on an integrated basis to meet the present and future needs of agricultural production and rural development. In meeting this objective, the IAP-WASAD will assist national governments and regional institutions in setting priorities concerning the use of water and land resources for agriculture and rural development, in updating their current policies and strategies, and in developing and implementing programmes to translate their policies and plans into action.

The FAO plays a catalytic role in the implementation of the Action Programme by creating greater awareness of the importance of integrated water management, responding to specific requests from member governments for technical cooperation, and assisting in mobilizing bilateral and multilateral donor support for technical assistance and investment for development.

RECENT DEVELOPMENTS

As a result of the UNCED Agenda 21 and the recommendations of the ICWE, the scope of IAP-WASAD has widened to include all major aspects of rural water management, notably, drinking water supply and sanitation for rural populations; agricultural water needs for crop production, livestock and aquaculture; soil and water conservation including watershed

DISCUSSION FORUM PAPER 2

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management; treatment, reuse and disposal of urban and rural wastewaters, drainage water and agro-industrial effluents; and the application of environmental management measures for the control of water-related diseases in rural development projects. Thus IAP-WASASD has transformed itself into a comprehensive and inter-sectoral rural water management programme, geared to meet the total water needs of rural populations under the framework of Integrated Rural Water Management.

The programme areas identified by the UNCED Agenda 21 under Sustainable Food Production and Rural Development include:

- Water supply and sanitation for the unserved rural poor;
- Water use efficiency;
- Waterlogging and salinity control and drainage;
- Water quality management;
- Water resources development programmes;
- Scarce water resources management;
- Water supply for livestock;
- Inland fisheries; and
- Aquaculture development.

FAO is committed to assist member nations in implementing these activities in collaboration with relevant UN organizations and in partnership with bilateral donors and NGOs.

MECHANISM OF COORDINATION

The need for three levels of coordination is apparent, namely, (i) coordination within FAO; (ii) coordination between FAO and relevant organizations in the UN system; and (iii) coordination at the country level.

Coordination within FAO

Within FAO, the responsibility of implementing the programme lies with the Water Resources Development and Management Service (AGLW) of the Land and Water Development Division (AGL). So far, activities have been coordinated with other relevant Services and Divisions in an 'ad-hoc' manner. However, on substantive issues, coordination with FAO's technical units has been routine, particularly in areas covering economic policy, water legislation, environment, human resources development, forestry and fisheries.

The position of IAP-WASAD in the framework of the FAO programme on Sustainable Agriculture and Rural Development provides another mechanism of coordination within the Organization. This is illustrated in the schematic representation of the FAO's International Cooperative Programme Framework for Sustainable Agriculture and Rural Development (see Figure 1, page 244).

FAO is also in the process of establishing Special Action Programmes (SAP) on selected areas and the establishment of a SAP on WASAD is under discussion. The SAP will establish a formal mechanism of coordination within the Organization.

Coordination within the UN System

The coordination within the UN System for IAP-WASAD is provided through the ACC-ISGWR. Since its initiation in 1989 (as a component of the Strategy for the Implementation of the Mar del Plata Action Programme), progress on IAP-WASAD is reported regularly by FAO to meetings of the ACC-ISGWR.

The ICWE and the UNCED have further strengthened the coordination of the programme within the UN System, particularly with UNICEF, UNDP, World Bank and WHO, under the programme framework of integrated rural water management.

The establishment of an Inter-Agency Working Group on Integrated Rural Water Management was suggested at the 13th session of the ACC-ISGWR and this issue will be discussed in this Technical Consultation.

Coordination at National Level

The FAO document on IAP-WASAD was distributed to all Member Nations of FAO through FAO Representations. FAO has a commitment to assist the Member Nations in implementing the programme upon request. Coordination of the programme at the country level is provided through the FAO Representation.

Country Programming Missions have been undertaken in six countries and in one shared lake basin so far. In three countries, namely, Egypt, Indonesia and Turkey, national coordination mechanisms for implementing IAP-WASAD have been proposed. In Mexico, the National Water Commission which has already established a mechanism for coordination, will serve the purpose of programme coordination.

PROGRAMME IMPLEMENTATION

The following steps have been adopted in implementing the IAP-WASAD.

- Receipt of request for participation in the IAP-WASAD by Member Government.
- Desk study on agricultural water management of the country which requested participation.
- Formulation of Terms of Reference and composition of mission members of the IAP-WASAD country missions.
- Consultation with relevant UN organizations and bilateral and multilateral donors.
- Undertaking the country missions.
- Formal submission of the WASAD Country Programmes to the Government.
- Assisting participating developing countries to seek funds to implement the programmes.
- Implementation of the Programmes.

Table 1 presents the technical disciplines of the IAP-WASAD country and lake basin missions and UN and bilateral agencies which participated in the missions and or consulted.

TABLE 1

Missions	Technical disciplines	Agencies consulted/ participated
Egypt	Water resources policy and planning Irrigation and drainage Water quality/water pollution Fisheries	CIDA[1] UNDP[2] WB[2]
Indonesia	Water resources policy and planning Water legislation Irrigation and drainage Watershed management Aquaculture	CIDA[1] JALDA[1] UNDP[2] WB[2]
Mexico	Irrigation and drainage Water quality and water pollution Watershed management	WB[2]
Tanzania	Water resources policy and planning Water legislation Irrigation and drainage Watershed management Fisheries	USAID[1] UNDP[2]
Turkey	Water resources policy and planning Water legislation Irrigation and drainage Water quality and water pollution Soil and water conservation Watershed management Fisheries	UNDP[2] WB[2]
Lake Chad Basin	Water resources/hydrology Irrigation and drainage Land use planning Environmental impacts	UNEP[1] UNDTCD[1] LCBC[1]

[1] Participated in missions and provided financial support.
[2] Consulted with organizations at the Headquarters and country levels.

