LINKING MAIN SYSTEM MANAGEMENT FOR IMPROVED IRRIGATION MANAGEMENT

Report of the APO Seminar on Linking Main System Management for Improved Irrigation Management held in Sri Lanka, 3-8 June 2002 (02-AG-GE-SEM-08)

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SUMMARY OF FINDINGS

INTRODUCTION

The Seminar on Linking Main System Management for Improved Irrigation Management was held in Colombo from 3 to 8 June 2002 being organized by the Asian Productivity Organization (APO) and hosted by the Government of Sri Lanka. The Ministry of Agriculture and Livestock, Sri Lanka and National Institute of Business Management (NIBM) implemented the program. Fourteen participants from 12 member countries and one observer from the International Water Management Institute and; five resources speakers from USA, New Zealand and Sri Lanka attended the Seminar. The objectives of the Seminar were to: 1) to discuss issues involved in linking main system management with field level management through water users' associations; and 2) to identify measures that could contribute to improved irrigation management in the APO member countries.

The Seminar consisted of the presentation and discussion of resource papers and country papers, as well as field visits to Polonnaruwa. The topics covered by the resource papers were: 1) Issues and Constraints in Linking Main System Management for Improved Irrigation Management; 2) Measures to Improve Linkage between Main System Management and Farm Level Management; 3) Irrigation Associations and Improved Irrigation Performance; 4) Sustainable Irrigation Development; and 5) Role of Public and Private Sectors, NGO's, Water Users' Associations and Other Stakeholders in Irrigation Management in the 21st Century. The country papers, on the other hand, focused on the issues and constraints affecting the management of irrigation systems, measures for improving irrigation management performance, particularly in terms of enhancing the linkage between main system management and field level management and future direction of irrigation management in the respective countries.

The highlights of the Seminar are presented below.

HIGHLIGHTS OF RESOURCE PAPERS

Issues and Constraints in Linking Main System Management for Improved Irrigation Management

An irrigation system consists of a set of interconnected subsystems linked together both physically and functionally. The linkage is hierarchical and continuous until water is delivered and applied at the farm level by the end-user. Hence, each level of these subsystems is dependent on the other and needs to cater for the next level of operation as best as practicable.

Management of irrigation systems involves forecasting irrigation supply likely to be available, estimating irrigation demand, matching supply and demand, scheduling and allocation, harnessing water resources, and distribution in an equitable, efficient, reliable and dependable manner. In addition, the irrigation system needs to be maintained in a reasonably operable condition and all activities need to be monitored and evaluated. In this process, each level of an irrigation system necessarily becomes a management and decision center. However, if the final objectives of irrigation are to be achieved, it is essential that these links are extended up to on-farm level and issues and constraints involved are continuously identified to get a best fit in a complex situation.

The main objective of farmers, in the context of countries like Sri Lanka, is to produce minimum level of food for subsistence and then to get the family income increased while the objectives of a farmers' organization or Water Users' Association (WUA) managing a subsystem could be equity in water distribution and minimizing conflicts between the communities they serve. On the hand, the objectives of the agency managing the main system would be appropriate water use and efficiency, while the state will have higher level national objectives such as food security, poverty alleviation and so on. The main objectives of other agencies involved such as agricultural agencies could be maximizing agricultural production of a particular crop or crops in the area or in the country. Irrigation systems are therefore expected to fulfill a wide range of objectives, but they are not always necessarily in harmony with the individual farmer's objectives.

Sometimes large systems have to carry water over a long distance in earthen canals with a large number of farmers to be served creating a problem of communication. Variation in demand could be unpredictable, for example, due to a sudden rainfall. Return flows and seepage and percolation too cannot be predicted to a level of accuracy desirable at micro level. Moreover, large-scale irrigation schemes are built with a large number of head and flow control structures, and these are sometimes cumbersome to operate and need a large number of trained staff. Instances of tampering with these structures by farmers are not rare. This situation is further aggravated in systems like Mahaweli, which consists of an interlinked network of feeder canals and reservoirs. The operational complexity resulting from shared infrastructure is another factor that governs decisions at farm level.

Irrigation management is constrained by the changes in land use and watershed characteristics, increase in population in traditional irrigation areas and resulting land fragmentation, as well as increased intra-sectoral (in sectors such as agriculture) and inter-sectoral demands. The demand for domestic water is on the increase in general all over the country with the increasing incomes and associated general improvement of quality of life. Environmental and ecological issues too are on the increase in most of the river basins with the increased economic activities affecting irrigation systems. Examples are unregulated sand mining in riverbed, unplanned brickmaking on the riverbanks, silting up of reservoirs, and unregulated well construction. Thus, efficiency improvement in irrigated agriculture both at main system and at on-farm level has become an urgent necessity of the day.

Effective management of both the main systems and on-farm systems needs accurate and reliable data in time. Further, data and information sharing mechanisms at different levels are also a key issue. New digital technologies such as Global Positioning System (GPS) and Geographical Information Systems (GIS) are needed to be adopted as early as possible as such technologies are now gradually becoming affordable.

As mentioned earlier, the irrigation system needs to be maintained at certain level of operability to meet on-farm requirements. The Operation and Maintenance (O&M) budgets made available by the governments are decreasing over the years in real terms while costs are on the increase. Finding ways and means to bridge the gap is vital for the very sustainability of irrigated agricultural systems. Cost-effective mechanization of maintenance activities is one of the strategies now being tried by the Irrigation Department of Sri Lanka. Cost sharing is being tried in different ways, but affordability of farmers needs to be taken into account.

Mechanisms for communication and coordination between main system management and on-farm operations were almost non-existent in the past. However, the Participatory Irrigation Management (PIM) practices implemented in Sri Lanka starting from 1978 have paved a way out of these dilemmas. Institutions such as farmer organizations and project management committees allow integration of different disciplines, agencies and participation of different stakeholders in the management. These also allow flow of information both upwards and downwards though still there are some shortcomings and gaps due to various reasons. It may be now time to investigate ways and means of expanding these concepts if they can be of benefit.

It could be concluded that the ideal system of water delivery at the on-farm level would be an "on demand" system where water can be applied based on the soil, crop water requirements and the rainfall. In such a system, water delivery will be flexible to coordinate with all farming activities such as land preparation, planting different crops with different crop water requirements, fertilizer and chemical application, staggering of crops to suit the market, etc. Technical and other interventions such as on-farm storage, automation in the main system, communication improvement, and planning and management interventions can make the gap smaller.

Measures to Improve Linkage between Main System Management and Farm-level Management

The irrigated agriculture sector produces around 60 percent of the value of crop production in Asia. Meanwhile the share of water allocated for the agriculture sector has been significantly decreasing, and per capita water availability in the Asian region is the lowest among the regions. With the current trend of water use, water demand will outstrip supply before the middle of this century. Therefore, improvement in the water use efficiency through proper management strategies is crucial to avoid the envisaged water crisis and to meet the future food requirement.

Participatory Irrigation Management (PIM) and Irrigation Management Turnover (IMT) are the main current irrigation management policies where main system management and farm-level management are operated by different institutions. Worldwide IMT performance measures shows mixed results. One of the main reasons for the negative results shown is the lack of proper linkages between main system and farm-level management.

From a review of the literature and past experiences, it is evident that the following factors determine the degree of linkage between main system and farm-level management: i) building effective Water Users' Associations (WUAs); ii) bureaucratic reorientation; iii) physical condition of irrigation infrastructure; and iv) support services for irrigation systems and economics of irrigated agriculture. Effective WUAs must perform well in water management, control structure maintenance, and organizational management activities.

To achieve these objectives, the WUAs should be strong and viable. The strength of WUAs will depend on the approach adopted for WUA formation (use of social mobilizers, stage of the project in which WUA was formed, approach adopted for WUA formation), structure of the organization (boundaries of WUA, size of the organization, level of vertical and horizontal linkages, mono/multi-objective organizations) and degree of member participation for organizational activities. All farmers in the watercourse must be members of the WUA without any socioeconomic obstacles, and they should actively participate in irrigation and organizational management activities, mobilizing resources in the form of cash and kind. WUA should have strong and transparent legal framework to implement incentives and sanctions. In addition, WUA must have visionary and dedicated leadership accountable to its entire membership. A successful WUA must be financially and technically capable to manage its activities and ability to meet internal and external threats. The WUA should be politically neutral and should diversify its activities from mono to multi objectives.

Bureaucratic reorientation is another essential aspect, which includes the reform of attitudes and objectives, philosophy, procedures, incentives and structures of the agency to improve the linkages with farm level. The government should also allocate necessary resources to fulfill the roles and responsibilities of the agency in main system management. The major challenge here is shifting a conventional and highly technical agency towards more people-oriented organization.

The physical condition of the irrigation infrastructure has an effect on timely and reliable supply of water. If the irrigation infrastructure is not functional, farmers will have no option other than neglecting the routine maintenance of the system. The finding shows that rehabilitation of the irrigation system before turnover provides better results in terms of agricultural productivity and water use efficiency.

Irrigation management has to be seen in a holistic manner, considering forward and backward linkages of agricultural policies. This approach ensures the greater output and income, which provide the incentive for the sustainable management of irrigation systems.

Irrigation Associations and Improved Irrigation Performance

Irrigation management has come to be seen as involving two aspects: the 'hardware' of physical structures, and the 'software' of social structures and organization. The latter includes administrative organizations and water users' associations. It is impossible to see how physical structures by themselves can lead to productive outcomes, just as neither administrative organizations nor water users' associations can succeed without each other and without a well-designed and well-functioning physical system.

This paper focused on water users' associations, which operate at the farm level and can be federated into larger organizations. As long as they remain accountable to water users, they differ from administrative organizations in terms of whose interests they are expected to serve.

The paper provided an analytical framework within which to understand irrigation management, dealing with three interlocking set of activities, relating in turn to: (a) the water used in irrigation; (b) the structures that control that water; and (c) the organizations at system level and farm level that control these structures which control the water.

Of special interest, this third set of *activities* includes particularly: (1) decision-making; (2) resource mobilization and management; (3) communication and coordination; and (4) conflict resolution. These organizational activities are equally relevant in the formal and informal domains of irrigation management. No social system functions purely in formal modes; there must be some ways of working that are tacit or implicit, not formally prescribed, and shaped more by tradition and precedent than by explicit, e.g., written prescriptions. Likewise, these four organizational activity areas can apply equally to intra- and inter-organizational domains. These four focuses of organizational activity, initially conceived in terms of water users' associations, are universal and apply as well for bureaucracies.

This analytical framework is given a spatial as contrasted to a functional reality with reference to the *levels* at which these respective activities occur, at primary, secondary, tertiary or lower levels. It is common practice to refer to the highest level of an irrigation system as the primary level, but in this framework, we consider the field level, which is essentially the same in all irrigation systems, large or small, as the first (primary) level. Systems can be compared in terms of the number of levels above this first level at which decision-making, etc. occurs.

Given this understanding of irrigation system management, the issue of federation of water user groups, at the field level, up to some kind of federation, encompassing two, three, four or more levels, arises. There are decisions that need to be taken *at each level* within a system, whether by water users or by administrative staff, as well as resource mobilization, and communication and coordination, and invariably some conflict resolution, which makes some kind of federated organizational structure appropriate.

This analysis sets the stage for consideration of how irrigation performance can be improved. The simplest way to do is to focus on *establishing or strengthening a set of roles, rules, procedures and precedents that can carry out the four basic functions* – decision-making, resource mobilization and management, communication and coordination, and conflict resolution – at each and every level. These roles, etc. establish social structure for irrigation management.

This general recommendation captures the most essential elements of irrigation management. There are a number of more specific issues that need to be considered, and these are addressed in the paper:

1. Issues of <u>membership</u>, whether based on water use or land ownership if these diverge.
2. The <u>boundaries</u> for irrigation organizations, whether administrative or hydrological.
3. Means for ensuring <u>accountability</u> of decision-makers to water users as well as other stakeholders.
4. <u>Enforcement</u> of decisions and formal powers for the associations.

The paper then discussed alternative approaches and suggested means for getting the best irrigation performance results through a 'learning process' approach, seeking to get higher productivity as well as equitable distribution of benefits and a sustainable system of management. Comparisons are made of more formal and more informal methods of forming organizations in terms of impacts on productivity, equity and sustainability.

The analytical frameworks were provided to help seminar participants understand better the roles for irrigation associations for improving irrigation performance and also for evaluating irrigation performance and main system management more generally across different cases. The concepts presented were developed during the 1980s when Cornell University was involved in efforts to improve irrigation management in a number of Asian countries. They thus are formulated to have broad application for the irrigation sector.

Sustainable Irrigation Development

Irrigation has played and will continue to play an important role in securing the food supply for the rapidly expanding population of the world. It is generally accepted that about 40 percent of the world's food production is obtained from only 17 percent of the agricultural area due to the yield increases made possible by irrigation. In the next 20-30 years as the population increases to 8 billion people, irrigated agriculture is expected provide the basis for 80 percent of the additional food production required.

However, even as the world benefits from adequate food production based on irrigated agriculture, the sector faces increasing criticism for a perceived lack of performance, unsustainable practices, and excessive adverse environmental impact. Furthermore, while total food production is adequate, there remain large numbers of people in many countries who are undernourished. Irrigation has enabled many farmers to improve their economic situation greatly, but poverty still holds many millions of people back from realizing their potential.

