PERSPECTIVES IN CANAL OPERATION MODERNIZATION: THE FAO POINT OF VIEW

by

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1. INTRODUCTION

The author is grateful to the organizers of the fourth meeting of the Information Techniques for Irrigation Systems network for the opportunity to present the point of view of FAO on perspectives in canal operation modernization, which will be placed in the broader context of irrigation scheme modernization.

Modernization of irrigation schemes is understood in this paper as a process of change from supply oriented to service oriented irrigation. The process involves institutional, organizational and technological changes. Modernization in that sense is a response to current social and economic trends which also affect the irrigation subsector with, in particular, a shift from protective to productive irrigation.

After having illustrated by the example of the Asia region how present transformations of the social and economic environment both impose and present an opportunity for an improvement in the performance of irrigation, the paper argues that a resolute modernization strategy is the most appropriate response. The paper then proposes concepts for the modernization of irrigation schemes and discusses changes with particular reference to irrigation systems of South-East Asia.

Modernization implies changes at all operational levels of irrigation schemes from water supply and conveyance to the farm level. Although improvements in canal operation will generally be a critical first step in the modernization process, it will be of utmost importance to always keep in mind that the objective is to improve irrigation services to farmers. It is they who have to take the final decisions on the modernization programmes and improvements should not stop at the canal level. The paper therefore puts more emphasis on process than on technological and options, which have already been extensively discussed during the previous meeting on Regulation of Irrigation Canals and presentations made throughout this meeting.

Interestingly, discussions during the two meetings show that trends at work in Asia and objectives of irrigation modernization are shared to a large extent by other regions, including our host country, Morocco: it therefore hoped that, although national irrigation systems will vary greatly as starting points of a modernization process, concepts, processes and the outline for a plan of action on modernization presented in this paper have a wider relevance.

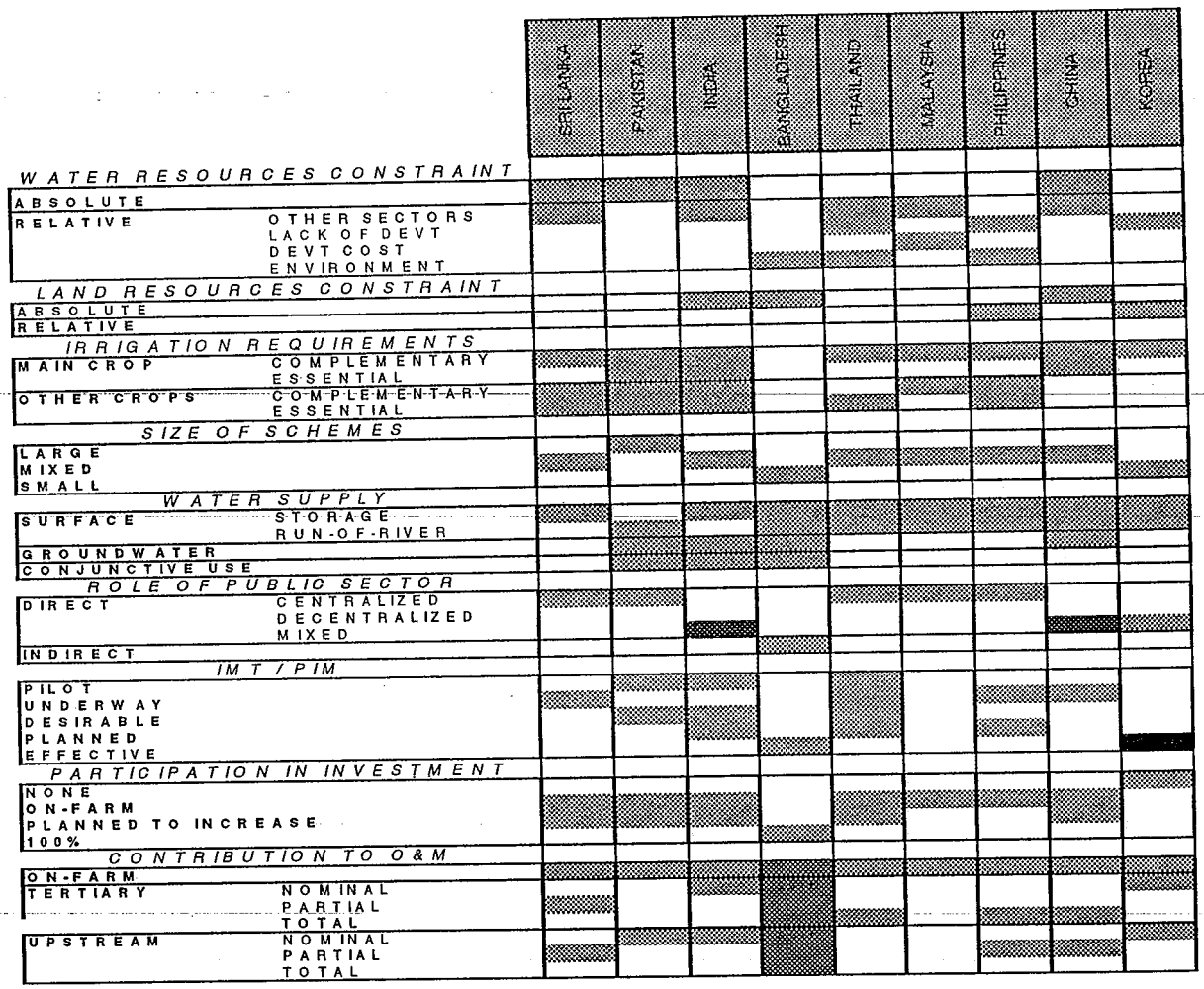
Finally, FAO's plans for future activities related to improvement and modernization of irrigation schemes are presented. In this context, cooperation with IIMI, CEMAGREF and national irrigation institutions and learning centres will be actively sought.