NEED FOR ENHANCED COLLABORATION

The scope of international action required by UNCED Agenda 21 calls for increased cooperation among organizations, both within and outside the UN system. At the UN-system level, an Inter-governmental Commission on Sustainable Development (IGCSD) has been established to coordinate the implementation of Agenda 21.

With regard to the implementation of Agenda 21 on the Protection of Water Quality and the Supply of Water Resources (Chapter 18), the ACC-ISGWR is expected to play a lead role under the guidance of IGCSD. In this context, the establishment of a Working Group on Integrated Rural Water Management under the framework of ACC-ISGWR is recommended. The function of this Inter-agency Working Group is two-fold:

- To collaborate with activities and programmes within and outside the UN system on rural water management such as: The UNDP/WB Programme on Water Supply and

Sanitation, The Water Supply and Sanitation Collaborative Council, The International Programme for Technology and Research in Irrigation and Drainage, and others; and

- To enhance coordination among participating UN organizations, to develop guidelines on integrated rural water management at national, regional and global levels, and to formulate and implement technical assistance programmes on Integrated Rural Water Management.

For the purpose of discussion, the following issues are raised:

- Are the various water programmes in rural water management implemented by the various UN organizations adequately coordinated in order to optimize human and financial resources within the UN system?

- Is there adequate coordination between the activities of the UN system and those of multi- and bi-lateral agencies outside the UN system and the NGOs in the field of rural water management?

- What mechanism could be recommended to enhance coordination on rural water management within and outside the UN system?

- Are there existing guidelines to promote integrated rural water management at national, regional and global level? If not, what action should be undertaken to fulfil this need?

- What mechanisms exist to undertake joint UN and ESA missions for national project formulation and programme implementation? How can these functions be carried out effectively?

Annex 1

Opening and closing addresses

WELCOME ADDRESS: Dr. Wim G. Sombroek, Director, Land and Water Development Division, FAO

Distinguished participants from Member Nations and United Nations organizations, and colleagues, most of us met in FAO in October 1991 and practically all of us in Dublin in January 1992.

It gives me great pleasure in welcoming you on behalf of Dr. Edouard Saouma, Director-General of FAO and in my personal capacity as the Director of the Land and Water Development Division, to this Technical Consultation on Integrated Rural Water Management. The Consultation is organized and hosted by FAO and co-sponsored by UNICEF, UNDP, the World Bank and WHO.

Our Director-General, in his Closing Address to the International Conference on Water and Environment, held in Dublin in January last year, underlined the importance of integrated management of water resources and inter-sectoral coordination, and, I quote : "..to implement this Conference's recommendations, policy and institutional changes will be required in many countries. Policies may have to be revised to promote integrated management of water resources and access to adequate supplies of freshwater by all those who need it. Concerted action will be needed, involving several sectors and ministries at the same time. In many cases, intersectoral mechanisms may have to be established to facilitate coordination".

This Consultation is convened as a bid to address these challenging tasks.

The Consultation has set-forth three clearly defined objectives, namely: to develop mechanisms to promote integrated rural water management; to identify subjects for concerted and coordinated action between agencies, countries and donor community including technical assistance to developing countries; and to establish guiding principles and modalities to prepare guidelines for integrated rural water resources management. Further, in order to be pragmatic and focus the discussion on real and priority issues, the Consultation is structured on three thematic subjects, namely, policy, strategy and planning; research and development of technologies; and capacity building . Accordingly, the objectives of the Consultation will be pursued under three technical sessions, corresponding to the three thematic subjects. Each technical session will have a keynote paper, a set of discussion papers and case studies, and will be followed by a meeting of a Working Group. The recommendations of the three Working Groups will be discussed in the plenary and the outcome will constitute the recommendation of the Consultation.

The Dublin International Conference and the UNCED Conference in Rio, July 1992, have established a broad international consensus on the common objectives and general principles of sustainable development. Chapter 18 of the UNCED Agenda 21 provides a solid and comprehensive basis for international cooperation in support of local, national, regional and international programmes for water resources and rural development.

The task of this Consultation is thus to define a programme for action within the framework of Agenda 21, Chapter 18 with specific focus on integrated rural water management. I have no doubt on the ability of this gathering to meet this challenge. The spirit of inter-agency cooperation is indeed very high, maybe better than ever before in the history of the United Nations system, I think partly through the effective functioning of the Administrative Committee for Coordination's Inter-Secretariat Group on Water Resources, on which Dr. de Haen will elaborate. FAO stands ready to further this cooperative effort, because it is committed to serve the Member Nations in the best possible and most effective manner.

OPENING ADDRESS: Dr. H. de Haen, Assistant Director-General, Agriculture Department, FAO

Mr. Chairman, ladies and gentlemen,

It is with great pleasure that I welcome you to this Technical Consultation. Let me briefly provoke your thinking on the subject of the Consultation. Let me structure this "provocation", following the key terms figuring in the topic of the consultation: "Integrated Rural Water Management".

Why the emphasis on "rural"? Firstly of course, because the support of sustainable rural development is the overriding mandate of FAO, but more generally because rural water supplies are in a particularly critical state in many parts of the world.

Rural societies differ from urban in many obvious ways, but it is not easy to define the differences so that they fit every case. Generally speaking, rural societies are those which are involved in the production of foods, fibres, and raw materials. They are also more involved in activities by which the foods, fibres, minerals and raw materials are processed and distributed and in the provision of services to the rural people. Population is traditionally classified as urban and rural according to the share of people living in communities above or below a certain population density. While urbanization is growing rapidly, most of the low-income countries are still primarily rural. In Sub-Sahara Africa two-thirds live in rural areas, in South Asia even 75 percent. South America is different: 75 percent live in urban centres. What is particularly alarming is that rural areas host the greatest share (sometimes as many as 80-90 percent) of the poor. These people lack the most essential things for their day-to-day life, including fresh water. The situation of these people is further aggravated because it is in the rural areas that poverty and environmental degradation come together most acutely, endangering both the production potential and the current already low levels of well-being.