Against this background, what are the issues for irrigation in the future, and how can the irrigation sector achieve the levels of production required while achieving sustainable development? This paper set out the key challenges facing sustainable irrigation development and argued that "sustainable development" is a misnomer, and that incremental development is a more realistic model to achieve the objectives of sustainability and poverty alleviation. The paper focused on irrigation as a means of achieving food security. For many people, sustainable development suggests that by following some specific set of interventions, the future operation of a particular irrigation scheme will be sustained for some unspecified period. This is clearly not the case, as any set of interventions is designed and implemented based on a further set of assumptions and predictions about the conditions (physical, social and political) in which the scheme will function.

These conditions are not static and even the one factor we have assumed to be effectively static in the past (climate) is now believed to be changing significantly. Therefore, to achieve sustainable increases in agricultural productivity, irrigation development must be considered as a continuous development process. The major challenge facing the sector is achieving and maintaining a harmony between the constructed infrastructure, the management institutions, and the demands and aspirations of both the farmers and an ever more interested civil society.

The paper explored some constraints and the development options that offer a higher likelihood of achieving acceptable levels of farm productivity, reductions in rural poverty and minimal environmental damage. It is suggested that the irrigation sector must continue to develop approaches to the design and implementation of management and infrastructure interventions that provide flexible and responsive support to the agriculture sector. The need to increasingly consider the impacts of agricultural development on the broader environment, that have impacts on the livelihood systems of the intended beneficiaries, will continue to constrain the freedom of movement available to the sector.

A major shift in thinking is required to move away from a distinction between the development and operational phases of a project life cycle. Rather the irrigated agriculture sector should assume that all irrigation schemes are in both phases at all times after initial completion of the infrastructure. The development plan for each scheme must focus on achieving the strategic goals set for the sector and the surrounding community. This places the irrigation scheme in the broader context of the river basin and socioeconomic scene, whereby decisions on investment in the irrigation system are considered not only in terms of the improvements in system performance but also in the contribution to improving livelihoods and minimizing environmental degradation.

Thus sustainable irrigation development will involve:

i. identification and definition of medium- and long-term development goals for the sector and region. By necessity, the long-term goals must be defined in consultation with civil society and the political groups in the country to minimize oscillations brought about by changing governments. The goals, and the movements towards achieving the goals, should be published widely.
ii. development of strategic management goals for the short- and medium-term planning of interventions to address short- and medium-term management objectives, responding flexibly to changing circumstances in the medium term. System managers and sector planners will need to keep an overview of the wider socioeconomic scene to ensure that interventions continue to address priority issues.
iii. shifting from a focus on short-term O&M planning to development of asset management plans focused on achieving given levels of water economy and productivity over the planning horizon of 10-20 years.
iv. using asset management plans to integrate recurrent and project budgets to achieve the strategic development goals, through incremental development.
v. recognition that sustainable increases in irrigation performance involve multiple partners in the government and private sectors and in society. Irrigation must play a responsible part in the use and protection of natural resources, most specifically land and water.

Role of Public and Private Sectors, NGOs, Water Users' Associations and Other Stakeholders in Irrigation Management in the 21st Century

The paper reviewed the status of irrigation management at present, and in the context of past experience and present trends, and then examined future challenges and potentials. The focus was on the roles of various stakeholders, especially public sector, organized private sector (OPS), water users' associations (WUAs) and NGOs. Irrigation management is a multifaceted, multidisciplinary affair that demands collaborative action, and it is difficult to separate the tasks and responsibilities of different stakeholders. Hence, the paper first addressed the "*Shared Responsibilities of Stakeholders*". Topics covered in this section included: a) role of agriculture and new challenges; b) role of irrigation production systems in the context of globalization and market-oriented development, and the *need for focusing on farmer profits*; c) water markets and pricing of water; d) need for multifunctional, business-oriented Farmers' Organizations (FOs); e) modernization of irrigation; f) improving *effective irrigated area, time productivity of water*, and managing beneficial as well as non-beneficial water uses; and g) watershed/river basin management. Subsequently, the paper examined the specific roles of the public sector, WUAs, OPS, and NGOs. In addition, it dealt with the roles of research, technology and funding agencies.

Despite the enormous progress made by many countries over the past few decades, irrigation management in the 21st century is faced with many challenges. Rising demands for limited water supplies from rural and urban sectors for agricultural, industrial and household uses pose a formidable challenge. Agriculture will continue to play a significant role in many countries, and it demands new strategies and procedures. For example, globalization changes the pattern of development, and the sector has to face with new challenges of structural adjustments toward liberalized markets. Hence, irrigation management strategies should be adjusted, and organizations and institutional arrangements should be restructured to cater to "market-oriented" growth. In this process, special emphasis should be given to new institutional arrangements that will be necessary for the commercialization of irrigated agricultural production systems, and there is a need for economies of scale to make agriculture profitable. Hence, it would be prudent to expand the role of WUAs to include non-water functions, including irrigation system modernization, diversified cropping, value addition, etc. In this, it is imperative that strengthened FOs such as farmer companies (FCs) establish business links with the OPS, for services, including input and output marketing. In that strategy, *the management of irrigation, including O&M responsibilities, would become an integral task of such business organizations.*

Despite the fact that there is continued interest in comprehensive river basin/watershed planning and studies, implementation of such plans or what is recommended by studies, with the participation of a full range of concerned stakeholders, is lacking. Rehabilitation and modernization (R&M) of irrigation systems should consider hydrological and other linkages between the subsystems of the irrigation system as well as interactions among different segments (micro/sub-watersheds) within the river basin/watershed, adoption of novel production technologies, and marketing of agricultural products. Such a strategy would *enhance farmer profits and this in turn will enhance their capacity to manage their systems. Effective irrigated area and the time productivity of water* would be enhanced through the rational selection of crops, cropping patterns, and timing of cultivation; diversified cropping including high-value crops; application of appropriate technology; and maximizing the utilization of rainfall in both irrigated and non-irrigated areas.

Traditionally, water was considered as a public good, and there were norms and regulations to ensure that everyone could benefit from water. However, the present trend is a shift from being a "public good" towards a "private good", due to budgetary constraints of the governments, efficiency in self-management by users, and also due to other pressures. Active user participation (and WUA responsibility) is important, not only in the day-to-day O&M of irrigation systems, but also in the formulation and implementation of relevant policy, as well as in legal and institutional arrangements. Multifunctional WUAs, FCs, cooperatives or other forms of federated FOs would be the most appropriate organizations for small farmers to coexist with free market forces. Such organizations would also help reach economies of scale and enhance the bargaining power. *On this basis, the paper suggested that the matured organizations would benefit if federate upwards and expand their scope, for instance, by expanding their area of work to cover main irrigation system, the watershed/river basin, and most importantly, enter in to other economic activities.*

When such a novel "Private Sector" is emerged from within the small farmer sector, it would be profitable for the OPS to establish mutually beneficial business links with farmers. The primary role of the OPS would be: a) to provide/sell inputs and services for rehabilitation and modernization, irrigation, and crop production; and b) purchasing outputs, mainly through *formal contractual agreements*. The OPS may also undertake R&M, and even post-R&M management of irrigation systems under different modes of operation, depending on specific conditions. It may even be involved in infrastructure development (e.g., R&M) and in establishing "joint ventures" with the present users.

For the proposed institutional transformation, a catalytic process or a "planned intervention" is required. Such a catalytic effort should be strong enough to generate the internal dynamism of the community and limited enough not to dominate it. Experienced and effective NGOs could play this catalytic role. With the diversified and expanded functions expected from the WUAs/FOs/FCs, the role and functions of the catalyst should also be changed. Capacity building and a continuous flow of information are required to enrich the implementation process facilitating interaction, debate and resolution. The prudent use of information technology in the generation, processing and analysis of information needed is crucial to support the planning, implementation and evaluation of participatory irrigation management. For this, the organizations may use Management Information Systems (MIS) and rigorous self-monitoring and evaluation (M&E).

In the end, *organizationally and financially fully autonomous business organizations should emerge and they should be accountable to their membership, be dynamic and responsive to changes, and maintain effective business partnerships with the OPS. Governments could then perform facilitating and regulatory functions and conflict resolution related to competing uses and users. An improved dialogue between governments, NGOs, people's organizations and the OPS as well as effective coordinating mechanism would be crucial for the sustainability of such partnerships*.

HIGHLIGHTS OF COUNTRY PAPERS

The guidelines for the preparation of country papers emphasized the following: 1) issues and constraints affecting the management of irrigation systems; 2) measures for improving irrigation management performance, with special reference to the linkages between main system management and field-level management; and 3) future directions for irrigation management.

Based on country paper presentations, this section first provides a brief comparative account on the present status of irrigation management in participating countries. This covers water resources and irrigation development and recent developments in participatory management. Subsequently a synthesis of papers is presented under the above topics.

Water Resources and Irrigation Development

Many countries in the region have had a long tradition of irrigation system development. However, there are exceptions, for example, in Fiji, irrigation system development is a recent phenomenon. Construction of large systems was the tradition in such countries like Pakistan and India while in Bangladesh, the recent developments were mainly for groundwater utilization. Scale of irrigation too, varies across countries – net irrigated area in India is over 53.5 million ha and in Pakistan, the live storage in the three major storage reservoirs is about 15.4 billion m^3 while Fiji constructed its first irrigation system in 1969 with a command area of 310 ha. In Mongolia, small and portable watering installations are becoming popular. Similarly, there exists variation across countries in regard to physical apparatus. For example, in Japan, almost all irrigation and drainage structures are paved with concrete. In addition, developed countries heavily utilize advanced information technology.

In general irrigation or agricultural water use still plays a significant role in most of the countries. At present, almost all the countries are focusing on improving management of existing systems rather than the earlier emphasis on constructing of new irrigation systems. This reoriented interest gathered momentum due to: diminishing land and water resources available for agriculture, and the increasing cost of developing new irrigated production systems; demonstrated under-performance of the existing systems; and comparative advantage of undertaking rehabilitation programs over new construction activities.

The seminar revealed that all the participating countries have taken initiatives in the "formation" of water users' associations, and promoting participatory irrigation management. This has been recognized as the major mechanism for linking main system management and field-level management. The degree of IMT and its success, however, varies across countries.

WUAs "formed" by the government agencies or "evolved" through catalytic processes launched by the agencies or by projects are the major mechanisms through which user participation is promoted. In Japan, the Republic of Korea and the Republic of China, a substantial effort has been taken to consolidate land, improve land and water-related infrastructure, and the current tendency is to establish advanced land and water use methods and decision support systems.

Water markets and irrigation service fee collection are not developed in many countries. However, there are exceptions, such as the groundwater utilization in Bangladesh (which constitute 90 percent of irrigation), command areas managed by irrigation associations in Korea, and certain pilot projects in Vietnam.

Issues and Constraints Affecting the Management of Irrigation Systems

Most commonly quoted issues and constraints are as follows:

i. Weak institutional mechanisms: Relative weakness in the institutional mechanisms has been identified as a major constraint in linking main system management and field-level management;
ii. Deferred/poor O&M and inadequate O&M funds;
iii. Inadequate policy and legal support for WUAs;
iv. Dilapidated physical structures: This could be due to many factors, including poor O&M and inadequate user consultation/participation in rehabilitation, etc;
v. Unreliable supply and water supply shortages: As mentioned earlier, most of the "cheaper" sources of water for irrigation are already in use. In addition, due to sub-optimal utilization and also due to competing uses and users, shortages in supply have become a common phenomenon in many countries;
vi. Lack of willingness to participate by farmers: Due to unawareness and inadequate intervention could be a prime reason. Also, the low farming profitability brings about low willingness of participation in irrigation management;
vii. Inadequate data/information and lack of performance assessment;
viii. Sedimentation of storage facilities and canal network;
ix. Weak on-farm water management;
x. Lack of consistency in policy;
xi. Unsatisfactory planning, funding and implementation of projects;
xii. Lack of rewards for efficient use of water: Lack of incentives for efficient use of water by farmers is quoted as a constraint;
xiii. Conflicts in resources reallocation: This is common in more developed countries. For example, in the Republic of China, rapid development in industrial and commercial sectors caused greater competition; and
xiv. Increased number of part-time farmers and aging of farming population: This is particularly relevant to more developed countries.

Future Directions for Irrigation Management and Measures for Improving Irrigation Management Performance, with special reference to the Linkage between Main System Management and Field-level Management

i. Establish WUAs (or any other forms of FOs) for effective farmer participation and for promoting agency-farmer linkages. Enhance investments in social capital;
ii. Federate WUAs;
iii. Improve legal provisions for setting up of WUAs with devolution of power;
iv. Irrigation system modernization;
v. Adequacy and consistency in government policy;
vi. Improved Communication Systems: Applications of Information Technology and Decision Support Models: Application of advanced information and communication technologies and decision support systems would enhance effective linkages between main system and field-level management;
vii. Change the "Mind-set" (attitudes) of Both Farmers and Bureaucracy: As the mindset of irrigation bureaucracy has long been conditioned to work in a particular mode and is "paternalistic" so a change is called for. Also, the attitudes of some farmers need to be changed;
viii. Demand-driven Irrigation Management: Especially due to increasing and diversified demand for new agricultural products and also due to severe competition in local and export markets, irrigation management faces novel demands. In this context, in order to improve irrigation efficiency, demand-driven irrigation is proposed;
ix. Adopting water-saving technologies;
x. Establish effective mechanisms for performance assessment and M&E, especially self-M&E; and
xi. Other Users of Water Should Share the Cost: Water is used for purposes other than irrigation, e.g., industry, conserving rural environment, preventing disasters including floods, conserving

traditional culture and beauty, sustaining rural communities, maintaining recreational facilities, etc. Therefore, these users, including the central government and local governments, should share the cost.