2. TRENDS IN IRRIGATION MODERNIZATION IN THE ASIA REGION

2.1 Major features of the national irrigation subsectors

A recent Expert Consultation held by FAO[1] was the occasion to review issues and recent trends in irrigation in Asia. In spite of the great heterogeneity among the nine countries which were represented at the expert consultation[2] in terms of natural resources endowment, agroecology and climate, agricultural, technical and institutional features of the irrigation subsector (see Table 1), they all face, to a varying degree, increasing water and land scarcity, share concerns related to the inefficiency and decay of their irrigation infrastructure, and are undergoing a process of reform of the management of the subsector.

Table 1: Main features of the national irrigation subsectors in selected Asian countries



In Sri Lanka, Pakistan, China and India, projections show a water deficit in the short to medium term and the water constraint is therefore defined as absolute. In the other countries, water availability for agricultural production is also considered an important constraint, which is defined as relative as there still exists a potential for further water resources development. In all countries, competition for developed

[1] Modernization of Irrigation Schemes: Past Experiences and Future Options, 26-29 November 1996, Bangkok.
[2] Bangladesh, People's Republic of China, India, Republic of Korea, Malaysia, Pakistan, Philippines, Sri Lanka and Thailand.

or future water resources from other sectors will require an improvement in irrigation water use efficiency. Groundwater depletion (Bangladesh) and salinization (Pakistan) are also a serious cause for concern.

Most countries present a mixture of small, medium and large irrigation schemes, the extremes being Pakistan on the one side with the 16 million ha Indus system, and Bangladesh on the other side where most irrigation is under supplied small schemes. In a great majority of schemes, water conveyance, distribution and on-farm application is by gravity. Sources of water supply are also quite diverse. Poorly regulated surface water resources are a specific constraint in Pakistan, Korea and the Philippines. Recent irrigation development in Bangladesh is groundwater-based but in view of the depletion of water tables, surface schemes will be given new consideration in the future. Conjunctive use is particularly developed in Pakistan and India to compensate for rigid warabandi and other local operational modes.

Public sector agencies (with, usually, a distribution of authority and responsibilities between central, federal state and other local political levels) and institutions still play a major role in irrigation management and development. However, most countries are undergoing a process of irrigation management transfer and/or privatization of irrigation management, in parallel to a more general process of political and administrative decentralization. Bangladesh, which has privatized tubewell equipment supply and irrigation services, represents a particular case. The degree of progress but also of success of IMT programmes varies among countries: from a fairly advanced and successful stage with functional water users' associations in the Philippines to rather disappointing pilot projects in Pakistan and established but non-functioning WUAs in Korea.

The level of cost recovery on investment and farmers' contributions to operation and maintenance of the schemes also greatly vary among countries and are still nominal in several countries. However, they are planned to increase in the future and are already substantial in most new irrigation development projects. Two notable exceptions are Korea, where farmers' contributions are nil for investment and but theoretical for O&M, and Malaysia, where it is not planned that they increase much in the future in rice granary schemes. Significantly, the problem in these two countries is to retain a strategic level of production of main crops (rice) while farming population is ageing and/or income from farming is less and less attractive compared with other sectors.

Table 2: Impact and opportunities and opportunities of socio-economic development

From subsistence to commercial farming	– Profitability, consolidation, variability – Spread equitably or allocate
Changing food and fiber consumption patterns	– Diversification of cropping patterns
Increased income expectations	– Farm labour costs, labour shortages, rural exodus – Staff labour costs
Increased competition on natural resources	– Diversion from existing water supply to other sectors – Competition for future water supply – Raise economic return to water – Competition for land
Increased budget resources	– Possibility to finance large investment programmes – Possibility to maintain or even increase subsidies – Less dependency on donor resources
Increased competition for budget resources	– Closer scrutiny of investment programmes
And change in economic policies	– Decrease subsidies – Increase efficiency of public services – Transfer, turn over, privatize – Food self-sufficiency not necessarily a policy objective – selection of crops with competitive advantage
Stronger banking system, savings and private capitals	– New options for financing irrigation development
Decentralization (political, administrative, fiscal)	– New options for irrigation planning and management
Growing awareness of environmental problems	– Environmental impact assessment – Mitigation of environmental impacts – Improved water and other input use efficiency
Higher levels of education	– Shifts in extension and training methods – New technical options for farmers and staff
Enhanced technology environment	– Information, communication, automation, mechanization
Better service environment	– Greater demand on and accountability of services
And new management concepts	– Change in service functions – Capacity to transfer functions to other operators
Developed industrial sector	– Local development & manufacture of irrigation equipment