The next task, even a more difficult one, is to define "integration". In mathematics, integration refers to the setting up and evaluating of a type of infinite sum. In the context of the European Community, integration means the process of unifying the economies of the european countries, implying not only the abolition of trade barriers, but ultimately setting up of a single set of monetary, fiscal and other governmental politics. So what do we mean by integrated water management, let alone integrated rural water management ? It is my impression that it does not refer to the amalgamation of the different water institutions and functions, but rather a process of joint planning and programming and programme implementation in order to optimize the utilization of the resource through the application of social, economic, political and technical instruments. However, this is something that I hope that this Consultation will more clearly define. I have no doubt in my mind on the vital importance of an integrated approach to water management defined in this latter sense. This is something that has been stressed over and over again in the Dublin Conference and "enshrined" in Chapter 18 of the UNCED Agenda 21. The keynote paper on policies, strategies and planning for integrated rural water management says " .. without the introduction of the concept of integrated rural water management, they (meaning many communities and millions of people) will all lose in terms of resource, environment and quality of life".

We all recognize two opposing realities. On the one side, we know that for all practical purposes freshwater resources are finite and that most of the economically viable development of these resources has already been implemented. Thus the potential to expand this resource base is marginal; in addition, water quality degradation resulting from pollution is "shrinking" the usable volume of freshwater.

On the other side, we are confronted by the increasing population and the associated expansion of economic activities, all of which require more water, putting tremendous strain on this already limited and fragile resource.

This is the dilemma that we are faced with. Are we doomed to fail, or can we succeed? There is a chance that we may succeed and we should not let go this chance. We can succeed, if we manage this precious resource making use of the tools that legal and economic policy, scientific and technological advancement have given to us. This is what this Consultation is about. We propose to discuss the application of these instruments in rural water management; what are they ? policies, strategies and planning - research and development - and human resources and institutional development (which we call capacity building). So we are in the right direction, but we should produce tangible results.

I shall only touch on two issues, which are close to my heart, namely, demand management and water pricing. In my mind these two are basic to integrated water management.

As I said earlier, it appears that we can do very little with the supply side of the water equation. But yet we have to balance the equation, which at the moment is heavily unbalanced, and the option we have is to manipulate the demand side. Thus demand management assumes central importance.

If I may quote the keynote paper which is to be presented in the Technical Session I on demand management. It says " the management of demand through the more efficient use of water and through changes in agricultural production practices as well as the reduction of wastage, is a vital issue in resources management strategies and planning...."

There is no question on the central importance of demand management aiming at efficiency, equity and long-term water security. We need to elaborate the concept of demand management into implementable policies programmes and actions. This is certainly a task that lies in front of this Consultation.

Water pricing on the other hand is a sensitive issue, but could be an effective instrument if properly understood and applied. Principle No. 4 of the Dublin Conference states "water has an economic value in all its competing uses and should be recognized as an economic good".

What is the economic value of water that we are talking about ? I consider that the true economic value of water consists of two components, namely, the value of the resource per se, as a utility or input to production; and the cost of service, meaning cost of development and supply. These components should be taken into consideration in water pricing policy analysis. However, the price that may be set, to be paid by the consumer may or may not include the full cost, depending on social, political and cultural considerations.

The Dublin statement sheds some light in this regard. It says, I quote, " within this principle (that water has economic value) it is vital to recognize the basic right of all human beings to have access to clean water and sanitation at an affordable price....". Certainly, it is this basic right which societies have in view when they refrain from charging consumers, in particular the poor sections of them, with the full cost of the resource. On the other hand, it seems to me that there is a general need to raise the awareness for the scarcity of the resource so that all users feel the scarcity and avoid excessive use. Irrigated agriculture has a particular responsibility and a high potential for savings in this regard.

The concept of pricing water could further be extended to pricing the cleaning operation of water at the end of the intended use. This is of great importance because all uses of water degrade the quality and this implies that some form of treatment will be needed to restore the quality in order to prevent the "poisoning of the hydrological cycle". Under certain circumstances, the quality degradation may be so slight that natural processes can take care of the cleaning process, but this is becoming increasingly difficult considering the acute state of pollution, shortage of water and clogging of the natural cleaning systems by mismanagement. Thus the "polluter pays" principle becomes relevant.

I fully realize the economic tools alone will not be sufficient to tackle the water problems that we are faced with. Technological solutions are of primary importance. To implement technological and economic tools and solutions, we need the institutional and human resources capacity and thus capacity building emerges as one of the key components.

The interrelationship of all these factors clearly indicate the vital need for an integrated approach. I am very happy to note that this Consultation has included all these components in its agenda. In this regard this is a unique technical consultation, because, for the first time, we are discussing technical issues that are concerned with multiple use of water in the rural context, and within the framework of policy, technology and capacity building.

This Consultation is convened, as mentioned by Mr. Sombroek, in response to the Dublin Conference and the Agenda 21 of the UNCED. These two conferences are indeed important milestones in the history of the United Nations system and their effort to provide coordinated assistance to Member Nations. However, in the field of water, I should mention another process of harmonization and coordination that has been effected in the United Nations system. This is the ACC-Intersecretariat Group on Water Resources, the popular acronym being ACC-ISGWR. This Group has been instrumental for a number of joint efforts on water within the United Nations system, and particularly during the past five years, has galvanized the spirit of inter-agency cooperation. Starting from the March 1989 Expert Consultation to formulate a Comprehensive Strategy for the Implementation of the Mar del Plata Action Plan in the 1990s and beyond, through the Dublin Conference and the preparatory process for UNCED, and up to this activity today, the ACC-ISGWR has been a "binding factor" in the UN system. I take this opportunity to commend the "Group" for their outstanding performance and needless to say that we strongly support this Group. At the same time I am aware of the fact that ACC-ISGWR is to be reviewed by the Inter-agency Committee on Sustainable Development, and it is our hope that the result of the review will further the objectives of inter-agency coordination of the ACC-ISGWR.