WORKSHOP OUTPUT

A workshop was conducted to provide an opportunity for further discussion and sharing of views and experiences among the participants. Specifically, two discussion points were taken up, namely: 1) what do you think are the major factors/issues that are hindering efforts to enhance linkages between main system and farm-level managements of irrigation systems with resulting enhancement of productivity and rural living standards in Asia and Pacific?; and 2) what specific measures can you suggest to address these factors/issues so that the linkages and productivity can be enhanced?

To facilitate the discussions the participants were divided into two small groups. The outputs of the two groups were presented in a plenary session and these have been summarized as follows:

Group 1. Japan, Mongolia, Taiwan, Vietnam, India, Sri Lanka, Thailand

Major Issues/Problems	Suggested Strategies/Measures
Farmers have different values/ incentives/purposes from agencies (e.g., water saving, water fee collection)	1. Participatory negotiation (transparency) and compromises and trade-offs to achieve the main goals of the irrigation system 2. Adherence to the various joint programs developed (crop calendars, water issue schedules, etc.) 3. Improve farmers' incomes through processing value adding and marketing arrangements
Lack of efficient service delivery programs at the main system level	1. Set up water fee system to make the agencies accountable to deliver agreed amounts in time and reliable ways (farmers become the customers) 2. Effective monitoring (e.g., joint council formed by the farmers and the agency personnel) 3. Information on the main system O&M should be made available to the farmers (transparency) 4. Improve the MIS
Mental barriers/status of governmental bureaucracy	1. Develop face-to-face interaction among farmers and the agency officers to expose them to the reality 2. Change performance evaluation system (structurally and functionally) 3. Accessibility of farmers to officials 4. Get farmer institutions linked into the main system management organizations/structures
Lack of coordination of governmental agencies	1. Rotation/shifting of employees among agencies through structural adjustments 2. Establish coordination committees and monitor their effectiveness 3. Effect institutional reforms
Lack of cooperation among farmers	1. Apply social sanction/pressure 2. Create incentives for farmers to cooperate 3. Empower the farmers' groups (small groups)
Lack of institutional capacity or initiative to organize farmers into viable groups	1. Make resource available for irrigation management agencies to hire external parties to play catalytic role 2. Exchange visits of farmers and the bureaucracy to enhance problem-solving capacity to solve problems (social engineering)

... To be continued

Continuation

Major Issues/Problems	Suggested Strategies/Measures
Inadequacy of funds	1. Prioritization of allocating limited funds (participatory fund allocation system) 2. Establishment of revolving funds 3. One-time grant to establish O&M endowment (functional grant) 4. Mobilize farmer resources (self-help maintenance program, etc.)
Politicization and interference	1. Empowerment of communities to build the pressure on politicians to change their altitudes 2. Raising the awareness of politicians at all levels (local/regional/national) 3. Set up laws and communicate them
Lack of accountability/transparency/knowledge for the whole system	1. Develop face-to-face interactions among farmers and agency officers to expose the officers to local reality 2. Improve communication among the groups (agencies and the farmers)

Group 2. Bangladesh, Fiji, India, Republic of Korea, Malaysia, Pakistan, Sri Lanka

Introduction

* Improved irrigation management is the key to better agricultural productivity and consequent improvement in the quality of human lives.
* There should be strong *institutional, physical and communication linkages* between main system management and farm-level management.
* The *enhanced linkages* could be utilized to build up social capital, which helps farmers to better livelihood and improving living standards.

Major Issues/Problems	Suggested Strategies/Measures
1. Farmers need initial capital to make FOs functional	Allocation of appropriate funds separately for PIM program
2. Inadequacies in the capacity of the farming communities in regard to water management and organizational development	Strengthening of capacity and organizational development. Water management training for the farmers and agency personnel is required.
3. Political will is lacking to transfer irrigation management responsibilities to the farmers	Development of political will through pilot projects, presentations, seminars and workshops
4. In general, the systems are in bad shape due to deferred maintenance. A blueprint approach practiced by agencies in most of the developing countries is not helpful	Need R&M. There is a need to "build capacity" to *physically link* main system and farm level
5. Poor recovery of O&M costs. All the beneficiaries do not share the cost	Ensuring proper cost recovery of irrigation facilities and their O&M from farmers, beneficiaries and government
6. Weak legal and procedural framework constrains the proper functioning of FOs	Strengthening legal and procedural framework for the proper functioning of FOs
7. "Paternalistic mind-set" and dependency syndrome	Changes in attitudes, of both farmers and the bureaucracy, including a change from "paternalistic" mind-set.

FIELD STUDIES

For their field studies the participants visited Minneriya Major Irrigation Scheme in Polonnaruwa district. The highlights of the visit are presented below:

Minneriya Major Irrigation Scheme

First, the group met with the project engineer and visited the Minneriya reservoir, sluices and the spill. At these sites the project engineer and his staff described the operation of the irrigation system and clarified issues raised by the participants. The reservoir has a storage capacity of 110,000 acre-feet and was originally constructed in 327 BC. Subsequently the participants visited the Project Management Office and interacted with a group of representatives of several FOs and the FC. The Additional Secretary of the Ministry of Agriculture and Livestock, Deputy Director of Irrigation (in-charge of the district), Project Engineer, Project Manager and few other government officers also participated.

Farmer representatives, while accepting the fact that "it is now easier to discuss and solve problems and interact with agencies", expressed concerns over certain issues. It was revealed that the irrigation system has not been properly rehabilitated for many years. FOs (WUAs) were of the opinion that they could undertake the full responsibility of O&M of the irrigation system if it is handed over to them after a complete rehabilitation process. At this point, the irrigation agency personnel admitted that the previous rehabilitation was limited to "essential structures". The farmer representatives said that they were not well organized at the time of rehabilitation and also they were not consulted adequately.

As a consequence of rising costs of production and declining product prices, especially at the time of harvest, farmers' incomes have fallen and farmers' capacity to pay irrigation fees as well as their ability to undertake O&M have declined. Sixteen thousand farm families cultivate the system's command area of 22,000 acres. The system was designed to irrigate only 12,000 acres, but now the area has expanded mainly due to the pressure of second and third generation farmers. Hence the farm size is small. The average yield is about 5 mt per ha. However, farmers complained that they do not make profits. Even though they do not pay an irrigation service fee, the farmers contribute labor to maintain canals and most of them pay Rs.100 per year to their organizations. This amount is inadequate for FOs to undertake full O&M. At this point, possible involvement of FOs and the FC in marketing was discussed. Silting up of the main reservoir and sedimentation of canals were also cited as constraints.

Farmers interacted with the participants to know more about the government support to agriculture in other countries, use of agricultural machinery, cost of production and profits and the price support mechanisms.

CONCLUSIONS

Irrigation systems constitute hardware (such as physical structures) and software (such as social structures and communication systems) and usually operate at multiple levels like field channel, distributory canal, subsystem and main system. Therefore, well-functioning WUAs could play an essential role in effectively linking the main system with field level. The seminar concluded that strong federated WUAs could be the prime factor affecting this linkage. Further it is proposed that the federated WUAs could be multifunctional FOs and expand their scope, for instance, by expanding their area of work to cover the main irrigation system, the watershed/river basin, and most importantly, enter into other economic activities, primarily input services, marketing and value addition. Naturally, federations of water users based on watersheds/river basins would include non-agricultural users as well. Where agricultural water use is dominant, the organizations could begin with irrigators' associations, and with maturity, they could expand the scope to cover other functions. Enhancing farmer incomes through FO (including FCs, where appropriate) intervention in marketing, and value addition are keys to success.

Almost all the participating countries are adopting participatory approaches in irrigation management to a varying degree. Success varies across countries, however. Usually, government (agencies) "form" WUAs. It is proposed that a planned intervention through a catalytic process (which follows a learning process approach) would be more beneficial so farmers are motivated and assisted to form their own organizations.

As farming communities usually do not have adequate economic and technical capacity to undertake the full responsibility of irrigation management, especially in major systems, capacity building and a gradual process of "transfer" is recommended. The seminar concluded that for such institutions and linkages to be effective, appropriate physical apparatus (hydrological linkages, control mechanisms and measuring devices, etc.) and communication systems should be in place. It was proposed that, if farmers do not have the financial capacity to undertake such improvements in the physical system, the respective governments should allocate special funds, which are separated from routine appropriations.

Performance evaluation systems should be changed, participatory negotiation processes should be promoted, and openness and transparency should be established. FOs should be strengthened to avoid political pressure. It was the consensus of the group that "political will" as well as the cooperation of government bureaucracy are important conditions for the success of farmer participation and FO development in many countries. In such cases, changing the attitude of the politicians and "bureaucratic reorientation" are essential. A collective effort comprising of awareness creation, appropriate training, demonstration effects of pilot projects and pressure from farmers and other stakeholders is proposed for this purpose.

It was the consensus of the meeting also participants that the respective governments should have appropriate and consistent policy and legal framework favoring participatory and shared management and effectively linking main system management with field levels.

It is proposed that R&M of irrigation systems should consider hydrological and other linkages between the subsystems of the main irrigation system as well as interactions among different segments (micro/sub-watersheds) within the watershed, adoption of novel production technologies, and marketing of agricultural products.

1. ISSUES AND CONSTRAINTS IN LINKING MAIN SYSTEM MANAGEMENT FOR IMPROVED IRRIGATION MANAGEMENT

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INTRODUCTION

An irrigation system consists of a set of interconnected subsystems linked together both physically and functionally. The linkage is hierarchical in nature and continuous until water is delivered and applied at the farm level by the end-user. Hence each level of these subsystems is dependant on the other and need to cater for the next level of operation as best as practicable. However, due to diverse nature of the subsystems, which is influenced by factors including human, cropping and farming systems in addition to the other links such as limitations of water resources and those of physical system itself; makes management of irrigation systems is a complex exercise.

Basically a canal irrigation system consists of a source which could be either storage reservoir or diversion from a river or a stream, called headwork; a primary or a main canal system; a secondary or a distributory system, taking water off from the primary canal; and a system of tertiary or field canals which feed the farms. There are irrigation schemes where water is augmented from catchments other than its own where a further dimension is added.

On the other hand, management of irrigation systems involves forecasting irrigation supply likely to be available, estimating irrigation demand, matching supply and demand, scheduling and allocation, harnessing water resources and distribution in an equitable, efficient, reliable and dependable manner. In addition, the irrigation system also needs to be maintained in a reasonably operable condition and all activities need to be monitored and evaluated.

In this process, each level of an irrigation system necessarily becomes a management and decision center on its own merit, which takes into account the different links. However, in order to achieve the final objectives of irrigation, it is essential that these links are extended up to on-farm level and issues and constraints involved are continuously identified to get a best fit in a complex situation.

OBJECTIVE CONFLICTS – DIFFERENT OBJECTIVES OF DIFFERENT PARTIES INVOLVED

Unlike agricultural enterprises such as plantations, irrigation systems are not "one investor, one manager, one user" entities. At least, there are three or four main parties involved and the objectives of irrigation systems need to cater in this perspective. The main parties involved would be the farmers, the Farmers' Organizations (FOs) or the Water Users' Associations (WUAs) and the agencies responsible and involved in management, and the state or the government.

The main objective of farmers, in the context of countries like Sri Lanka is to produce minimum level of food for subsistence and then to get the family income increased while the objectives of an FO or WUA managing a subsystem could be equity in water distribution and minimizing conflicts between the communities they serve. On the other hand, the objectives of agency managing the main system would be appropriate water use and the efficiency while the state will have higher level national objectives such as food security, poverty alleviation and so on. The other agencies involved such as agricultural agencies' main objective could be maximizing agricultural production of a particular crop or crops in the area or in the country.

Irrigation systems are therefore expected to fulfill a wide range of objectives but they are not always necessarily in harmony with the individual farmer's objectives, who is finally using and managing the water on farm.

Nature of an Irrigation System

Conventional irrigation systems quite differ from other networked service delivery systems like electricity supply systems though attempts are at times being made to compare. Water in irrigation canals does not flow along dedicated lines such as electrical or telecom lines where high degree of control is possible. On the other hand, large systems have to carry water over a long distance in earthen canals; with large number of farmers to be served; with a problem of communication; over a long distance and also with some times unpredictable variation in demands such as reduction of irrigation demand in certain parts of the system due to a sudden rainfall.

Other uncertainties include unpredictability (to a level of accuracy desirable at micro level), of effective rainfall, return flows, and seepage and percolation due the nature of media and terrain through which the water flow.