Table 3: Main issues in irrigation scheme modernization

ISSUE	RESPONSE	*MEASURES*
Population growth & national food security	→ Increase and secure food production	• *Augmenting irrigated land and/or cropping intensity* • *Reclaiming land* • *Maintaining soil fertility* • *Upkeeping irrigation system* • *Reducing yield gap* • *Improving crop husbandry* • *Agricultural support services* • *Develop conducive environment to agricultural investment* • *Increasing profitability of agriculture*
Water resource constraint	→ Protection of water resource → Water resource management (quantity and quality) → Further develop surface water resources → Develop conjunctive use → Develop alternative water resources → Optimize rainfall use → Improve water use efficiency by irrigation → Develop appropriate cropping patterns	
Irrigation system performance • **Economic** • **Financial** • **Water use efficiency** • **Reliability** • **Flexibility** • **Equity** • **Cropping intensity** • **Environmental**	→ Optimize water use throughout the year → Match supply with crop water requirements → Reduce transportation and conveyance losses	• *Rehabilitation of infrastructure* • *Upgrading infrastructure* • *Improving design* • *Improving operation* • *Improving maintenance* • *Improving flexibility and responsiveness*
	→ Intermediate storage → Upgrade existing institutions → Institutional reform → Water pricing → Improved on-farm water management	• *Upgrading infrastructure* • *Improving scheduling*
Degradation of irrigation infrastructure	→ Rehabilitation programmes → Rehabilitation/modernization programmes	
	→ Improving financial base for O&M	• *Increasing water charges* • *Transferring costs to users* • *Transferring O&M to users* • *Improving pattern of public expenditure* • *Improving income from farming*
	→ Reducing O&M costs	• *Increasing efficiency of O&M* • *Improving designs* • *Increasing accountability of agency* • *Transferring O&M to users*

2.2 Social and economic trends

Most of the countries in the region are going deep societal and socio-economic transformations, characterized by fast economic growth, especially in the industrial and services sectors, liberal macro-economic policies, development of trade, reforms and privatizations in public sector and institutions, development of the civil society, and growing awareness of environmental issues and problems. These trends can be found as a common thread in most of the country papers. In general, it is estimated that these profound changes in the environment call for a deep transformation of the irrigation subsector, most notably an improvement of it's economic, technical, and environmental performance, diversification of produce and cropping patterns, changes in management systems and structures, financial and fiscal sustainability.

On the other hand, improved levels of education and of technological environment, more dynamic markets and diversified financing systems, more efficient and decentralized administration, and new management models, constitute as many favourable conditions for an improvement of the performance of the irrigation sub-sectors and modernization of irrigation schemes. Table 2 presents a synthesis of the driving forces of socio-economic development as they may affect the modernization of irrigation schemes.

2.3 Main issues in the modernization of irrigation schemes

The adoption by governments in the region of modernization policies and programmes, more specifically, is in response to four main issues which are more directly related the irrigation subsector. These are:

- Population growth and national food security;
- Water scarcity;
- Improving the performance of irrigation schemes;
- The degradation of existing infrastructure.

These four issues are of course inter-related by causal or hierarchical relationships. The emphasis on one or more of these issues as an entry point to modernization of irrigation schemes varies according to local circumstances and to sources of information. For India (but also Pakistan and Sri Lanka), the first two issues are paramount in calling for a substantial improvement in the performance of irrigation while infrastructure is degrading fast. For Thailand, the main factor seems to be a beckoning water crisis. For the Philippines and Malaysia, improving the efficiency of irrigation infrastructure is put in the foreground, whereas for China, it is the degradation of the existing irrigation infrastructure which calls for not only their rehabilitation but their modernization through a crash programme. Put together however, these four issues and the responses they call for in terms of policy goals, strategies and specific objectives and measures at each level provide a general framework which more or less applies to most of the countries in the region, which is presented in Table 3.

Modernization of irrigation schemes is a part of a broader transformation of the water and agricultural sectors, responds to a complex set of institutional, technical, operational and economic issues, and would consist in a complex set of institutional, technical, operational and agricultural changes, generally associated with changes in water pricing and cost recovery. When modernization is given a specific meaning, it is clearly distinct from rehabilitation. There is a general agreement on the specific objectives of the improvement of the performance of irrigation systems, in terms of delivering water to farmers in a more efficient, flexible, reliable and equitable manner. Most frequently mentioned technical and technological aspects are the following:

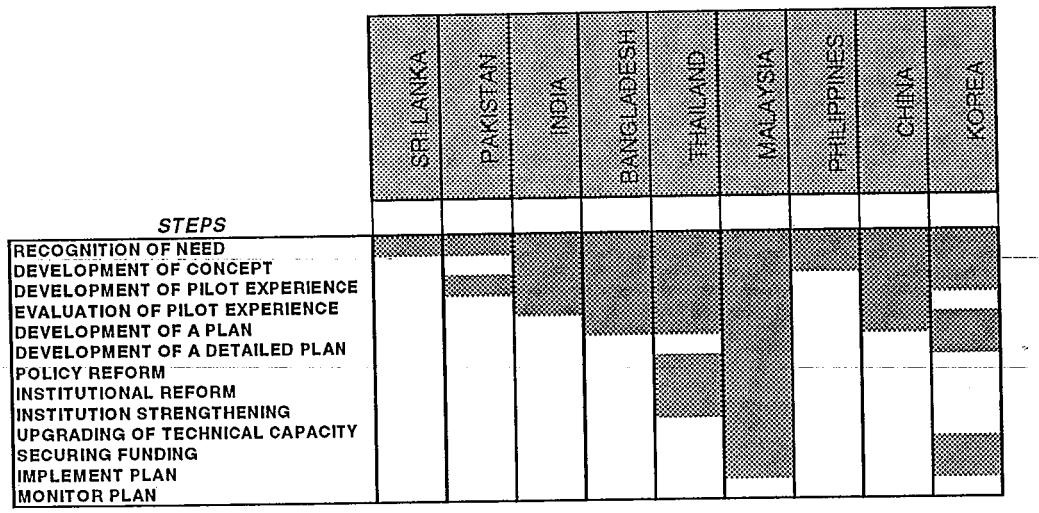
- installation of motorized gates
- provision of on-farm pond and night storage
- lining of existing canals
- installation of measuring devices