You have an immense task ahead, but this not insurmountable, because you are a specialized and dedicated group, and you have resolved to work on a programme that is focused on key issues that confront sustainable water management and is of interest to all mankind and future generations.

FAO looks forward to the recommendations of the Consultation.

CLOSING ADDRESS – COMPREHENSIVE WATER RESOURCES MANAGEMENT: A FRAMEWORK: Dr. Guy Le Moigne, Senior Adviser, Agriculture and Water Resources, The World Bank, Washington DC

I am delighted to be present at this Technical Consultation organized by FAO and to share with you my views on comprehensive water resources management (CWRM) as part of the concluding remarks. The world faces the twin prospects of increasing competition for water and deterioration in water quality. The competition for water on an international level is often the aspect which receives the most attention in the media — properly so, since it has the potential to lead to serious conflict. But the conflict over water and the degradation of water quality in all the user subsectors within countries are as important.

The competition in many developing countries is now (and will increasingly be) between the urban and rural sectors. The two main factors fomenting this competition are high population growth combined with rapid urbanization. Countries with some of the greatest potential for internal or external strife over water resources also have high birth rates, as in parts of the Middle East and Africa. By the turn of the century, only seven years from now, seventeen of the world's twenty-four cities with over ten million inhabitants will be in developing countries, compared with only one in 1960. Assuming steadily rising living standards, the demand for water will increase dramatically, especially in the urban and industrial sectors.

FRAGMENTED APPROACH TO WATER RESOURCES MANAGEMENT

Why do we need a new approach? Quite simply, it is clear that in many developing countries, existing approaches are not suitable in the physical, economic or an environmental sense: (i) water is misallocated; low-value uses consume a significant share of the resource, while high-value uses suffer shortages; (ii) water quality is not monitored leading to inappropriate use of low quality water; (iii) water and sewage services, especially for the poor, are inadequate; and (iv) costs of new water development are mounting. These issues cannot be addressed by the present fragmented approach to water resources leading to inappropriate investment and failure to consider adequately alternative uses of water and water conservation.

CWRM is an alternate approach, one that is being encouraged by international agencies. The concept underlying the approach has existed for a long time, but it has recently received strong international support at several conferences, including the June 1991 conference in Delft on Capacity Building in the Water Sector and the January 1992 conference in Dublin on Water and the Environment. The UN Conference on Environment and Development in Rio de Janeiro in June 1992 concluded that "the holistic management of fresh water as a finite and vulnerable resource, and the integration of sectoral water plans and programmes within the framework of national economic and social policy, are of paramount importance for actions in the 1990s and beyond".

ELEMENTS OF CWRM

The principles of CWRM viewed at the Bank include a comprehensive analytical framework coupled with decentralized management of water resources and the active participation of water users in both analysis and management. The analytical framework requires the examination of water resources, usually with a rive basin as the spatial unit, by considering potential uses and possible effects, especially environmental effects. Protection, enhancement and restoration of water quality, and abatement of pollution are principles which must suffuse each of the aspects of comprehensive water management mentioned previously.

A comprehensive analytical approach does not mean comprehensive planning; it is not intended to make rigid, centralized prescriptions for water management. Decentralizing the actual management has many benefits, among which is helping the public sector better perform the needed functions of regulation. The participation of key "stakeholders" is necessary at the stage of analysis to account for all effects and externalities and in management to ensure the sustainability of the systems.

The comprehensive approach also relies on appropriate incentives for providers and users of water. These are necessary if we are to allocate water to the best possible use and price water services properly to foster financial discipline and accountability among water providers and users. In the long run, distortions in pricing and water charges are incompatible with sustainable water resources management on either a national, local or project basis. Providing such incentives does not necessarily conflict with another important principle of the World Bank's water policy — alleviating poverty. Inadequate water services are particularly hard on the poor, most importantly because of the spread of disease, and research suggests that the poor would be willing to pay for reliable, safe water — indeed, they often pay more to buy water from street vendors than they would, on average, for water rates.

Countries need to strengthen the capacity to adopt CWRM if the process of analysis and management are viewed as iterative exercises. It is not enough to rely only on external expertise and resources. Ownership of any programme in the sector by the decision-makers and participation by key stakeholders are crucial to its success.

IMPLICATIONS FOR IRRIGATION

All the principles outlined above — a comprehensive analytical framework, decentralized management, participation of stakeholders, providing incentives and capacity building — rest on the foundation of preserving the world's environment and resource base. This is the bedrock of sustainable development. For those involved in agriculture, the main challenge will be on improving water conservation through policy, technological and management interventions. Perhaps the most important areas for work are:

- proper operation and maintenance of existing systems;
- managing water demand through efficient pricing, including cost recovery or regulatory measures, and related education and training;
- ensuring widespread user participation;
- adopting adequate steps to enhance water and land quality measures; and
- adopting improved, water-efficient technologies and regulations.

Many of these issues have been discussed at this Consultation. These discussions are useful for the finalization of the policy paper at the Bank. Clearly, CWRM will require the combined talent and resources of all agencies. In this regard, we welcome FAO's participation in the efforts to improve water resources management worldwide. For the Agriculture and Natural Resources Department in the World Bank, these efforts imply significant attention to working closely with the Bank's Operations Departments. The recent reorganization of the Bank requires that we devote a larger portion of our time to operational support than hitherto. We have been called upon to work with out operational colleagues to transfer best practices in water resources management across countries and regions. FAO, with its global experiences, could also contribute to the design and implementation of water-related projects and programmes partly financed by the Bank by participation in Bank missions for sector work and for project activities throughout the project cycle. Such participation would serve the objectives of strengthening our combined understanding of the borrowers' needs and of introducing to the borrower FAO's expertise in water resources management. Further requests for FAO assistance from the borrower might follow on the basis of early involvement in the project cycle.