Operational Complexity of Physical System

Large-scale irrigation schemes are built with a large number of head and flow control structures such as regulators and turnout structures, safety devices such as canal spills, measuring devices to measure water at control points, to name a few. They are sometimes cumbersome to operate and need a large number of trained staff. Instances of tampering of these structures by farmers are also not rare.

In regard to the operations, when water is transmitted over a large distance, adjustment in one place may cause variation of water levels and flows in other places of the canal which are difficult to predict and will take some time to become hydraulically steady affecting the water supply at the downstream.

Accommodating Changes Over Time

Changes that have taken place over the years since the initial construction of the systems have made it necessary to review the current operational criteria with the original design criteria of these systems. Such changes include the following:

a) Increase in population in traditional irrigation areas and resulting land fragmentation;
b) Changes in land use, variation in watershed characteristics that affect inflow such as deforestation reducing catchment detention but causing flash floods; and
c) New developments such as *Samanalawewa*.

These changes necessarily will have an impact on farm management involving changes to on-farm practices including cropping patterns and calendar and irrigation methods. Factors such as market and consumption patterns will also have a bearing on the changes that can take place at farm level.

Multipurpose Schemes

Some of the large irrigation schemes are part of multipurpose schemes generally coupled with generation of hydropower. Moreover, with the changes of climate and increasing demand for power, it has increasingly become necessary to adjust the cropping patterns, as much as possible to match with such changes. Staggering of cultivation or even abandoning some extent have become necessary in the recent past.

Interlinked Systems

Large number of irrigation schemes in this country are interlinked physically either due to their being fed by diversions from elsewhere such as Mahaweli system or being located in the same basin forming a cascade. Cropping activities and on-farm management in these systems are necessarily not independent from each other, because the water supply and drainage patterns are governed by the conditions in the macro system. As these systems consist of an interlinked network of feeder canals and reservoirs, the operational complexity resulting from shared infrastructure is another factor that governs the decisions at farm level.

Competing Demands

Despite the fact that a large number of water resource projects have been developed, still competition and scarcities in some parts do exist as a result of increased intra-sectoral demands in sectors such as agriculture and increased inter-sectoral demands due to new demands that are emerging.

Increased intra-sectoral demand within agriculture, due to "unauthorized" expansion of cropped extent and "illicit" tapping of water at upstream of the irrigation systems which have resulted from the necessity of providing food/employment for expanding population in the agricultural areas, such as in Huruluwewa Irrigation Scheme in North Central province of Sri Lanka, is very common in most of the irrigation schemes. On the inter-sectoral demand perspective, while in some river basins of Sri Lanka the competition is bi-sectoral as in the case of Samanalawewa Hydropower Project and Kaltota Irrigation Scheme in Walawe River basin, in some other basins such as Menik Ganga in southern Sri Lanka, the competition is multi-sectoral due to increased demands of agriculture, domestic, industrial, religious and cultural use and wildlife at same time.

With the increasing incomes and associated general improvement of quality of life coupled with the government's policy to provide safe drinking water to everyone, in general, the demand for domestic water is on the increase all over the country. In the typical irrigated areas, most of the water resources have already been developed for irrigation and these irrigation projects cater for domestic and other needs of the irrigation communities but may not have designed to cater for domestic water demands of the other people living outside. Urban and new population centers such as Anuradhapura in North Central in Sri Lanka have now developed within these areas, which have created a new demand for domestic water.

Thus efficiency improvement in irrigated agriculture both at main system and at on-farm level has become an urgent necessity of the day.

Ecological, Environmental and Water Quality Issues

Environmental and ecological issues are on the increase in most of the river basins with the increased economic activities affecting irrigation systems. Examples are unregulated sand mining in riverbeds, unplanned brickmaking on the riverbanks, silting up of reservoirs and unregulated well construction. Effects can range from reduced quantity of water available to timing of abstractions among other things. Pollution of water bodies and environmental issues such as possible salinity buildup in certain areas need attention in management of both main systems as well as on-farm.

FUTURE PROSPECTS

Data Management

Effective management of both the main systems and on-farm systems needs accurate and reliable data in time. Furthermore, data and information sharing mechanisms at different levels are also crucial.

Naturally, there are constraints for acquisition of some of the data due to limitations in resources and technology. New digital technologies such Global Positioning System (GPS) and Geographical Information system (GIS) need to be adopted as early as possible as such technologies are now gradually becoming affordable.

Limitation on Operation and Maintenance Funds

As mentioned earlier, irrigation systems need to be maintained at certain levels of operability to meet on farm requirements. O&M budget made available by the governments is being decreasing over the years in real terms while the costs are on the increase. Hence, finding ways and means to bridge the gap is vital for the very sustainability of irrigated agricultural systems.

Cost-effective mechanization of maintenance activities is one of the strategies now being tried by the Irrigation Department of Sri Lanka. In addition, cost-sharing is being tried in different ways but affordability of farmers needs to be taken into account.

Communication and Coordination

Mechanism for communication and coordination between main system management and the on-farm was almost non-existent in the past. However, as a result of the Participatory Irrigation Management (PIM) practices implemented in Sri Lanka, which had started on experimental scale in 1978, has paved a way out. The institutions formed under the PIM program, which include the FOs, the project management committees, etc., allow some integration of different disciplines, agencies and ensure the participation of different stakeholders in the management. It also allows the flow of information both upwards and downwards though still there are some shortcomings or gaps due to various reasons. It may be now time to investigate ways and means of expanding these concepts if they can be of benefit.

Training and Awareness

As in most other instances, knowledge and awareness gaps exist which need to be continuously identified and improved for successful linking of management of different parts of the system. Non-availability of some information to stakeholders and the transparency issues are also need to be taken into account.

CONCLUSION

The ideal system of water delivery at the on-farm level would be a system of "on demand", where water can be applied based on the soil, crop water requirements and the rainfall. In such a system, water delivery would become flexible to coordinate with all farming activities such as land preparation, planting with different crops with different crop water requirements, application of fertilizer and chemicals, staggering of crops to suit market and so on. However, as discussed above, farm being one of the subsystems of a big system in this situation, there has to be some tradeoffs. Technical and other interventions such as on-farm storage, automation in main system, communication improvement and some planning and management interventions can make the gap smaller.

2. MEASURES TO IMPROVE LINKAGE BETWEEN MAIN SYSTEM MANAGEMENT AND FARM-LEVEL MANAGEMENT

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INTRODUCTION

Irrigation-based agricultural development has been the major path of agricultural development in most of least developed countries. Irrigation is vital as a source of livelihood for the rural population. Irrigated agriculture sector produces around 60 percent of the value of crop production in Asia. This includes about 80 percent of Pakistan's food, 70 percent of China's food and over 50 percent of India and Indonesia's food (Wolff, 1997).

Although irrigated agriculture has been by far the dominant water user, the competing demand for the water from other sectors has increased tremendously over the years and consequently, the share of water allocation for agriculture sector has been significantly decreasing (Table 1).

Table 1. Dynamics of Water Withdrawal by Sector in Asia

(As a percentage of total withdrawal)

Sector	Assessment								Forecast		
	1900	1940	1950	1960	1970	1980	1990	1995	2000	2010	2025
Agriculture	98.5	95.5	94.9	93.3	90	85.5	81.6	80.7	79.9	77.5	72.3
Industry	1	2.6	3.8	4.2	7	8.6	8.5	8.5	8.6	10.0	13.2
Municipal needs	0.48	1	1.3	1.6	2.5	3.6	6.9	7.4	7.8	8.7	11
Reservoirs	0	0.01	0.02	0.6	1.5	2.2	2.9	3.2	3.6	3.7	3.4

Source: I. A. Shiklomanov (ed.), 1997.

It has been estimated that by 2025, a condition of water stress would be experienced in 46-52 countries, which will affect about three billion people (Panayotou, 1993). Therefore, the critical importance of effective water resources management and reliable water supply for the survival of the mankind and the sustainable development has been realized throughout the world. If one considers the per capita water availability on a regional basis, the Asian continent shows the lowest (Table 2).

Table 2. Dynamics of Water Availability by Regions

(Unit: 000 m^3/year/capita)

Region	Water Withdrawal								
	Assessment						Forecast		
	1950	1960	1970	1980	1990	1995	2000	2010	2025
Australia and Oceania	203	149	118	99.6	85.8	80.8	75.9	68.3	61.4
South America	109	83.1	63.6	49.8	40.6	37.0	33.4	26.3	24.1
Europe	5.51	4.99	4.53	4.17	3.99	3.96	3.93	3.89	3.92
Africa	18.2	14.6	11.2	8.3	6.18	5.35	4.53	3.4	2.46
Asia	9.18	7.41	6.13	4.78	3.84	3.60	3.36	2.96	2.35

Source: I. A. Shiklomanov (ed.), 1997.

The rising population, widespread hunger, declining grain stock, increasing water pollution and thereby intensified demand on irrigation resources required more efficient management of water resources and effective operation and maintenance (O&M). According to UNESCO, with the current trends of water use (including increasing pollution) water demand will outstrip supply before middle of this century. Therefore, measures to improve irrigation system management and efficient allocation of water resources are gaining importance.

IRRIGATION SYSTEMS MANAGEMENT MODELS

Farmer-Managed Irrigation Systems

Farmer-Managed Irrigation Systems (FMIS) are entirely operated and maintained by irrigation communities without external assistance. These systems included both indigenous systems and the systems which are turned over by the state to farming community. There are historical evidences that suggest farmers' involvement in construction, management and maintenance of small-scale irrigation systems in Asia. Eighty percent of the total irrigated area in Nepal, about 15,000 minor tanks in Sri Lanka and 5,500 irrigation systems in Philippines are traditionally managed by farmers (Siy, 1989).

Agency/State-Managed Irrigation Systems

The state-managed irrigation systems are constructed, owned and managed by the government/relevant government agency. In general, government-controlled irrigation systems are relatively large and technically complex compared to FMIS. The governing agency may be financially and organizationally autonomous from the central government or dependent on government control. Research findings shows that the performance of FMIS in terms of cropping intensity, technical efficacy of infrastructure and water availability are higher than government-managed irrigation systems (Tang, 1992; and Benjamin, *et al*., 1994).

Joint Management of Irrigation Systems

Throughout the world, the joint management of irrigation systems by irrigation agency and water users has become a popular model after the 1980s. The level of participation of different stakeholders in irrigation management under this model varies from place to place. Generally, management responsibility at primary level of irrigation schemes (head systems and main canal) lies on state/line agency and the O&M of secondary (distributory canal) and tertiary level (field channels) is the responsibility of water users. Water Users' Associations (WUAs) have been formed at users level to perform the task. Therefore, under the concept of joint or participatory management, WUAs have to be involved actively in system management, which has led to the more complete concept of Irrigation Management Turnover (IMT).

IMT has been variously referred as "turnover" (Indonesia and Philippines), "management transfer" (Mexico and Turkey), "privatization" (Bangladesh), "disengagement" (Senegal), "post-responsibility system" (China), "participatory management" (India and Sri Lanka), "commercialization" (Nigeria), and "self-management" (Niger) (Geijer, *et al*., 1996). IMT is being in practice worldwide as a recent management tool to improve management efficiency and to reduce government cost. It has been seen as a vital component of the structural adjustment program.

IMPACT OF IIRRIGATION MANAGEMENT TURNOVER ON IRRIGATION PERFORMANCE

Although the involvement of farmers in the construction and maintenance of small irrigation systems was a practice since ancient times, the management transfer of large-scale irrigation systems from bureaucracy to people is a relatively new concept. Little systematic evidence exists to date to assess the impact of irrigation management transfer and joint management of the irrigation systems. The performance assessment results from various parts of the world shows mixed results.

There are eight expected impacts mentioned in the literature with the turnover of irrigation systems to farmers:

1. ***Improved Productivity and Food Security***

This is expected from the contribution of enhanced productivity of water to both the production and service area. However, there are disagreements in this regard among scientists because yield is influenced by numerous complex factors. Therefore, the effect of participation on yield would be extremely difficult to measure (FAO 1980; and Turral, 1995). There are a number of case studies that have been done in different parts of the world to find out the above relationship. The results observed are mixed. After management transfer, cropping intensity increased by 200 percent with noticeable yield increase in Niger (Lonsway and Amadou, 1994); increase in dry season benefitted area and dry season yield in Philippines (Bautista, *et al*., 1994; and de Reyes and Jopillo, 1989); significant increase in crop production in China (Johnson, *et al*., 1994) and Egypt (Aziz, 1994). In Sri Lanka, IMT evaluation results show that neither productivity nor area under cultivation increased significantly due to management turnover (International Irrigation Management Institute and Agrarian Research and Training Institute [IIMI and ARTI], 1997).

2. ***Improved Relations and Reduction in Conflict between Government Officers and Farmers and among Farmers*** (FAO, 1980)

It was hypothesized that frequent meetings and consultation between agency and farmers causes fewer misunderstandings and reduced conflicts. The hypothesis was true in several places (Uphoff, 1986; and Musa, 1994). Restrepo and Vermillion (1994) found from a study conducted in Colombia that irrigation management transfer has improved the accountability of government staff to farmers, improved the timeliness and responsiveness of management decisions and decreased the additional political appointments for staff positions. These aspects are important to reduce misunderstanding between the irrigation agency and farmers. There are also conflicting evidences reported from various places. For instance, Restrepo and Vermillion (1994) mentioned that irrigation management transfer in some district organizations in Columbia has led to a rise in water distribution problems, primarily due to conflicts between large versus small farmers, relative weakness of the organization and poor enforcement of laws.