- conjunctive use
- pressurized irrigation systems
- improvement of communication systems
- improvement of information system for prediction of crop water requirements
- automation of systems
- modification of design criteria to simplify operation and to improve water management
- improved on-farm irrigation techniques

2.4 Status of national modernization programmes

There seems to be a general recognition of the need to modernize irrigation schemes and countries describe themselves as being engaged in modernization programmes at various stages of implementation from concept development to full implementation. However, progress in the region is rather slow when compared with other regions, and particularly with countries like Mexico or Turkey. Concepts related to service-oriented irrigation are not yet widespread or understood.

Table 4: Status of modernization programmes in selected Asian countries



3. CONCEPTS FOR IRRIGATION MODERNIZATION: APPLICATION TO SOUTH EAST ASIA

3.1 Protective vs. productive irrigation

Irrigation schemes in large parts of India and Pakistan have been built on the design logic of "protective irrigation". The idea is to reach as many farmers as possible to protect them against crop failure and famine which would occur without irrigation in regions with erratic monsoon rainfall. Water available in rivers or reservoirs is spread thinly over a large area. The amount of water a farmer is entitled to receive is insufficient to cover the full water requirements on all his land for an average rainfall year. Protective irrigation systems are based on scarcity by design. While there are different management principles in India (Warabandi, Shejpali, crop sanctioning) they all involve the problem of rationing scarce water in a supply based system where the objectives of individual farmers differ from those of the scheme management. Typical irrigation systems have very few control structures. Canals are run at full supply level or have to be closed, in order to achieve equal distribution of water to ungated chak outlets and to avoid deposition of silt. Construction costs are low but maintenance costs are high in comparison to the

low level of irrigation service[3]. Protective irrigation systems have worked well through most of the past 100 years. They have been able to mitigate the effects of severe droughts and are still the backbone of the agricultural economies in Pakistan and India.

However, it is now becoming apparent that the design logic of these systems may no longer be adequate for modern productive irrigated agriculture in an increasingly global economy which is driven by market forces (see section II.2 and table 2). The most pressing problems include: low efficiency in water distribution and use, unreliable water delivery, widespread vandalism of structures, poor maintenance, water-logging and salinity, insufficient cost recovery. Farmers could cope with these inefficiencies and make full use of advances of the green revolution in cases were they had access to fresh groundwater. However in areas which are less fortunate, because of saline or insufficient groundwater, yields are stagnating or declining. Successful irrigation systems feature high yields, service oriented irrigation management and financial autonomy. They may be described as productive irrigation.

Table 5: Protective vs. productive irrigation

	PROTECTIVE	PRODUCTIVE
HYDRAULIC		
Water duty	Low	High
Canal supplies	Constant flow	Varying flow
Control	Supply oriented	Demand oriented
AGRICULTURE		
Intensity	Low	High
Seasons	One to two	Two to three
Crops	Low water demanding	High water demand
MANAGEMENT		
Water	Planned scarcity	Planned sufficiency
Cropping pattern	Prescribed/controlled	Free
SOCIO-ECONOMIC		
Objectives	Poverty alleviation	Agricultural growth
Benefits	Spread	Concentrated
Optimization of	Unit of water	Unit of land
Labour	Family labour	Hired labour
Orientation	Subsistence	Market

FAO's position is that a resolute modernization of irrigation schemes, through a combined strategy of institutional, managerial and technological change with the objective to change from a supply to service oriented mode of operation, building on current economic trends, is the adequate strategic choice to the present economic and social environment. Other options include maintaining the status quo, with an exacerbation of existing problems, or enforcement of the protective irrigation concept by irrigation

[3] for a more detailed discussion of protective irrigation systems see: Scarcity by Design. Protection Irrigation in India and Pakistan. Special Report. M. Jurriens, P. Mollinga and P. Wester (1996)

authorities which would have to continue to be dependent on state subsidies: levels of irrigation service and agricultural productivity will remain low except where canal water is supplemented by private wells.

3.2 Concepts of modern irrigation

Appropriate modernization is a process which incorporates new design procedures and new equipment with a vision of future operations. Modern design is the result of a thought process. Configuration and the physical components are selected in the light of a well defined and appropriate operational plan. Advanced concepts of hydraulic engineering, irrigation engineering, agronomy and social science should be used to arrive at the most simple and workable solution. A modern irrigation design is not primarily defined by specific hardware components and physical configurations, but will have all or some of the following characteristics:

- The overriding principle of modern irrigation is that irrigation is a service to farmers which should be as convenient and efficient as possible. Farmers ultimately have to generate the benefits which keep the system functioning.