Annex 2

Agenda

15.03.93
Monday

OPENING SESSION

0900:	Welcome by the Chairman, W.G. Sombroek, Director AGL, FAO
0905:	Opening Address, H. de Haen, Assistant Director General, AGD, FAO
0920:	Election of Officers of the Consultation
0925:	Adoption of Agenda
0930:	Coffee Break

TECHNICAL SESSION I
Chair: Carel de Rooy, UNICEF

Keynote Paper

0945:	Policies, strategies and planning for integrated rural water management, B. Appelgren, FAO.

Discussion Papers

1030:	Framework for analysis to enhance efficiency in agriculture and urban water use, H. Savenije, UNDP.
1100:	Institutional and legal issues in rural water management, S. Burchi, FAO.
1130:	Role of water supply and sanitation in integrated rural water management - Policy analysis, C. de Rooy, UNICEF.
1200:	Global water information system: contribution to integrated rural water management, P. Pallas, FAO.
1230:	Lunch Break

Case Studies

1400: Policies, strategies and planning for rural water supply and sanitation in India, R. Gopalakrishnan, UNICEF

1430: Integrated water resources and rural development in Indonesia, Alirahman, Indonesia

1500: Coffee Break

Working Group on Policies, Strategies and Planning

1515: Meeting of the Working Group

1730: Close of Day 1

16.03.93
Tuesday

DISCUSSION FORUM
Existing Mechanisms of Coordination and Programme Implementation
Chair: Frank Hartvelt, UNDP

0830: The Water Supply and Sanitation Collaborative Council, B. Locke, WSSCC

0850: The International Action Programme on Water and Sustainable Agricultural Development, A. Kandiah, FAO

0910: The International Programme for Technology and Research in Irrigation and Drainage, A. Subramanian, World Bank

0930: Coffee Break

TECHNICAL SESSION II
Chair: Dennis Warner, WHO

Keynote Paper

0945: Technologies for improving water use efficiency and environmental protection in rural water management. Lessons from an irrigation research programme, A. Subramanian, World Bank

Discussion Papers

1030: Research and development for integrated rural water management, A. Kandiah, FAO

1100: Reuse of community wastewater: health and environmental protection - research needs, I. Hespanhol, WHO

1130: Environmental management for disease vector control in rural water resources development projects, R. Bos, WHO

1200: Monitoring of integrated rural water management programmes - water supply and sanitation, D. Warner, WHO

1230: Lunch Break

Case Studies

1400: Research and development on drinking water supply and sanitation, UNDP/World Bank

1420: Research and development on irrigation and drainage technologies in Turkey, S. Kodal, Turkey

1440: Water resources management and use of wastewater - The Sultanate of Oman, I. Hespanhol, WHO

1500: Environmental management measures for disease vector control in rural water development projects, B. Snellen, PEEM Collaborating Centre, ILRI

1520: Monitoring of water supply and sanitation projects in Togo, D. Warner, WHO

1540: Coffee Break

Working Group on Research and Development

1600: Meeting of the Working Group

1730: Close of Day 2

17.03.93
Wednesday

TECHNICAL SESSION III
Chair: Guy Le Moigne, WB

Keynote Paper

0945: Capacity building for water sector management, F. Hartvelt, UNDP

Discussion Papers

1030: Building managerial capabilities in developing countries, C. de Rooy, UNICEF

1100: Technology transfer mechanisms and programmes for rural water management, A. Kandiah, FAO

1130: Participatory approaches in planning and management of irrigation schemes, T. Facon, FAO

1200: Educational approaches to building awareness and actions in rural communities for integrated rural water management, Mayling Simpson-Hébert, WHO

1230: Lunch Break

Case Studies

1400: Capacity building for rural water supply and sanitation, World Bank/UNDP

1420: Capacity building for agricultural water management in Egypt, A. El-Beltagy, Egypt

1440: Water management in irrigated agriculture in Mexico, L.A. León Estrada, Mexico

1500: Health comic magazines in Burundi: a means of communication with children and their families, Mayling Simpson-Hébert, WHO

1520: Promotion of environmental management for vector control through agricultural extension, R. Bos, WHO

1540: Coffee Break

Working Group on Capacity Building

1600: Meeting of the Working Group

1730: Close of Day 3

18.03.93
Thursday

PRESENTATION OF REPORTS BY WORKING GROUPS
Chair: Frank Hartvelt, UNDP

0830: Report of the Working Group on Policies, Strategies and Planning.

0930: Coffee Break

0945: Report of the Working Group on Research and Development

1030: Report of the Working Group on Capacity Building

1130: Report on Mechanism of Coordination

1230: Lunch Break

1400: Drafting of Consultation Report and Recommendations (Drafting Committee)

Geographical Information System and its application in water management, E. Ataman, FAO

1500: Coffee Break

1530: Shuttle Bus to F Building

1600: Remote Sensing Technologies and their application in water resources management, D. Lantieri, FAO

1730: Shuttle Bus to B Building

Close of Day 4

19.03.93
Friday

CONCLUDING SESSION
Chair: W.G. Sombroek, Director, AGL, FAO

0930: Presentation of the Report and Recommendations of the Consultation and Adoption of the Report and Recommendations

Closing Address, G. Le Moigne, Senior Advisor, Agriculture and Water Resources, World Bank

Closing Formalities

1130: Closure of the Consultation

Annex 3

List of participants

MEMBER NATIONS

EGYPT	Adel El-Beltagy Director General Agriculture Research Center Ministry of Agriculture and Land Reclamation
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	Bryan Locke Deputy to Executive Secretary WSS Collaborative Council World Health Organization 20 Avenue Appia CH-1211 Geneva 27, Switzerland