3. ***Improved Water Management and System Maintenance*** (FAO, 1980; Turral, 1995)

There is an underlying assumption that FMIS are managed more efficiently than those run by public officials and are more responsive to the needs of their users. In participatory management, in addition to the above factor, frequent interaction between agency and farmers and among farmers leads to more effective coordination in allocation of water and system maintenance activities. Research findings suggest that management transfer programs in Mexico and Nigeria have resulted in gains in water distribution efficiency and equity (Musa, 1994; and Palacios-Velez, 1995) and improvements in the infrastructure maintenance in Philippines, India, Nigeria and Indonesia (de Reyes and Jopillo, 1989; Shah, *et al*., 1995; Musa, 1994; and Gerards, 1995). Lonsway and Amadou (1994) observe that there is overuse of water in some systems in Niger, up to 60 percent more than theoretical requirements, and absence of discipline in water management, which has caused observable salinization of certain soils. The canals, which needed collective intervention, are not maintained properly causing rapid deterioration of the overall system.

4. ***Increased Collection of Loan Amortization and Contribution to Labor and Material from the Community*** (FAO, 1980)

Bautista, *et al*. (1994) found more convincing results from their Philippines' experience of a management turnover program. According to them, water fee collection efficiency in management turnover areas was significantly higher compared to non-management turnover areas. Management turnover areas have lower repair and maintenance cost than non-management turnover areas, which implies that WUAs absorbed most of the repair and maintenance costs and management turnover has contributed to the prevention of the rapid deterioration of the system physical facilities. Turral (1995) highlights the conflicting evidences in O&M fee collection, which are high in some areas and highly erratic in others. He further pointed out that, one of the most disturbing negative impacts emerging from management turnover is that farmers are keen to price-down irrigation water, even to the point of seriously neglecting routine maintenance.

5. ***Willingness of Farmers to Accept Responsibility for System O&M due to the Development of A Sense of Ownership and Control over Irrigation and Choice of Crop Production*** (FAO 1980; and Turral, 1995)

If the farmers have a sense of ownership, they will not only maintain system, but also ensure that structures and facilities are not damaged (Lowdermilk, 1986).

6. ***Improved System Design and Construction***

This would be consistent with local resources and conditions and contribution of local knowledge on hydrology, topography, agronomy, geology, climate and property rights. Participatory approaches offer an opportunity to combine the local indigenous knowledge with the technical and financial resources of the irrigation agency. The continuous monitoring by users is envisaged to help the construction of infrastructure according to local requirements and to maintain the quality of construction at a standard level and according to site-specific needs. Farmer participation in the design and construction led to better sitting of structures and canals in Thailand and economized construction in Indonesia (Bruns, 1991).

7. ***Effective Coordination of Agricultural Services and Farming Practices***

This has been one of the components in the matrix management of Integrated Management of Irrigation Schemes (INMAS) program in Sri Lanka (Harding and Franks, 1988).

8. ***Other Social Changes with Long-term Implications***

Development of viable rural institutions and participation of users in the irrigation management undoubtedly can give intangible positive social changes with long-term implications (Bottrall, 1981; and FAO, 1980). The development of local leadership, enhancement of farmer skills and capacities for self-management and resource mobilization, setting up of a mechanism to articulate local needs and interests to the government sector and other external institutions for a self-sustaining and self-reliant development are the main expected benefits.

The impacts of IMT presented in this section are mostly from pilot projects, case studies and action research and therefore may not be relevant to full-scale country programs. It is apparent from the results that, the impacts are highly location-specific, program-specific and time-specific. However, significant benefits may accumulate to users as a result of self-management of irrigation system, which are not immediately evident. This has been true in the small-scale FMIS worldwide.

IMT is a process that cannot happen spontaneously or in a short time. The process needs some efforts and systematic intervention to create viable WUAs, especially in the large canal irrigation systems. The efforts also needed to change the roles, functions, attitudes and structures of state irrigation agencies in order to share their powers and controls with WUAs. The most crucial determinant of irrigation management in canal-based large systems lie in the intermediate zone between main system and farm level (Chambers, 1977; Coward, 1977; and Uphoff, 1986). Therefore, it is vital importance to consider the measures, which improve the linkages between main system and farm-level management in order to increase the efficient use of irrigation resources.

CONDITIONS TO IMPROVE LINKAGES BETWEEN MAIN SYSTEM AND FARM LEVEL MANAGEMENT

Building Effective WUA

Development of effective and strong grassroots level organization is important to perform the O&M tasks and to maintain linkages with top-level management. In large systems, usually WUA is a vehicle functioning between the main system management and farm-level management. The necessity of user organizations in irrigation system management has been emphasized by numerous authors (Korten, 1989; and de Reyes and Jopillo, 1989). The real and tangible benefit or reward of collective water management activities is real control over water (Hunt, 1989; and Geijer, *et al*., 1996). Uphoff (1986) identifies adequacy, reliability, and timeliness supply of water, decreased cost or difficulty in acquisition of water, and reduced conflicts in water use as the incentives for users participation.

In order to get above benefits/performance, WUA must be strong enough and viable to perform the tasks of control structure management such as design and construction; operation of structures and maintenance of structures; organizational management activities such as decision-making, resource mobilization and management; two-way communication and conflict management; and water management activities such as acquisition of water, allocation of water, distribution of water, and drainage of water (Uphoff, 1986). From the review of literature, research observations and past experiences, it is evident that the viability and strength of WUA basically depend on following factors.

Approach Adopted for WUA Formation

1. ***Use of Social Mobilizers***

Organizations do not form spontaneously. Experiences of WUA building programs from various parts of the world shows that, organization building often requires trained social catalyst from outside to mobilize the people and to strengthen the organization. Wijayaratna (1992) emphasizes that, "*such a catalytic effort should be strong enough to generate the internal dynamism of the community and controlled enough not to dominate it*". This was the approach in building Farmers Organizations (FOs) in Gal Oya, Sri Lanka (Uphoff, 1986) and by the National Irrigation Administration (NIA) in the Philippines (de Reyes and Jopillo, 1989) which are recognized as successful institutional building efforts in the recent past.

2. ***Stage of WUA Formation***

One of the important factors, which determine the sustainability of WUAs, is the institutionalization of the learning process of institutional building through a planned intervention (Wijayaratna, 1992). Government should use a strong and appropriate intervention strategy to develop the institution right from the design and construction of the irrigation system. The involvement of farmers at all levels creates the sense of ownership, which is very important for the sustainable management of irrigation facilities. In Indonesia, management turnover in irrigation schemes are most likely to succeed if at the initial stage farmers are involved in design and construction of irrigation system improvements (Bruns and Atamanto, 1992). Therefore, development of WUAs and turnover of management responsibilities to farmers only reduces government recurrent cost, which is not a viable option.

3. ***Method of WUA Formation***

According to Carruthers and Morrison (1994), one of the five reasons, which caused failures in past initiative of WUA program, is the imposition on organization by donors or governments. The success is depends on how WUA were formed by the external agent. The need for the organization should be realized by the community itself and request should come from the users side. In other words bottom-up development approach is the most sustainable development tool in rural transformation.

Structure of the Organization

1. ***Boundary of WUA***

Research observations and past experiences show that WUAs should be developed based on hydrological boundaries, not as village base or other administrative boundaries (Uphoff n.d.) This may facilitate the increased cohesiveness among water users, because they have a common interest in the O&M of the irrigation system in which they have to share the water from a common facility regardless of their location in the watercourse. This is vital to minimize conflicts and mistrust and to increase the loyalty among users. The benefits of the collective action would be contained within the group.

2. ***Size of the Organization***

Size of the organization is an important factor affecting sustainability that varies with layout of the irrigation system, technology used and socioeconomic variables (Cernea and Meinzen-Dick, 1994). The size itself includes the size of the organization command area and size of membership. There is no blueprint organizational size to fit all the irrigation projects. The larger units of organizations able to aggregate greater amount of resources (labor, money, information) and the requirements of per capita resource mobilization are likely to be less (Uphoff, 1986). Uphoff wrote that such organizations are, however, more susceptible to the negative effects of opportunism, feelings of solidarity and mutual responsibility would be weakened by the personal relationship. Moreover, the costs of maintaining an organization for decision-making, communication and conflict resolution will increase with the size of an organization (Uphoff, 1986; and Cernea and Meinzen-Dick, 1994). Uphoff (1986) and Coward (1980) concludes that fairly small units are more feasible in terms of cost of organization, effective water delivery and system maintenance, preparation of cropping calendar and plant protection, etc. The group should be, however, large enough to accomplish the distinguished tasks by collective action.

3. ***WUA Linkages/Nested Organization***

Vertical and horizontal integration among WUAs in an irrigation system are vital to make arrangements to share common property resources in an equitable manner. Water users in an irrigation system are interdependent for water and its management process within a watercourse and between the watercourses.

Water wanted in one part of the system might deprive farmers in the other parts. It has been emphasized by several authors of the significance of having federated or system level nested organizations with effective horizontal and vertical linkages (Ostrom and Benjamin, 1991; Wijayaratna, 1992; and Cernea and Meinzen-Dick, 1994). Wijayaratna (1992) wrote that, federated organizations are useful to develop the new skills to enhance the collective bargaining power and to undertake business-oriented activities with economies of scale. This may help to reduce, avoid or remove the outside pressure such as political threat. The latest organizational development trend has gone from the system level to river basin or catchment level organizational development. The river basin water management organizations relegate and allocate water at basin level to different interest groups within the basin/catchment units.

4. ***Mono/Multi-objective Organization***

There is emphasis from social science researchers that irrigation-based WUAs should take water management as a base function, but it is necessary to diversify the organizational activity (Uphoff n.d.; Wijayaratna, 1992; Turral, 1995; and Helmi, 1996). WUA can be involved in the provision of services to farmers such as agrochemical, fertilizer, seed materials, credit, etc. and undertake maintenance and rehabilitation contracts from the line agency, livestock enterprises and fisheries, marketing of agricultural products, operation of farm machinery and so on. The provision of multiple services would in theory strengthen WUAs and assist in their sustainability through the buildup of necessary finance to manage irrigation system as well as organization (Turral, 1995). Therefore, other things being equal, the quality of performance of local organizations appears to be somewhat greater for multifunctional organizations (Uphoff, 1986).

Degree of Members Participation

The participation of all members in the process of decision-making, group activities and resource mobilization are vital for the sustainability of the organization. This has been stated by Bottrall (1985) as; "*for effective cooperation all farmers in a particular water course must be members of the organization and abide by its rules. No one can opt out. As in all forms of co-op organizations, failure by any individual to cooperate with his neighbors will have the effect of undermining discipline and morale on which the associations development depends....*" A key element for the success in the indigenous FMIS as described by Siy (1989) is the mobilization of members' contribution on a regular and equitable basis among all the members.

Quality of the Leadership

To develop and manage a strong viable and functional user organizations it is vital to have strong, sincere and visionary leaders with a long-term program (Uphoff, 1986; and Bautista, *et al*., 1994). The leaders must have the capability to carry out managerial and organizational tasks such as planning, decision-making, resource mobilization and management, communication and conflict management. They should have special skills and experience in water management and strong commitment. Coward (1980) identifies three elements as the basis of the accountability model of irrigation leadership: small scale, local selection and direct compensation by the organization. Leaders often serve for long time; they nevertheless are subject to review and replacement. The choice is always based on their proven capability rather than their wealth or status.

Financial and Technical Capacities of WUA

Finance is an essential ingredient to run the system and to perform entrusted O&M activities. Accounting skills, financial control and auditing are some of the necessary skills required for the organization further to the financial mobilization for the organization. Since farmers are understandably reluctant to part with their money and suspicious about what will happen to it, the organization must follow systematic procedures in financial management and be accountable to the members (Smout, 1990). One of the major reasons for the rise and fall of an organization is quality of financial management.

Farmers' skills and knowledge on technical aspects of irrigation system O&M and the capability of doing the O&M in technically complex large canal irrigation systems should be increased. Therefore, WUA development programs essentially must consists of capacity development component in order increase the technical competency of the farmers.

Organization Communication Mechanism (Internal/External Communication)

A strong organization must have a proper communication network between its members, government officers and other stakeholders to pass messages and WUA decisions. The accountability and transparency for an organization is necessary to shape their performance in direction acceptable to the irrigation group. Methods adopted for the internal communication and organizational transparency plays a key role in this regard. As mentioned by Cernea and Meinzen-Dick (1994), accountability of an organization to the entire memberships not just a subset of farmers is the most crucial principle for long-term viability. Otherwise one cannot expect the farmer's participation by providing their resources, and the organization will be weak without active member participation. The degree of participation for various organizational activities is also determined by the effectiveness of the communication tools used by the organization. Users and officials must have rapid communication access to resolve conflicts effectively among users and between users and officials. This is indispensable for the organizational sustainability (Ostrom and Benjamin, 1991).