- Modern irrigation schemes can be imagined to consist of several sub-systems or levels with clearly defined interfaces, where water is measured and controlled.

- Each level is financially autonomous and hydraulically as independent as possible. Transactions at each level are transparent for the next lower or upper level.

- Each level is technically able to provide reliable and timely water delivery to the next lower level. At each level there are the proper types, numbers and configurations of gates, turnouts, measurement devices, communication systems and other means to control flow rates and/or water levels as desired.

- Each level is responsive to the needs of its clients. Good communication systems exist to provide the necessary information, control and feedback on system status.

- Each level of delivery has confidence, based on enforceable rights, in the reliability, timeliness, and equity of water which will be supplied from the next higher level. Effective mechanism for conflict resolution are in place.

- The hydraulic design of the water delivery system is created with a well-defined operational plan in mind. The operational plan is established with a clear understanding of the needs of the end users.

- The hydraulic design is robust, in the sense that it will function well in spite of changing channel dimensions, siltation, and communications breakdowns. Automatic devices are used where appropriate to stabilize water levels in unsteady flow conditions.

- Motivated and trained operators are present at all levels of the system. They are not necessarily the farmers themselves but preferably hired professionals. Instructions for individual operators are well understood and are easy to implement.

- Maintenance is the obligation of each level. Maintenance plans are defined during design and are adequately funded and implemented.

- There is a clear recognition of the importance and requirements of agriculture and of the existing farming systems. Engineers do not dictate terms of water delivery; rather agricultural and social requirements are understood at all levels and in all stages of the design and operation process.

3.3 Operational levels, objectives of irrigation scheme operation, and required changes

In large irrigation schemes there are typically four or five levels of irrigation operation to consider:

- On-farm irrigation.
- Distribution systems of about 500 to 2000 ha, which are frequently controlled by water-user organizations (WUA) and consist of:
  a. A minor canal supplying water to several large turnouts (chaks),
  b. Final distribution systems downstream of the chaks outlets, supplying 20 to 40 individual plots.
- Primary canals (major or branch canals) which deliver water to the minors and are usually operated by the irrigation department (ID).
- Dams and the watershed, controlled by the National Water Authority.

The purpose of each of the operational service levels (dam, major, minor, chak) in the water delivery system must be to provide the appropriate degree of service to the next lower level. In turn, each lower receiving level (farm, WUA, ID, dam) will compensate the next upper level for the services received, thus creating an autonomous system. The operational objectives may differ from one level to another. There should be a consensus that the primary objective of scheme operation is to enable farmers to improve the quality and quantity of crop yields, while ensuring or improving economical and environmental sustainability. Consensus is also required on the following:

1. The service concept should be adopted throughout the system. This will require improved flow measurement, water level control, communications, etc. throughout all levels of the water delivery network down to the individual turnout.
2. A general consensus should be reached that a major cause of the low performance of irrigation projects is low level of irrigation service received by the farmers and the resulting low application efficiencies on individual fields. Therefore, the benefits of a modernization program will only be realized if there is an improvement at farm level in reliability, equity, and flexibility of water delivery. The question is not whether improved reliability, equity, and flexibility is desirable - the question is how exactly can it be obtained.
3. The question of how much flexibility should be provided to each farm should be decided by the members of water user associations themselves. The water user associations must decide what level of service should be extended down to the individual field level in their particular cases. However, they must also face the financial consequences of their decision.

Because the purpose of an irrigation project is to enhance on-farm production and profitability, any analysis of the operation of an irrigation project must begin with the farm level. Future agricultural development and on-farm irrigation technology will require profound changes in the present operation of all service levels. Operations which are under the control of the water user associations will also require improvements and funds must be allocated for those needs. The concept of service in the larger canals must include the vision of the eventual, future use of water on the individual farms. Table 6 presents, for each operational level, required changes and actions needed.

Table 6: Present operation vs. future operation at the different operational levels