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	Dennis Warner Manager Community Water Supply and Sanitation World Health Organization 20 Avenue Appia CH-1211 Geneva 27, Switzerland
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H. de Haen	Assistant Director-General, Agriculture Department
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B. Appelgren	Senior Officer, Water Resources, Development and Management Service
E. Ataman	Manager (Geographic Information System), Research and Technology Development Division
S. Burchi	Senior Legal Officer (Land and Water), Environmental Resource Law, Legal Office
T. Facon	Technical Officer, Water Resources, Development and Management Service
R. Gommes	Remote Sensing Centre, Research and Technology Development Division
A. Kandiah	Senior Officer, Water Resources, Development and Management Service
A.P. Koohafkhan	Senior Officer (Environment and Sustainable Development), Environment and Sustainable Development Coordinating Centre, Research and Technology Development Division

D. Lantieri	Remote Sensing Centre, Research and Technology Development Division
B. MacCall	Senior Programme Development Adviser, Field Programme Development Division
A. Mashali	Soil Resources, Management and Conservation Service
T.H. Mather	Consultant
T. Michaelsen	Forest and Wildlands Conservation Branch, Forest Resources Division
P. Pallas	Officer-in-charge, Water Resources, Development and Management Service
Ramadhar	Chief, Technical and Economic Cooperation among Developing Countries, Development Department
R. Stringer	Situation and Policy Studies Service, Policy Analysis Division
A. Tabet	Investment Centre
L. Vermeiren	Senior Officer, Water Resources, Development and Management Service

Annex 4

Excerpts from the Report of the United Nations Conference on Environment and Development

Rio de Janeiro, 3-14 June 1992

Section II, Conservation and Management of Resources for Development, Agenda 21 (Vol. II)

CHAPTER 18

PROTECTION OF THE QUALITY AND SUPPLY OF FRESHWATER RESOURCES: APPLICATION OF INTEGRATED APPROACHES TO THE DEVELOPMENT, MANAGEMENT AND USE OF WATER RESOURCES

INTRODUCTION

18.1 Freshwater resources are an essential component of the Earth's hydrosphere and an indispensable part of all terrestrial ecosystems. The freshwater environment is characterized by the hydrological cycle, including floods and droughts, which in some regions have become more extreme and dramatic in their consequences. Global climate change and atmospheric pollution could also have an impact on freshwater resources and their availability and, through sea-level rise, threaten low-lying coastal areas and small island ecosystems.

18.2 Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases. Innovative technologies, including the improvement of indigenous technologies, are needed to fully utilize limited water resources and to safeguard those resources against pollution.

18.3 The widespread scarcity, gradual destruction and aggravated pollution of freshwater resources in many world regions, along with the progressive encroachment of incompatible activities, demand integrated water resources planning and management. Such integration must cover all types of interrelated freshwater bodies, including both surface water and groundwater, and duly consider water quantity and quality aspects. The multisectoral nature of water resources development in the context of socio-economic development must be recognized, as well as the multi-interest utilization of water resources for water supply and sanitation, agriculture, industry, urban development, hydropower generation, inland fisheries, transportation, recreation, low and flat lands management and other activities. Rational water utilization schemes for the development of surface and underground water-supply sources and other potential sources have to be supported by concurrent water conservation and wastage minimization measures. Priority, however, must be accorded to flood prevention and control measures, as well as sedimentation control, where required.

18.4 Transboundary water resources and their use are of great importance to riparian States. In this connection, cooperation among those States may be desirable in conformity with existing agreements and/or other relevant arrangements, taking into account the interests of all riparian States concerned.

18.5 The following programme areas are proposed for the freshwater sector:

(a) Integrated water resources development and management;

(b) Water resources assessment;

(c) Protection of water resources, water quality and aquatic ecosystems;

(d) Drinking-water supply and sanitation;

(e) Water and sustainable urban development;

(f) Water for sustainable food production and rural development;

(g) Impacts of climate change on water resources.

F. WATER FOR SUSTAINABLE FOOD PRODUCTION AND RURAL DEVELOPMENT

Basis for action

18.65 Sustainability of food production increasingly depends on sound and efficient water use and conservation practices consisting primarily of irrigation development and management, including water management with respect to rain-fed areas, livestock water-supply, inland fisheries and agro-forestry. Achieving food security is a high priority in many countries, and agriculture must not only provide food for rising populations but also save water for other uses. The challenge is to develop and apply water-saving technology and management methods and, through capacity-building, enable communities to introduce institutions and incentives for the rural population to adopt new approaches, for both rain-fed and irrigated agriculture. The rural population must also have better access to a potable water-supply and to sanitation services. It is an immense task but not an impossible one, provided appropriate policies and programmes are adopted at all levels — local, national and international. While significant expansion of the area under rain-fed agriculture has been achieved during the past decade, the productivity response and sustainability of irrigation systems have been constrained by problems of waterlogging and salinization. Financial and market constraints are also a common problem. Soil erosion, mismanagement and over-exploitation of natural resources and acute competition for water have all influenced the extent of poverty, hunger and famine in the developing countries. Soil erosion caused by overgrazing of livestock is also often responsible for the siltation of lakes. Most often, the development of irrigation schemes is supported neither by environmental impact assessments identifying hydrologic consequences within watersheds of interbasin transfers, nor by the assessment of social impacts on peoples in river valleys.

18.66 The non-availability of water-supplies of suitable quality is a significant limiting factor to livestock production in many countries, and improper disposal of animal wastes can in certain circumstances result in pollution of water-supplies for both humans and animals. The drinking-water requirements of livestock vary according to species and the environment in which they are kept. It is estimated that the current global livestock drinking-water requirement is about 60 billion litres per day and based on livestock population growth estimates, this daily requirement is predicted to increase by 0.4 billion litres per annum in the foreseeable future.

18.67 Freshwater fisheries in lakes and streams are an important source of food and protein. Fisheries of inland water should be so managed as to maximize the yield of aquatic food organisms in an environmentally sound manner. This requires the conservation of water quality and quantity, as well as of the functional morphology of the aquatic environment. On the other hand, fishing and aquaculture may themselves damage the aquatic ecosystem; hence their development should conform to guidelines for impact limitation. Present levels of production from inland fisheries, from both fresh and brackish water, are about 7 million tons per year and could increase to 16 million tons per year by the year 2000; however, any increase in environmental stress could jeopardize this rise.