Other External Factors

1. ***Land Tenure and Social Divisions***

There are various types of land tenure patterns in irrigation systems such as owner operator, share tenancy, mortgage, lease, etc. The level of incentives and interests of farmers on irrigation system management investment varies between type of land ownership especially between secure tenant group and non-secure tenant group. At the mean time, the degree of cooperation in rural organization also may vary between different castes and social divisions. Therefore, efforts are needed to overcome any negative effects posed by this external dynamism of an organization during the institutional building programs. The catalysts and leadership have big role to neutralize such social issues.

2. ***Political Intervention***

Rural grassroots level institutions can be effectively used by politicians to achieve their political goals. Razaak (1992) noted from Gal Oya Water Management Project in Sri Lanka that, WUA, which were politically neutral, only could perform well in organizational and water management activities. Government commitments, political will, formal supports towards organizational development and farmers self-management and legal backing are necessary conditions for the sustainability of WUAs (Wijayaratna, 1992; and Restrepo and Vermillion, 1994).

3. ***Legal Support***

Opportunistic behavior of users in the irrigation system management was one of the main factors, which caused failure in the past initiatives of organizational development (Carruthers and Morrison, 1994). There are three types of opportunistic activities, namely; free riding, rent seeking and corruption behavior (Ostrom, 1990). These activities validate the argument on the importance of having well-crafted institutional setup to reduce the scope for opportunism. Having a clear legal entity and effective sanctions against rule breakers can substantially reduce opportunistic behavior (Uphoff, 1986; Korten and Siy, 1989; Lonsway and Amadou, 1994; and Bautista, *et al*., 1994). Government has to create necessary conditions and suitable legal reforms to enforce sanctions against opportunistic farmers. In the Philippines, legal recognition of irrigators' association was a precondition for their active collaboration with government in irrigation development (Korten and Siy, 1989). Lonsway and Amadou (1994) view that one of the reasons for the non-realization of viable self-management of irrigation system by WUAs in Niger is non-implementation of prescribed sanctions which provokes a laxity of discipline on the system. The legal framework should be strong and transparent which provides farmer's rights and benefits as well as duties and responsibilities (Meinzen-Dick, *et al*., 1995).

Bureaucratic Reorientation

The main system management is canal irrigation's 'blind spot' where irrigation agency has to play a key role in Participatory Irrigation Management (PIM). An irrigation system as a socio-technical profile requires more than just farmer involvement. The involvement of farmers in the system management will not be fruitful unless main system management is effective and responsive to farmers needs (Bottrall, 1985; and Uphoff, 1986). Coward and Uphoff (1986) noted that in the past, irrigation facilities constructions were often unproductive, irrelevant and extravagant. Getting farmers to take on O&M responsibilities of this nature of facilities may be futile – ditches that are incorrectly located, structures are unnecessary or gates are overly designed. The reasons for the above design faults include professional bias, lack of accountability to beneficiaries, and higher level of corruption and malpractice. This process not only shows the gap between farmers, project implementers and the infrastructure, but also makes farmers passive recipient of benefits. The key to the success in this aspect is closing the gap between bureaucracy and poor poses formidable requirements for the reorientation of the organizational structure and management systems of large public bureaucracy (Wijayaratna, 1992). Line agencies also have to play an important role in developing organizational technical and financial capabilities of WUAs to carry out their tanks effectively.

The level of farmer's involvement in O&M work is also affected by the activities and attitudes of agency staff. The major variables which would affect the farmers are: level of officer's cooperation with farmers; level of willingness of officer to share their authority and power; level of flexibility of officers; how much "credit" that officers would be willing to give farmers for their skills, traditional knowledge and wisdom, etc. The major problem in this is the reluctance of officers to share power, authority and knowledge with farmers. The dominant reason for this situation may be the fear that agencies may loose their clout, power and income. At the same time agencies may have reservations on the capacities of farmers to take over responsibility to operate technically complex irrigation infrastructure.

Merrey (1987) defines correctly how an intervention project should under take bureaucratic reorientation.

> *"A project which includes specific program to reform objectives, philosophy, procedure, incentives or structures of the agency, in order to adapt to working more effectively with farmers' groups and more responsibility to the users' needs is classified as 'institutional building'. A project, which includes minor innovation to upgrade capacity to manage the system without changing the style and methods of management is, classified as 'minimal participation'. A project that include no such efforts, even if there is some technical training to facilitate the physical reconstruction, is classified as 'no participation'".*

Therefore, it is vital to propel the highly technically-oriented, conventional state irrigation agencies into people-oriented and strategic organizations. This process not only necessitates the organizational change, political will and policy guidance from the top; but also changes of norms, perceptions and attitudes of public irrigation staff.

Physical Condition of Irrigation Infrastructure

The physical condition of the irrigation infrastructure has an effect on timeliness and reliable supply of water deliveries, which is the major tangible benefit of farmers for their participation. Unless the systems works and financially manageable, farmers will not be willing to take over management. Thus functional irrigation infrastructure is one of the major factors determine the linkage of main system and farm level management and sustainable irrigation management (Geijer, *et al*., 1996).

Physical condition of irrigation infrastructure should be able to operate and maintained by the user community within the limits of financial and technical capacity. Otherwise farmers have no options other than to neglect the infrastructure, which would lead to deterioration of the system causing serious second-generation problems. Research findings from Mexico, Argentina, Turkey, Colombia and Philippines (Groenfeld and Sun, 1997) indicates that, unless the systems works farmers are not willing to take over management responsibilities. Razaak (1997) mentioned that the irrigation systems, which are rehabilitated before management turnover to WUA, were more successful than deteriorated systems. Samad and Vermillion (1999) observed that, agricultural productivity and returns to land in irrigation systems have improved significantly in Sri Lanka, where both system rehabilitation and management turnover have taken place.

Support Services for Irrigation Systems and Economics of Irrigated Agriculture

Building support from policymakers and all the line agencies is essential for successful user participation. Irrigated agriculture is a chain process with multiple links that need careful knitting in order to obtain best results. Water supply alone is not sufficient for the best results. Consistent services in farm credit, extension, training, supply of quality seeds, farm implements, agro-chemicals, marketing, etc. and cognizance of backward and forward linkages of agricultural policies are essential. The various policies have direct and indirect linkages with degree of farmers' participation and also cooperation with the bureaucracy.

Economics of irrigated agriculture provides incentives for care and management of irrigation facilities. As Korten (1989) correctly pointed out, the key performance measure of irrigation management is Willingness to Pay (WTP) of farmers for the irrigation services. The basic factor affecting the level of WTP for O&M of irrigation system is profit margin obtained from irrigated agriculture. Profit margin also determines the farmers' capacity to mobilize resources for the sustainable maintenance. Sustainable maintenance of irrigation infrastructure required mobilization of adequate resources including cash and kind (Aheeyar, 1999). However, the mobilization of cash and materials towards WUAs is highly dependent on the economics of irrigated agriculture. Therefore, irrigation management component should be adopted as an integrated package with other aspects of irrigated agriculture such as extension, input supply, credit and marketing which influence the farm productivity and income level. There must be parallel programs to solve the farmers' agricultural problems, which hinder the achievement of high productivity and increased income.

CONCLUDING REMARKS

Despite large amount of public investments in development of irrigation infrastructure and considerable amount of money spent to operate and maintain the infrastructure, most of the countries in the world are facing substantial water shortages resulting mainly from mismanagement of water resources. Therefore, sustainable management of water resource is imperative to avoid the envisaged water crisis. PIM and IMT have now become worldwide trends in the irrigation sector development and management. The improvement in the linkages between main system and farm-level management is crucial in joint management.

Main system and farm-level management are interrelated and determined by many interrelated factors. Basically, WUA, as a key player at farm level, has to perform very well in water management, control structure maintenance and organizational management activities.

The strength and viability of WUA is a necessary condition to perform the above tasks. The strength of WUA is determined by the complex multiple factors, mainly quality of leadership, degree of members' participation and approach adopted for WUA formation. In addition, WUA should be normally small in size, based on hydrological boundaries with horizontal and vertical linkages and should be politically neutral. WUA should have strong and transparent legal framework to implement incentives and sanctions.

Bureaucratic reorientation from conventional agencies to people-oriented institutions is essential to improve the linkages and also to mobilize the farmers. The process will necessitate the change of policy from the top level in order to charge the norms, perceptions, attitudes and procedures of public agency and its staff.

An irrigation system is a subsystem of a larger set of agro-economic and socio-political systems. Irrigation water serves as an input of the broader agriculture system. Therefore, irrigation management has to be seen in a holistic manner. It should essentially take into account the backward and forward linkages with agricultural policies, pricing and market interventions to make irrigation sustainable. The holistic approach also ensures the greater output and income from broader system, which provide incentive for the users to mobilize their resources towards irrigation system O&M.

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3. IRRIGATION ASSOCIATIONS AND IMPROVED IRRIGATION PERFORMANCE

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INTRODUCTION

Irrigation management has come to be seen as involving two aspects, made vivid by familiar analogies from the domain of computers where this contrast is easily evident. We talk first about the "*hardware*" of irrigation which includes the full set of *physical structures* that: i) *acquire* water, whether by dams, weirs, pumps of other means; ii) *distribute* water within the command area and among users through channels, canals, control structures and farm gates, and also, to the extent needed; and iii) *drain* water from fields and from the command area (this need is often forgotten).

These structures, very visible and (literally) concrete, are complemented and managed by the "*software*" of irrigation, the organizations with their own *social structure*, which are needed to operate the physical structures that in turn manage the water, which is the lifeblood of irrigation and of the agriculture that it sustains. This 'software' should be seen as having two aspects of its own:

a) *Administrative organizations*, whether public sector, private sector, or user-established, which include roles, rules, precedents and procedures for decision-making and implementation for irrigation, and in particular for *main system management*; and
b) *Water users' associations* (WUAs) or other kinds of farmer groups or irrigation organizations that distribute water among members and handle operation and maintenance at levels below the main system level.

For this seminar to come to grips with improving main system management, we need to get beyond a dichotomous way of thinking ('hardware' vs. 'software') and to consider three components with each critically important and each linked with the other two:

A. Physical Structures – the 'hardware' which reach from main system to user levels;
B. Administrative Organizations – the 'system-level software'; and
C. Water User Associations – the 'user-level software'.

It is impossible to see how physical structures by themselves can lead to productive outcomes, just as neither administrative organizations nor WUAs can succeed without each other and without a well-designed and well-functioning physical system.

This said, however, one can see how administrative organizations, at least in medium-size or large-scale irrigation systems, must play a central role as they are 'between' the physical structures for acquisition and distribution and the water users, occupying a position in the process that is like a fulcrum or pivot.

Other resource papers will address the roles and functions of main system management and its linkages with farm-level management. This paper will focus on WUAs, which operate at the farm level and can be federated into larger organizations. As long as they remain accountable to water users, they differ from administrative organizations in terms of whose interests they are expected to serve. If they are bureaucratic and represent government interests or public interests at large, they become administrative organizations themselves. To understand the roles and contributions of WUAs, we need a suitable analytical framework for thinking about irrigation management in general, encompassing both main system and farm-level management.

THE ELEMENTS OF IRRIGATION MANAGEMENT

Irrigation management can be understood in terms of *three interlocking sets of activities*, each with a different but complementary focus, respectively.

* The *water* used in irrigation;
* The *physical structures* that control that water; and
* The *organizations*, both system-level and farm-level, that control these structures, which control the water.

Water is of course the ultimate focus of irrigation efforts, to get the right amounts at the right time to farmers' fields so that they can *make most productive use of their other resources* – land, labor and capital (this last category includes the investment in seed, which is expected to produce a good crop).

Physical structures are instrumental for getting and applying water, and organizations – either administrative or participatory – are instrumental for managing these physical structures. In Figure 1, we see how these focuses of decision-making and activity converge within a common framework (from Uphoff, 1986).