Present Operation	Future Operation	Action Needed
Service Level between the Minor and Primary Canals		
Minor canals: Typically only one change of flow-rate at the head of the canal every 1-7 days.	Multiple changes of flow-rate per day at the head of each secondary canal.	This means that simple rehabilitation such as replacement of broken gates is insufficient; the future operation will be completely different.
Primary canals: Typically only one change of flow rate at the head of the canal every 3-7 days.	Multiple changes of flow rate per day.	It will require a better understanding of the operational relationship of structures in primary and secondary canals.
Silt and aquatic weed growth reduces flow capacity.	Reduced blockage of flow.	Basic maintenance and rehabilitation, with improved equipment and access to canals.
Service Level between the Farm and Minor Canal		
Rotation schedule	Arranged schedule	Improved communications
Inequitable water delivery to farm-turnouts. Tail-ender do not get equitable supplies	Equitable water delivery	Improved final distribution system
Water distribution system (open ditches) dif-ficult to access and maintain. Seepage losses.	Simplified maintenance and operation. Reduced seepage losses.	Lining of canals or pipelines or installation of pipelines.
Water delivery only possible to one farm at a time.	Water deliveries to more than one farm at a time or at least with more flexibility.	New design criteria for flexible service. Different methods of conveying and measuring water. Fewer farms served by a single turnout.
Insufficient capacity for flexible deliveries.	Larger capacities, so that multiple farms can be serviced simultaneously.	Different types of water delivery control and conveyance between the canal turnout and the farm. If possible interim storage reservoirs.
Lag time between water delivered at the canal turnout and water reaching the field.	Reduced lag time.	Piped distribution, or Fewer farms served by a canal turnout.
Flow rates are only measured at the canal turnout.	Multiple deliveries downstream of the turnout. Flow is controlled and measured at each farm during simultaneous deliveries.	New delivery control and conveyance systems. Development of portable, totalizing flow measurement devices for canals and pipelines.
Frequent spills. If a farmer shuts off the water to his plot, the water must be switched to another farmer.	Farmers may be able irrigate independently.	Remote monitoring, automation, piped distribu-tion. Options depend upon location and economics.
On-Farm Level		
Poorly designed and maintained traditional surface irrigation systems (basin) in many areas, lack of proper land grading.	Well designed and maintained on-farm irri-gation systems. Mix of modern level basin, furrow, sprinkler, and drip. Irrigation sys-tem designs to meet individual field crop, soil, topography, economic, and labour requirements.	Capability to supply each farm below a chak outlet at request with a constant flow rate. Private companies are able to design new on-farm irrigation systems.
Irrigation frequency and rate are scheduled by tradition or on instruction from ID (warabandi, Shejpali)	Irrigation frequency, rate and duration customized to match more closely irrigation technology, soil, weather, crop, and labour schedules.	More flexible and reliable water deliveries. On-farm storage for drip and sprinkler systems. Water deliveries must be available on an arranged ba-sis. Improved communication between the farmers and water suppliers.
Insufficient awareness of correct agronomic practices and irrigation inputs.	Improved awareness of necessary inputs and agricultural practices.	Education about on-farm irrigation, agronomic inputs, soil/water/plant relationships.
Annual water consumption per plot is unknown to farmer, or not understood in terms of volume.	Water allocations will be done on a volumetric basis, with annual or seasonal limitations.	Ability to measure flow rate and volumes delivered to individual plots. WUA and farmer will both need to keep records.
Water losses are only understood in terms of surface runoff. The magnitude of deep percolation losses is not understood.	Water losses will be understood to include both surface and deep percolation losses.	Improved rules for water distribution. Improved record keeping. Improved law enforcement procedures.

3.4 Plan of action

There are two major hurdles for the implementation of proper modernization processes. First, a full understanding of the above principles is needed by all participants in the modernization process. Second, some additional funding for design, construction, and maintenance of the new hardware and introduction of new operation procedures is required. It is estimated that these funds amount to about 5 percent of the construction costs. The wholehearted support of the present operators is important to success of any modernization program, and they must be in a position to participate in the decision-making process: consensus building and training will therefore be a critical component of the modernization process. As an example an outline of a plan of action is provided in the text box.

Proposed Action Plan

1. Policy Actions
   a. Appoint a national coordinator of modernization activities.
   b. Set priorities and make strategic choices.
   c. Obtain national and regional consensus on vision and proposed actions.
   d. Inform all levels of consensus.
   e. Form national and regional review panels.

2. Training
   a. Provide refreshing training for key ID staff.
   b. Conduct training for field personnel, consultants, and water user associations.
   c. Training for individual farmers will be important in later programs which invest in improvements downstream of the chak outlet.

3. Planning and Implementation
   a. Develop/publish new official design procedures for field engineers.
   b. Diagnose the degree of service, problems, and needs in individual projects.
   c. Develop specific action plans with approval by review panels and users.
   d. Implement plans.
   e. Monitor results.

Policy Actions:
Modernization actions must be prioritized because there are rarely sufficient funds available to pay for the full range of desirable modifications. Available funds should be used to make reasonable steps toward modernizing the total conveyance systems. Diagnostic research tools are important in helping to decide how to best invest funds. Funds should be spent to strengthen the weakest link in meeting the primary objective, and it may not be obvious what that weakest link is. Very sophisticated and complex solutions which consume the majority of funds on a small area or small portion of a project should be avoided. Instead, investments should be made which simultaneously make significant (but not necessarily ultimate) improvements in water delivery control and also lay a foundation for future sophistication. It is essential that these investments be made with a vision toward the future, so that they will not hinder future improvements. Once an initial consensus has been reached at the national or state level, regional meetings must be held to explain the intent, reasons for the decisions, and implications on present maintenance and rehabilitation work. Participants in each regional meeting including water user associations and local ID personnel, should then discuss the guidelines and arrive at a consensus on a local variation of the guidelines. National and regional panels should be established to provide technical guidance and backstopping.

Training:
All training should be conducted in the context of the broader purpose of modernization - to improve on-farm production and profitability, and to protect or enhance the environment. The changing functions of ID personnel require a larger knowledge basis. A top priority is that the key personnel and individual professionals be familiar with the recent advances in on-farm irrigation. Training topics should therefore include not only water delivery modernization options and canal maintenance, but also improved on-farm irrigation methods.

Modern irrigation is knowledge-based and therefore long-term training needs will have to be planned and organised for principal groups involved: the engineers, designers, and technicians within ID and the water user associations; managers within ID and the water user associations; consultants who will provide design assistance; persons from the banking and financial industries; university and extension personnel; and farmers.