Objectives

18.68 The key strategic principles for holistic and integrated environmentally sound management of water resources in the rural context may be set forth as follows:

(a) Water should be regarded as a finite resource having an economic value with significant social and economic implications reflecting the importance of meeting basic needs;

(b) Local communities must participate in all phases of water management, ensuring the full involvement of women in view of their crucial role in the practical day-to-day supply, management and use of water;

(c) Water resource management must be developed within a comprehensive set of policies for (i) human health; (ii) food production, preservation and distribution; (iii) disaster mitigation plans; (iv) environmental protection and conservation of the natural resource base;

(d) It is necessary to recognize and actively support the role of rural populations, with particular emphasis on women.

18.69 An International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD) has been initiated by FAO in cooperation with other international organizations. The main objective of the Action Programme is to assist developing countries in planning, developing and managing water resources on an integrated basis to meet present and future needs for agricultural production, taking into account environmental considerations.

18.70 The Action Programme has developed a framework for sustainable water use in the agricultural sector and identified priority areas for action at national, regional and global levels. Quantitative targets for new irrigation development, improvement of existing irrigation schemes and reclamation of waterlogged and salinized lands through drainage for 130 developing countries are estimated on the basis of food requirements, agro-climatic zones and availability of water and land.

18.71 FAO global projections for irrigation, drainage and small-scale water programmes by the year 2000 for 130 developing countries are as follows: (a) 15.2 million hectares of new irrigation development; (b) 12 million hectares of improvement/modernization of existing schemes; (c) 7 million hectares installed with drainage and water control facilities; and (d) 10 million hectares of small-scale water programmes and conservation.

18.72 The development of new irrigation areas at the above-mentioned level may give rise to environmental concerns in so far as it implies the destruction of wetlands, water pollution, increased sedimentation and a reduction in biodiversity. Therefore, new irrigation schemes should be accompanied by an environmental impact assessment, depending upon the scale of the scheme, in case significant negative environmental impacts are expected. When considering proposals for new irrigation schemes, consideration should also be given to a more rational exploitation, and an increase in the efficiency or productivity, of any existing schemes capable of serving the same localities. Technologies for new irrigation schemes should be thoroughly evaluated,, including their potential conflicts with other land uses. The active involvement of water-users groups is a supporting objective.

18.73 It should be ensured that rural communities of all countries, according to their capacities and available resources and taking advantage of international cooperation as appropriate, will have access to safe water in sufficient quantities and adequate sanitation to meet their health needs and maintain the essential qualities of their local environments.

18.74 The objectives with regard to water management for inland fisheries and aquaculture include conservation of water quality and water quantity requirements for optimum production and prevention of water pollution by aquacultural activities. The Action Programme seeks to assist member countries in managing the fisheries of inland waters through the promotion of sustainable management of capture fisheries as well as the development of environmentally sound approaches to intensification of aquaculture.

18.75 The objectives with regard to water management for livestock supply are twofold: provision of adequate amounts of drinking-water and safeguarding of drinking-water quality in accordance with the specific needs of different animal species. This entails maximum salinity tolerance levels and the absence of pathogenic organisms. No global targets can be set owing to large regional and intra-country variations.

Activities

18.76 All States, according to their capacity and available resources, and through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could implement the following activities:

(a) **Water-supply and sanitation for the unserved rural poor:**

(i) Establish national policies and budget priorities with regard to increasing service coverage;

(ii) Promote appropriate technologies;

(iii) Introduce suitable cost-recovery mechanisms, taking into account efficiency and equity through demand management mechanisms;

(iv) Promote community ownership and rights to water-supply and sanitation facilities;

(v) Establish monitoring and evaluation systems;

(vi) Strengthen the rural water supply and sanitation sector with emphasis on institutional development, efficient management and an appropriate framework for financing of services;

(vii) Increase hygiene education and eliminate disease transmission foci;

(viii) Adopt appropriate technologies for water treatment;

(ix) Adopt wide-scale environmental management measures to control disease vectors;

(b) **Water-use efficiency:**

(i) Increase of efficiency and productivity in agricultural water use for better utilization of limited water resources;

(ii) Strengthen water and soil management research under irrigation and rain-fed conditions;

(iii) Monitor and evaluate irrigation project performance to ensure, *inter alia*, the optimal utilization and proper maintenance of the project;

(iv) Support water-users groups with a view to improving management performance at the local level;

(v) Support the appropriate use of relatively brackish water for irrigation;

(c) **Waterlogging, salinity control and drainage:**

(i) Introduce surface drainage in rain-fed agriculture to prevent temporary waterlogging and flooding of lowlands;

(ii) Introduce artificial drainage in irrigated and rain-fed agriculture;

(iii) Encourage conjunctive use of surface and groundwaters, including monitoring and water-balance studies;

(iv) Practise drainage in irrigated areas of arid and semi-arid regions;

(d) **Water-quality management:**

(i) Establish and operate cost-effective water-quality monitoring systems for agricultural water uses;

(ii) Prevent adverse effects of agricultural activities on water-quality for other social and economic activities and on wetlands, *inter alia*, through optimal use of on-farm input and the minimization of the use of external input in agricultural activities;

(iii) Establish biological, physical and chemical water-quality criteria for agricultural water-users and for marine and riverine ecosystems;

(iv) Minimize soil run-off and sedimentation;

(v) Dispose properly of sewage from human settlements and of manure produced by intensive livestock breeding;

(vi) Minimize adverse effects from agricultural chemicals by use of integrated pest management ;

(vii) Educate communities about the pollution-related impacts of the use of fertilizers and chemicals on water-quality, food safety and human health;

(e) **Water resources development programmes:**

(i) Develop small-scale irrigation and water-supply for humans and livestock and for water and soil conservation;