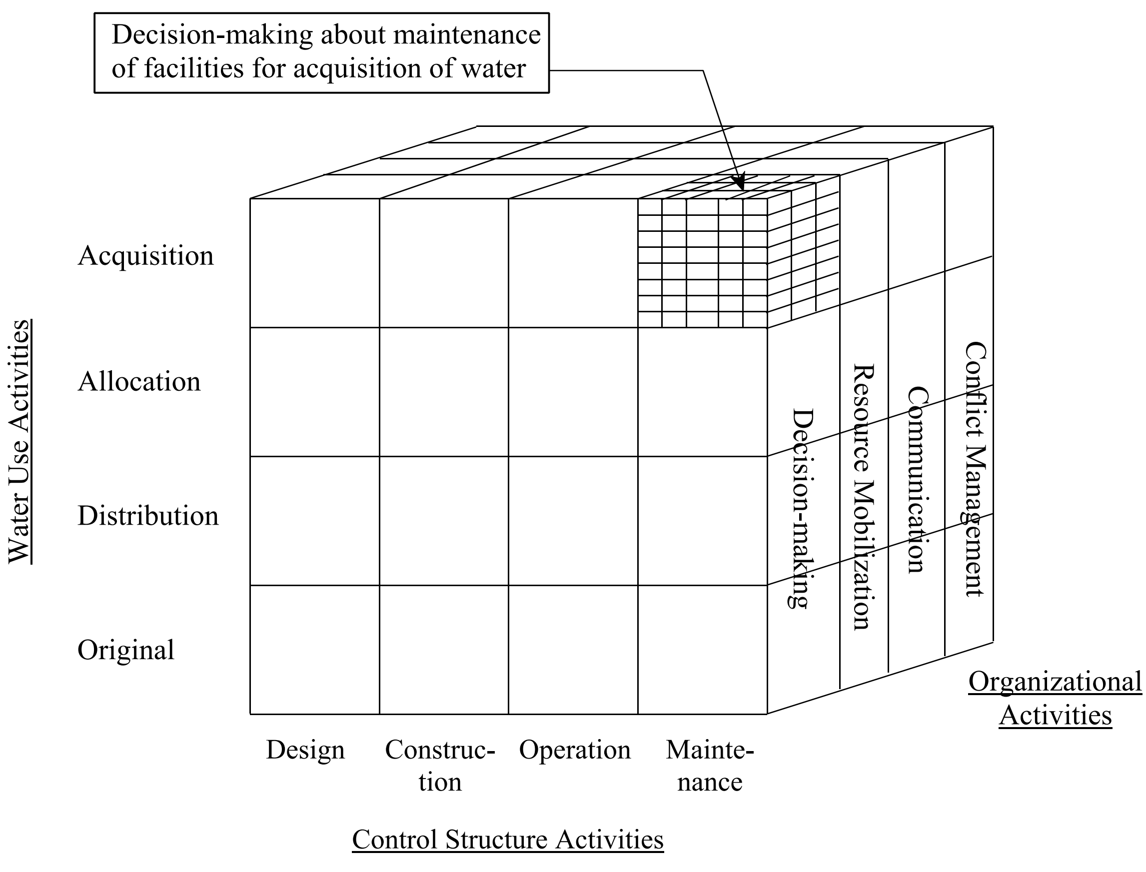

Figure 1. Matrix of Irrigation Management Activities

(Reproduced from Uphoff, 1986)

Coincidentally, one can identify *four* major kinds of activities that are associated with each of these *three* focuses (Uphoff 1986: 37-53). For the first set of activities focused on *water* use, there must be:

i. *acquisition* of water, from surface or sub-surface sources, by creating or operating structures like dams, weirs or wells, or by actions to obtain for users some share of an existing supply;
ii. *allocation* of water by assigning rights to users, thereby determining who shall have access to water;
iii. *distribution* of water brought from the source among users at certain places, in certain amounts, and at certain times; and
iv. *drainage* of water, where this is necessary to remove excess supply.

For the second set of activities focused on *physical structures*, there must be:

i. *design* of structures such as dams or wells to acquire water, channels and gates to distribute it, and drains to remove it;
ii. *construction* of such structures (or implementation in the case of allocation systems) to be able to acquire, distribute and remove water;
iii. *operation* of these structures to acquire, distribute and remove water according to some predetermined plan of allocation; and
iv. *maintenance* of these structures in order to have continued and efficient acquisition, allocation, distribution and removal of water.

All four of these activities apply, in appropriate forms, to all four of the first set of activities. For the third set of activities pertain to the *organizations* that manage irrigation, at any and all levels, there must be:

i. *decision-making* for acquisition, allocation, distribution and/or drainage, to design, construct, operate or maintain physical structures, and regarding any organizational tasks;
ii. *resource mobilization and management*, including the mobilization and application of funds, manpower, materials, information or any other inputs needed;
iii. *communication and coordination* regarding any of the activity areas noted above, conveying information about decisions, resource mobilization, conflicts to be resolved, etc.; and
iv. *conflict resolution*, dealing with differences of interest that arise from activities of acquisition, allocation, distribution, drainage, design, construction, operation, or maintenance, or from any organizational activities.[1]

Each of these four can pertain to any of the 16 combinations of water-related and structure-oriented activities implied by the preceding analysis.

These four organizational activities are equally relevant in the formal and informal domains of irrigation management. No social system functions purely in formal modes; there must be some ways of working that are tacit or implicit, not formally prescribed, and shaped more by tradition and precedent than by explicit, e.g., written prescriptions. One can consider both formal and informal processes for decision-making and for resource mobilization. There can be, and usually are, both formal and informal channels for communication and coordination and conflict resolution. This is as true for administrative organizations as for WUAs, though the proportion of informal activity may be greater in the latter.

Likewise, these four organizational activity areas can apply equally to *intra- and inter-organizational domains*. There can be decision-making within an organization and between organizations, or within a field-channel water user group and between this group and other similar groups or higher-level groups. Resource

[1] These four organizational tasks were determined very inductively from an extensive review of the literature on irrigation management and from experience with irrigation management. We conferred with Robert Chambers who had done the most influential writing to date on main system management and who supported this framework for analysis (personal communication). It turns out that these four basic organizational activities correspond to the general social systems analysis of Talcott Parsons (1951), which has been very influential in sociology. He identified as the four basic functions of all social organization: goal attainment, adaptation, integration, and pattern maintenance. Once the abstraction of these terms is resolved, they correspond almost exactly to decision-making, resource mobilization, communication and coordination, and conflict resolution.

mobilization can be within an organization or between organizations, and the same is true for communication and coordination and for conflict resolution. These four focuses of organizational activity, initially conceived in terms of WUAs, are universal and apply as well for bureaucracies.

THE LEVELS OF IRRIGATION MANAGEMENT

It is common practice to refer to the highest level of an irrigation system, that level at which the whole amount of water available to an irrigation system is allocated and distributed, as the *primary* level. Those levels at which supply has been divided once and is then allocated and distributed within that area is called *secondary*, and so on, to a *tertiary* level, and in large systems, to *quaternary* level. This is a top-down view of the task of irrigation management.

Given that all irrigation systems, large and small, are very similar at the field-level, it has been suggested that we take a bottom-up view in thinking about the management of irrigation according to levels. The quaternary level in a very large system is no different from the primary level in a small system such as found with a simple river diversion source of supply. Both may contain the same area, such as 20 ha and have the same number of farmers, e.g., 15 or 20.

In Figure 2, one can see this similarity visually. What is referred to, as farm-level management is essentially the same in the lowest level of Example IV as in the small system sketched in Example I. The main difference is that in the latter case, there are no higher levels of decision-making, resource mobilization, communication, and conflict resolution to deal with. The complexity of management increases practically by orders of magnitude as one goes to a two-level, three-level or four-level system.

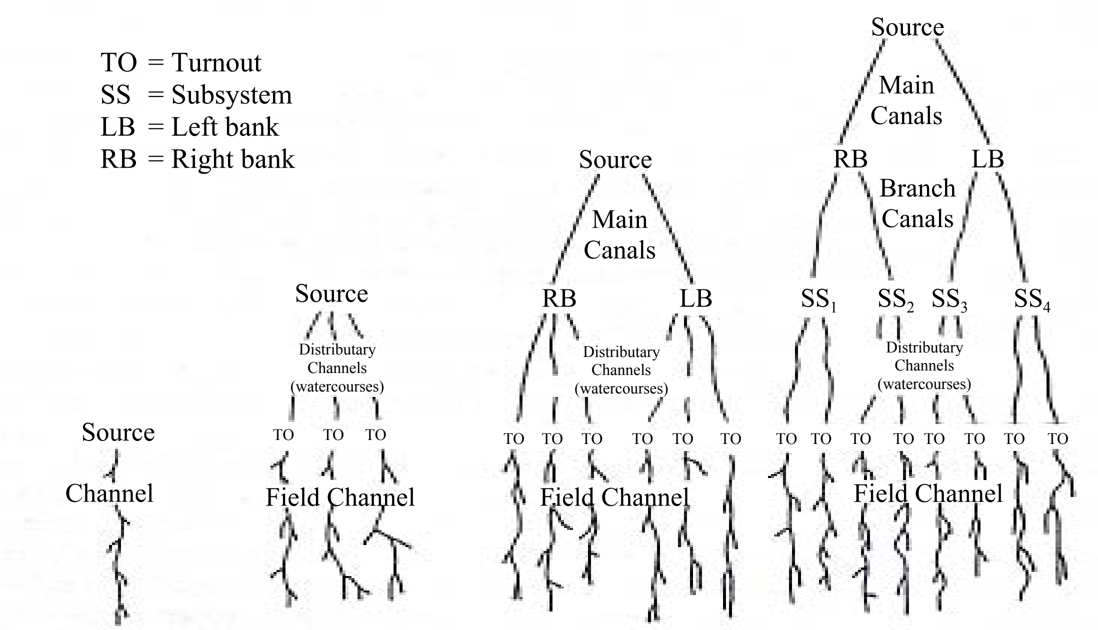

Figure 2. Schematic Comparison of Irrigation System Structures, by Number of Levels of Operation and Possible Organization

Talking about "the primary level" is not very illuminating if one is dealing with irrigation systems of sizes as difference as Examples I and IV. Even the difference between Examples III and IV can be very substantial, since our analysis of a broadly representative set of irrigation system from Asia, Africa and Latin America (Uphoff, 1986: 67-75) found that *one-level systems* have command areas generally under 40 ha. Similarly, the lowest levels in two-, three- or four-level systems usually command an area up to about this size, serving farms directly with water from a single 'field channel' or 'watercourse' (terminology differs).

Two-level systems, or the second level up from the field-channel level that serves farms in larger systems, are usually between 40 and 400 ha, while *three-level systems* of the third level up in larger systems are usually between 400 and 4,000 ha. Beyond 4,000 ha, one is likely be dealing with *four-level systems* or even more complex ones, with possibly five or six levels at which there is some subdivision and allocation of water among subordinate command areas.

The exact size of the command area associated with each level is affected by factors like soil quality, water reliability, and population pressure, so there will obviously be a range of area associated with each level. As noted above, the variation found in each level is more or less an order of magnitude, on other words, a tenfold difference. But one seldom finds a two-level system larger than 400 ha, or a four-level system less than 4,000 ha.

This analysis of levels is introduced here to underscore that "farm-level" irrigation management needs to be viewed in the context of *how many levels* of decision-making, resource mobilization, etc. there are above the field-channel or watercourse level in the irrigation system. At how many levels above this level does one have control and allocation of water? none? one? two? three? The *complexity* of a system in terms of number of levels, not just its absolute size, is important for understanding and improving main system management.

ISSUE OF FEDERATION

With a visualized understanding of the spatial and organizational structure of an irrigation system (Figure 2), the question of federated WUA structures becomes easier to address. The physical facts underlying irrigation water is a homogeneous substance, it is subjected uniformly to the pull of gravity mean that there is a degree of homogeneity within an irrigation system as well as similarity across systems.

Since there are decisions that need to be taken *at each level* within a system, whether by water users or by administrative staff, as well as resource mobilization, and communication and coordination, and invariably some conflict resolution, some kind of federated organizational structure is appropriate.

The term 'water users' association' is ambiguous on matters of structure (levels) or scale (size). To be effective, there need to be decision-making and management capabilities at the lowest level, referred to as the farm level, though in irrigation terms, this means the field-channel or watercourse level, where individual farms are served, simultaneously or in turn, by a common source of water.

One can refer to the user organizations at this level, whether formal or informal, as *water user groups* (WUGs). They are likely to have 10-20 farmer-members according to experience worldwide. If landholdings are larger, the number of members in a WUG will be lower, and if they are smaller, the number will be higher. At the level above this, assuming there are at least two levels, one usually has a WUA formed of representatives from the WUGs, though possibly all farmers served at this distributory canal level will constitute the organization even if they are not often or continuously involved in decision-making, delegating this to representatives.

In larger systems, with three or more levels, these WUAs are usually joined into one or more higher level organizations, perhaps referred to confusingly as "the WUA". Nomenclature is not consistent or standardized in the irrigation sector. But the principle is clear: a structure of organization should be built up where decision-making, resource mobilization and management, communication and coordination, and conflict resolution occur at multiple levels – *and between the various levels* when and as necessary.

Basically the social structure ('software') needs to match the nested command areas created by the physical structures ('hardware') for irrigation management. Possibly there will be no farmer organization at a particular level, but there will then certainly be some administrative person or persons who fill in the need for decision-making, resource mobilization and management, communication and coordination, and conflict resolution *at that level* and jointly with decision-makers, resource mobilizers and managers, communicators and coordinators, and conflict resolvers at levels above and below that particular level.

In a small system with one or two levels, practically all of the functions are likely to be handled by farmers or their chosen representatives. In larger systems, we usually see a sharing of responsibilities. At the lowest and next-to-lowest level, farmers will probably have full or almost full responsibility for these different functions, but at higher levels, this responsibility is delegated to or exercised jointly with administrative staff. Indeed, at the highest level, there may be joint membership in an irrigation management body (council, committee) with farmer-representatives and officials sitting together to deal with the functions that any social organization, and particularly an irrigation management organization, must handle.

IMPROVEMENT IN IRRIGATION PERFORMANCE

The foregoing analysis sets the stage for consideration of how irrigation performance can be improved. The simplest way to do is to focus on *establishing or strengthening a set of roles, rules, procedures and precedents that can carry out the four basic functions*: decision-making, resource mobilization and management, communication and coordination, and conflict resolution – at each and every level. These roles, etc. establish social structure for irrigation management.