Specialised training materials and sessions should be available for officers and the technical staff of the water user associations. Since these people hold the purse strings to future investments, and since their decisions have such a tremendous impact on the final outcome of policy decisions, it is important that they have an understanding of some basic principles of hydraulics and water control, as well as knowledge of some maintenance options.

Planning and implementation:

New Design Manuals
Many field engineers in Asian countries are using design manuals which are based on outdated design concepts which treat irrigation water control as a steady flow problem. The real need in modernization is something different - it is to solve the problems unsteady flow conditions in canals and pipelines. The field engineers need new design guidelines because they may not have the background, confidence, or authority to deviate from existing official practices.

Assessment of Current Status
Time is of essence under the modernization program. A rapid assessment must be made of the technology needs and present level of performance of each individual project prior to allocation of funds for specific actions. This assessment should not only address symptoms (traditionally performance assessment focus on water use and distribution efficiency and conditions such as high water tables, high salinity, and crop yields) but also focus on the level of service by questionnaire-based or rapid appraisal-type field investigations.

Assessment of the Needs for Physical Improvements
Larger schemes should be broken down (partitioned) into sub-units (main canals, secondary and tertiary canals) corresponding to operational levels and operators, for the assessment of the needs for physical improvements. The responsibility for such an assessment should rest with the authority in charge for the particular works. The canals under control of a water user association should be assessed by members of that association, with technical assistance from the ID. Major points to consider would be: all-weather access to critical sites; maintenance equipment; communications network; improved control on the main canals; automated secondary canal headings; new turnout designs and long crested weirs.

Planning Procedure
Planning groups should be created at each level. Their first action would be to participate in the local assessments and review the results of the rapid assessment of the current operations and symptoms. They would then try to achieve consensus on the vision for the future operations. Special training in important technical aspects of modernization would be useful. The proposed planning procedure implies that the formation of effective water user organizations (WUAs) and definition of water rights are pre-requisites for physical improvements. After these first steps, local planning groups should:

1. Develop technical and management options for modernization (including time and cost estimates).
2. Request input from the review panel regarding additional options/modifications to the original ideas.

3. Present a list of technical recommendations, justifications, costs, and implications to the WUAs.
4. Modify the recommendations based upon the desires of the WUAs, and present these new recommendations to the WUAs as many times as required.
5. Request input from the regional or national review panel.
6. Receive new approval from WUAs.
7. Conduct a complete economic feasibility study.
8. Receive final approval from WUAs.
9. Implement the program.

Results of the first stage of modernization

The modernization program to this stage would have resulted in the installation of a limited number of better gate types at critical locations (with sufficient capacity to accommodate future requirements), accounting for flows and volumes with proper measurement and control structures, improved communication, and an increased number of canal turnouts. Assuming that maintenance is reasonably good, the operation at this stage should now provide: equitable deliveries to the chaks, except in some areas with insufficient canal capacities which is a problems of the original design; good control of flow rates at farm turnouts; reasonably flexible deliveries, with the capability to provide deliveries to individual farms with 2-3 days advance notice; some tail-ender problems in the form of spill at the ends of all secondary and tertiary canals.

The water delivery infrastructure would not be perfect but should be quite reliable and equitable and reasonably flexible. Once these steps have been taken, noticeable improvements in project water management should be observed. Additional benefit would occur when improvements are made downstream of the chak outlet. Those improvements could be sustained because the water delivery infrastructure is robust and very functional.

Once the basic water delivery infrastructure has been improved, the objectives of improving agricultural production and profitability would probably have to address the following remaining problems (listed in order of importance for the majority of areas):

1. Poor on farm irrigation technologies and management. The on-farm irrigation efficiencies may be in the range of only 50%. However, on-farm irrigation efficiency can only be improved when the infrastructure is in place to enable farmers to adopt more efficient technologies and management. Prior to this stage of modernization, unreliable or inflexible water deliveries would have discouraged farmers from investing in better on-farm irrigation systems.
2. Inadequate technological agronomic inputs (fertilizer, seed varieties, appropriate pesticide applications).
3. Physical bottlenecks in the water delivery system which prevent adequate water deliveries in some areas.
4. Inflexibility in deliveries and lack of control at individual farm turnouts.
5. On-farm and project drainage problems.
6. Some inflexibility in water deliveries to the chaks and some tail-ender spills.

IV. RELEVANCE OF THE SOUTH EAST ASIA EXAMPLE

While the need to change from protective to productive irrigation may be unique for the SE Asia, the trend towards more commercial operation of irrigation systems, withdrawal of state agencies from micro management, and increasing competition about fresh water resources is universal. This is amply illustrated this for Asia and by presentations made at RIC'97 and at this very meeting for other regions, and indeed by the experience of Morocco.There is a pressing need to improve the performance and economic viability of large irrigation systems. Successful irrigation systems feature high yields, service oriented irrigation management and financial autonomy. Therefore, while of course national circumstances, technical and operational aspects would vary greatly across countries, FAO believes that the concepts of modern irrigation and proposals for modernization processes and plans of action, which are in fact inspired by the experience of Mexico, have a wider validity.