(ii) Formulate large-scale and long-term irrigation development programmes, taking into account their effects on the local level, the economy and the environment;

(iii) Promote local initiatives for the integrated development and management of water resources;

(iv) Provide adequate technical advice and support and enhancement of institutional collaboration at the local community level;

(v) Promote a farming approach for land and water management that takes account of the level of education, the capacity to mobilize local communities and the ecosystem requirements of arid and semi-arid regions;

(vi) Plan and develop multi-purpose hydroelectric power schemes, making sure that environmental concerns are duly taken into account;

(f) **Scarce water resources management:**

(i) Develop long-term strategies and practical implementation programmes for agricultural water use under scarcity conditions with competing demands for water;

(ii) recognize water as a social, economic and strategic good in irrigation planning and management;

(iii) Formulate specialized programmes focused on drought preparedness, with emphasis on food scarcity and environmental safeguards;

(iv) Promote and enhance waste-water reuse in agriculture;

(g) **Water-supply for livestock:**

(i) Improve quality of water available to livestock, taking into account their tolerance limits;

(ii) Increase the quantity of water sources available to livestock, in particular those in extensive grazing systems, in order to both reduce the distance needed to travel for water and to prevent overgrazing around water sources;

(iii) Prevent contamination of water sources with animal excrement in order to prevent the spread of diseases, in particular zoonosis;

(iv) Encourage multiple use of water-supplies through promotion of integrated agro-livestock-fishery systems;

(v) Encourage water spreading schemes for increasing water retention of extensive grasslands to stimulate forage production and prevent run-off;

(h) **Inland fisheries:**

(i) Develop the sustainable management of fisheries as part of national water resources planning;

(ii) Study specific aspects of the hydrobiology and environmental requirements of key inland fish species in relation to varying water regimes;

(iii) Prevent or mitigate modification of aquatic environments by other users or rehabilitate environments subjected to such modification on behalf of the sustainable use and conservation of biological diversity of living aquatic resources;

(iv) Develop and disseminate environmentally sound water resources development and management methodologies for the intensification of fish yield from inland waters;

(v) Establish and maintain adequate systems for the collection and interpretation of data on water quality and quantity and channel morphology related to the state and management of living aquatic resources, including fisheries;

(i) **Aquaculture development:**

(i) Develop environmentally sound aquaculture technologies that are compatible with local, regional and national water resources management plans and take into consideration social factors;

(ii) Introduce appropriate aquaculture techniques and related water development and management practices in countries not yet experienced in aquaculture;

(iii) Assess environmental impacts of aquaculture with specific reference to commercialized culture units and potential water pollution from processing centres;

(iv) Evaluate economic feasibility of aquaculture in relation to alternative use of water, taking into consideration the use of marginal-quality water and investment and operational requirements.

Means of implementation

(a) ***Financing and cost evaluation***

18.77 The Conference secretariat has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about $13.2 billion, including about $4.5 billion from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, *inter alia*, the specific strategies and programmes Governments decide upon for implementation.

(b) ***Scientific and technological means***

18.78 There is an urgent need for countries to monitor water resources and water-quality, water and land use and crop production; compile inventories of type and extent of agricultural water development and of present and future contributions to sustainable agricultural development; evaluate the potential for fisheries and aquaculture development; and improve the availability and dissemination of data to planners, technicians, farmers and fishermen. Priority requirements for research are as follows:

(a) Identification of critical areas for water-related adaptive research;

(b) Strengthening of the adaptive research capacities of institutions in developing countries;

(c) Enhancement of translation of water-related farming and fishing systems research results into practical and accessible technologies and provision of the support needed for their rapid adoption at the field level.

18.79 Transfer of technology, both horizontal and vertical, needs to be strengthened. Mechanisms to provide credit, input supplies, markets, appropriate pricing and transportation must be developed jointly by countries and external support agencies. Integrated rural water-supply infrastructure, including facilities for water-related education and training and support services for agriculture, should be expanded for multiple uses and should assist in developing the rural economy.

(c) ***Human resource development***

18.80 Education and training of human resources should be actively pursued at the national level through: (a) assessment of current and long-term human resources management and training needs; (b) establishment of a national policy for human resources development; and (c) initiation and implementation of training programmes for staff at all levels as well as for farmers. The necessary actions are as follows:

(a) Assess training needs for agricultural water management;

(b) Increase formal and informal training activities;

(c) Develop practical training courses for improving the ability of extension services to disseminate technologies and strengthen farmers' capabilities, with special reference to small-scale producers;

(d) Train staff at all levels, including farmers, fishermen and members of local communities, with particular reference to women;

(e) Increase the opportunities for career development to enhance the capabilities of administrators and officers at all levels involved in land- and water-management programmes.

(d) ***Capacity-building***

18.81 The importance of a functional and coherent institutional framework at the national level to promote water and sustainable agricultural development has generally been fully recognized at present. In addition, an adequate legal framework of rules and regulations should be in place to facilitate actions of agricultural water-use, drainage, water-quality management, small-scale water programmes and the functioning of water-users' and fishermen's associations. Legislation specific to the needs of the agricultural water sector should be consistent with, and stem from, general legislation for the management of water resources. Actions should be pursued in the following areas:

(a) Improvement of water-use policies related to agriculture, fisheries and rural development and of legal frameworks for implementing such policies;

(b) Review, strengthening and restructuring, if required, of existing institutions in order to enhance their capacities in water-related activities, while recognizing the need to manage water resources at the lowest appropriate level;

(c) Review and strengthening, where necessary, of organizational structure, functional relationships and linkages among ministries and departments within a given ministry;

(d) Provision of specific measures that require support for institutional strengthening, *inter alia*, through long-term programme budgeting, staff training, incentives, mobility, equipment and coordination mechanisms;

(e) Enhancement of involvement of the private sector, where appropriate, in human resource development and provision of infrastructure;

(f) Transfer of existing and new water-use technologies by creating mechanisms for cooperation and information exchange among national and regional institutions.