V. FAO'S FUTURE PROGRAMME OF ACTIVITIES

More and more countries subscribe in their national water policies and irrigation development strategies to the above principles. However progress in the field is slow. There are four major hurdles for the implementation of proper modernization processes. First, a full understanding of the principles and options is needed by all participants in the modernization process. Second, transparency and accountability must be improved through modern management principles and tools. Third, the powerful and prestigious irrigation bureaucracy in many countries must be reformed from top-down management of water scarcity to a service oriented mode of operation. This involves foremost a change in attitude. Fourth, additional funding for the upgrading of the new water control and communication devices is required. Time has come to modernize irrigation systems through a combined strategy of institutional, managerial and technological reforms. FAO's Water Resources, Development and Management Service is preparing in this specific domain a programme of activities designed to overcome the hurdles and to provide scheme managers and planners with essential concepts and tools to improve the performance of irrigation.

Several institutions are working together to bring about such a change. The World Bank and the International Program on Technology Research in Irrigation and Drainage (IPTRID) have since some time promoted the technological modernization of large irrigation systems through concept development, case studies and specific sector loans. IIMI, in cooperation with the Economic Development Institute (EDI) and FAO has been working on the institutional side of the modernization process looking at institutional reforms and the conditions of turn over of management responsibility from irrigation agencies to farmer associations. The ITIS network is another worthy initiative supported by IIMI and CEMAGREF. Mexico and Turkey have recently implemented large scale sector operations involving turnover of state run irrigation schemes to water user associations supported by a process of technological modernization. Progress in Asia is much slower and at present limited to a few experimental schemes. There is an urgent need to create awareness on the options for irrigation scheme modernization. The availability of a tool to diagnose quickly the performance of irrigation schemes and to identify cost effective ways of modernization would greatly support the process.

The overall strategy is to develop intellectual partnerships with receptive irrigation agencies for mutual benefit and advancement. An example is the close cooperation with the *Administration du Génie Rural* of Morocco. FAO's programme will be designed to make maximum impact with limited resources, concentrating on four major areas where critical gaps exist.

The **first** component is intended to develop **diagnostic tools** that will permit manager of irrigation systems to identify performance problems in their schemes and cost effective ways of modernization. The diagnostic tools will feature interactive multi-media technology and decision support software. Users will be guided through a set of questions supported by pictures, diagrams or sketch to identify most likely causes of performance deficits.

The **second** component is **concept development and capacity building in technical modernization.** As explained above modernization requires a good understanding of the underlying concepts of modern water control and a change in attitude of many professionals. Many existing design manuals do not address the problem of unsteady flow and the interaction of different types of control structures in extended irrigation systems. In order to overcome these shortcomings the following is envisaged:

- Development of guidelines and concepts for the updating of design manuals.
- Development of national training courses and a certification programmes for irrigation design engineers.
- Establishment of a site on the Internet to provide a platform for exchange of experience, sources of know-how and promotion of the subject.
- Evaluation and documentation of the impact of modernization will be undertaken through case studies and analysis of existing literature and documents.

The **third** component will promote **institutional reforms**, privatization and greater participation of the farmers in the management of irrigation systems. Institutional reforms, brought about by the inability of state agencies to micro-manage irrigation schemes and the demand for user involvement in decision making, are an essential element in the modernization of irrigation. Transfer of management responsibility to WUA has been propagated since some years as the most appropriate solution. Considerable experience has been gained but the approach of communal management has not always been successful. Alternative models of commercial and private irrigation are emerging. It is time to synthesize existing experience and to reflect on the conditions of successful communal irrigation versus commercial irrigation. Specific activities will include:

- Development of guidelines for the formulation of bylaws of WUA, supported by a documentation and analysis of existing bylaws in cooperation with the FAO Legal office.
- Development of guidelines on training and extension programs on irrigation management transfers;
- Support in the implementation of irrigation management transfer training programmes and workshops in cooperation with national irrigation agencies and international partners.

Lastly, the **fourth** component will address the need to improve day to day **management of irrigation systems**. Management of irrigation systems in a business and service oriented mode is a complex operation. It requires advanced managerial skills and the ability to process and interpret large amounts of data. For example water requests and water deliveries have to be recorded and matched with conveyance capacity, seasonal water allocation and total water availability. Water deliveries have to be converted into financial transactions. Payrolls and financial assets have to be managed as well as stocks, spare parts, vehicles and construction equipment. Maintenance programs have to be implemented and closely followed. Modern information and management systems are imperative to assist managers in performing efficiently their tasks. Since some time FAO has invested considerable effort in developing such a management support tool. A DOS operating software package, called SIMIS, is available and presently being tested in several irrigation schemes. The new WINDOWS version will be developed in partnership with a specialized institution. After development and testing, the programme package will be licensed to a number of regional institutions for dissemination and maintenance. These institutions would provide training and backstopping services to users of the program.

Field projects in Morocco, FYR Macedonia, Turkey, Mexico, and India will contribute to irrigation system modernization. Projects in Egypt, Thailand, Barbados, Turkey, Mexico, Peru and Malawi will provide case material and possibilities for testing of the management information system and of institutional reforms.

It is expected that cooperation will continue with IIMI, as in the past, for this future progarmme of activities. The author has been very pleased to participate in this meeting of the ITIS network and would like to congratulate it's organizers and all the participants: he is convinced that a more organic participation of FAO in this network, with IIMI, CEMAGREF and national institutions represented here could be envisaged, in particular in the context of the second component briefly described above.

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