This is a general recommendation that captures the most essential elements of irrigation management. One wants irrigation associations (WUAs) to have organizational capabilities (roles, rules, precedents and procedures, supported by appropriate norms, values, attitudes and beliefs) that can enable them to carry out the fundamental functions of any organization. These roles, rules, etc. should not be imposed by some outside agency, though there can be suggestions made, and good examples can be provided.

Membership

The issue of membership is important for the effectiveness of any organization, as Ostrom (1992) has discussed. For irrigation management it is essential to have inclusive membership, where all water users are participating in the decision-making, resource mobilization, etc., either directly or indirectly through chosen representatives. In irrigation it is possible, even easy, to know at least in principle, who all the potential members are. This contrasts with many other sectors of rural development and natural resource management, particularly with forest management where users are quite mobile and anyone can join this category, whether legally or not. In irrigation, where water use is related to land, a non-mobile resource, it should be clear in principle who should be included in any WUA.

This statement needs to be qualified in two directions. Possibly some or many irrigation water users are not landowners but instead are either hired laborers or sharecropping tenants who have no legal rights to the land. Often, WUA membership is restricted to landowners as persons having a permanent interest in the land and water resources, not a transient interest. In this case, decisions might be made by persons (landowners) other than those who would implement them (tenants), or resource mobilization for creating permanent assets might be expected from persons with no long-term stake in them.

Membership can be one of the most vexing issues for WUAs. It can be further complicated when some water users have no rights to receive water, such as encroachers cultivating in reserved areas alongside canals or in drainage areas, but take water anyway. Their actions can interfere with water distribution schedules or at least with system maintenance. Where the number of unauthorized water users is noticeable, some way needs to be found to include them within the operational scope of WUAs since their actions can subvert WUA decisions and are often a source of conflict within irrigation systems.

Boundaries

Given the nature of the irrigation enterprise, governed always to some extent by the forces and limits of gravity, attention has to be paid to the geographic boundaries of WUAs. The physical structure seen in Figure 2 indicates that command areas at the different levels are nested within each other. Often, however, there are administrative or political boundaries that do not correspond to the hydrological boundaries set by physical structures and the upstream-downstream relations established by gravity.

It is very important that the units for decision-making and for communication and coordination reflect hydrological units. It is possible that resource mobilization and management and also conflict resolution could be undertaken by units crossing hydrological lines, but it is best that all four functions be matched within the same organizations, whether administrative bodies or WUAs. An Irrigation Department (ID) is almost always structured organizationally to correspond to hydrological units, except at district level where the larger administrative unit may not match any irrigation system boundaries.

One can find that ID subdivisions do not match administrative boundaries for this reason, as in Sri Lanka where administrative units called "ranges" were created as alternatives to districts because the latter were not meaningful for irrigation management when irrigation scheme boundaries did not conform to those of districts. Even then, one can have large irrigation schemes such as Gal Oya that cross-district boundaries and create problems for management even if the ID units correspond to hydrological units. The boundaries of WUAs need to follow hydrological boundaries as much as possible, with a strong burden of proof laid on any deviations from this principle.

Accountability

Irrigation management is often considered essentially an administrative matter, one from which all "politics" should be systematically excluded. While there are good reasons to keep all partisan politics out of irrigation management, when a scarce resource is being allocated, it is important that a high degree of consensus is created to support the process. This requires opportunities for all affected by decisions to have some input to them and cooperate in carrying out the resulting decisions. Hence, there is a need for a system of accountability if not one with all the formal trappings of governance.

We have found that formal processes of election and voting on motions can become divisive and create conflicts where different processes oriented toward reaching consensus would produce more amicable and efficient, as well as equitable, outcomes. In the Gal Oya experience in Sri Lanka (Uphoff, 1996; and Wijayaratna and Uphoff, 1997), an initial proposal to choose farmer-representatives by elections, indeed by secret ballot, was superseded by a process of selecting farmer-representatives by consensus, after an open discussion of the qualities that members wanted in a representative (Uphoff, 1996: 334-336).

At the field-channel level, this proved to be superior to what could have been achieved by elections. At higher levels, where interests and acquaintances were more heterogeneous, the option of elections was maintained, but seldom used, as farmers sought to develop and maintain broad and deep agreement on what should be achieved through their organizations. Leadership sought to realize this consensus, not to pursue an agenda that was not widely supported.

There are situations in which farmers may not find it worth their while to invest much effort in the tasks of WUAs. There is some empirical evidence to support the proposition that participation will be most desirable and effective in some middle range of water availability (Uphoff, *et al*., 1990). When water is abundant, there is no need to conserve it; thus investments of time and energy in its management give little return and farmers are reluctant to bear the costs of organization.

At the other extreme of water scarcity, at best there is a simple rationing system, with little gain from trying to adjust water deliveries to achieve some optimizing results; in such a situation, participation gives little payoff and farmers might as well have some kind of executive authority implementing a system of fixed distribution, hoping for as much equity as possible. Democratic processes are more likely to create conflict and division than to reduce them, so they are less desirable than where such processes can achieve productive gains through cooperation, more likely when water is neither very scarce nor very abundant.[2]

Enforcement and Formal Powers

It is important that all members expect that decisions reached will be carried out, quickly and fairly. The process by which decisions are arrived at is important to their implementation. Where there has been open discussion and broad participation, direct or indirect, in decision-making, followed by broad participation in resource mobilization, communication and conflict resolution, decisions become almost self-enforcing.

At the same time, it is important that such processes, often mostly informal, for decision-making, etc. be backed up by some formal powers and sanctions. A lack of formal channels and procedures makes it more tempting for individuals who are inclined to assert their interests over those of other water users, making water distribution a zero-sum or negative-sum enterprise rather than a positive-sum one, to do so. This indicates that some combination of formal and informal processes will be optimal for the effective operation of WUAs.

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[2] One limitation on this latter conclusion is that cooperation could be engaged in to increase the supply of water, through investments in facilities or through collective action that acquires water illicitly (see Uphoff, *et al*., 1990).

This said, I would add a personal view based on our experience in the Gal Oya Irrigation Scheme. When introducing WUAs, rather than begin with the formal establishment of organizations, it may be better in terms of effectiveness and long-term sustainability to start with informal organizations. Field-channel groups are small enough and undertake those kinds of activities so that informal groupings are quite appropriate. Such an approach ensures that the new roles and associated rules, procedures and precedents are voluntary, assented to by all, and also "owned" by all. Rather than provide water users with a "supply" of organization, it seems preferable to build up the "demand" for such organization, through demonstrated benefits and good performance.

Those farmers who might be tempted to seek office for the sake of power and personal benefits have little opportunity to gain from an informal organization because if it is not meeting members' needs, they can easily withdraw their contributions and cooperation. On the other hand, those farmers who have shown skills and commitment when the organization operated on a purely voluntary basis are most likely to be selected as officers when an informal organization becomes formally established. Thus the kind of persons who are attracted to leadership positions will be different, and more beneficial, if the process of WUA formation is not driven from outside.

Creating WUAs by getting a constitution approved by a group of new members and having them elect officers is the conventional way to proceed. Our approach in Gal Oya was to "work first, organize second", assisting informal WUAs to operate in a problem-solving mode for three or six months, or even longer, until members felt they would benefit from some more formal organizational structure. This has led to organizations that have retained their effectiveness for over 20 years (Uphoff and Wijayaratna, 2000).

Alternative Approaches

In general, it is tempting to focus on the design and introduction of WUA roles, rules, precedents and procedures for improving irrigation management, things that I would characterize as "structural" because they relate to observable aspects of social relations and social organization. These things represent structural forms of social capital as discussed in Uphoff (2000) and elaborated with regard to irrigation management in Uphoff (2002b). These aspects of organization – roles, rules, precedents and procedures – are important for giving visibility and stability to WUAs.

However, my experience with introducing WUAs – into one of the most difficult and most poorly managed irrigation schemes in Sri Lanka, according to official assessments (Uphoff, 1996) – suggests that at least equal attention and support should be given to the "normative" dimensions of WUAs, to what can be described as the "cognitive" side of social capital. It is important that this "soft" side of WUA "software" be strengthened for best results. This aspect has been discussed at greater length in Uphoff (2002a).

Perhaps most important is the process approach taken. It is critical that the establishment or support of WUAs not be undertaken in a top-down manner, which Korten (1980) describes as a "blueprint" approach. Rather, a "learning process" approach is more likely to lead to the kind of organizational capacities that are effective, efficient and sustainable (Uphoff, *et al*., 1998: 19-44).

Achieving the Best Irrigation Performance Results

To summarize them, to get improvements in irrigation management, one wants to achieve *higher productivity* from available irrigation water, including also an *equitable distribution of benefits* and a *sustainable system of management* that is both low-cost and effective. One could try to achieve such results mostly through better main system management placed in the hands of an administrative organization, whether a government ID, a private company, or a farmer-owned company or cooperative. But such a result is unlikely.

There is need for water users to cooperate in carrying out any decisions, in mobilizing resources to help pay for the system's management, in sharing information, and in minimizing the conflicts that can undermine the social fabric and even the physical structures essential for good irrigation system performance. This requires more than main system management; there needs to be many effective *connections with and among water users*. For this, irrigation organizations play an indispensable role, *assuming some of the responsibilities* that must otherwise be discharged by administrative personnel, or *assisting in carrying out these responsibilities* in an organizational setup of joint or shared management.

In this paper, I do not go into the evidence that such systems of joint or shared management if resting on a firm institutional base of WUAs starting at the field-channel level and building upwards to a federated structure, including both farmer-representatives and officials, can be very effective, substantially improving main system management. This has been reviewed cross-nationally in Uphoff (1986) and is dramatically and clearly seen in the case of the Gal Oya Irrigation Scheme in Sri Lanka (see Uphoff, 1996; Wijayaratna and Uphoff, 1997; Amarasinghe, *et al*., 1998; and Uphoff and Wijayaratna, 2000). The experience in that scheme led to participatory irrigation management becoming a national policy for Sri Lanka (Brewer, 1994).

This paper has provided some analytical frameworks for thinking about irrigation organizations within the context of main system management for improving irrigation performance. It has also addressed key issues such as membership, boundaries, accountability, and enforcement, also outlining some of the approaches to creating WUA capacity for improving management. This is a large subject and one, which needs to have empirical foundations as well as analytical clarity and consistency. This is why the seminar participants contributing country experiences to the discussions. The intention of this resource paper was to help synthesize particular learning into broader themes for more general consideration and possible application.

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4. SUSTAINABLE IRRIGATION DEVELOPMENT

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INTRODUCTION

This paper explores the issues that face irrigation in the future, drawing on recent experiences in Asia and elsewhere to illustrate some cases where interventions have fallen short of sustainable development targets. The paper argues that sustainable development is often misinterpreted and that incremental development is a more realistic model to achieve the objectives of sustainability and poverty alleviation. In the paper the focus is on irrigation as a means of achieving food security. However, effective utilization of water to achieve high productivity is a major objective, and this is now widely recognized to include enhanced rainfed agriculture and agricultural system. Therefore, the boundaries between rainfed and irrigated agriculture are becoming increasingly blurred requiring practitioners in agricultural development to have a broader perspective. The use of sustainable livelihood concepts has also changed the development canvas by bringing the analysis of the entire socioeconomic setting into focus.

Background

The world's food production has more than doubled over the last four decades outpacing population growth, surely a remarkable achievement. But there remains unfinished business in the provision of household food security. In spite of global abundance of food, malnutrition persists in several parts of the world.

The growth rate of the world's food production, although declining by 0.4 percent in the 1990s, still substantially outpaces the growth in population. This is especially true in the developing countries where food production increased 3.4 percent annually, exceeding the annual population growth of 1.5 percent in the 1990s. Increased food availability has helped increase the per capita consumption further at the global level.

However, there remains an imbalance between cereal production and exports from developed countries and cereal deficits and imports to developing countries. The cereal production surplus (production minus consumption) in the developed countries has increased from 11 percent of the total consumption in 1990 to 15 percent of the total consumption in 1999. Increased production in the developing countries during the 1990s was sufficient to keep their cereal production deficit in 1999 at the same level as the production deficit in 1990.

Increases in irrigated areas during the 1990s occurred mostly in developing countries where more than half the net irrigated area development was in China and India (Table 1). Private investments, largely in groundwater development, have contributed to most of the growth in net irrigated area in India and China in recent years.

More than two-thirds of the total cereal production in India is from irrigation (IWMI, 2001) and about two-thirds of that is from tube-well irrigation. In China, tube-well irrigated areas have increased rapidly, accounting for about 26 percent of the actual irrigated area between 1985 and 1995 (FAO 2000). Estimates show that over 60 percent of total cereal production in China is from irrigation and a substantial proportion of this is due to irrigation from groundwater.

Table 1. Net Irrigated Area Growth

Year	World		Developed Countries		Developing Countries	
	Total (million ha)	Annual Growth (percent)	Total (million ha)	Annual Growth (percent)	Total (million ha)	Annual Growth (percent)
1961	140	-	38	-	102	-
1990	242	1.9	65	1.9	177	1.9
1997	266	0.9	66	0.1	200	1.2

With increased groundwater development, there is a growing concern that declining groundwater tables and increased salinity in irrigated areas will affect future expansion of food production possibilities. For example, a large proportion (60-70 percent) of the total cereal production in India is in states, which are operating above or at the full potential level for sustainable groundwater use. Much of the area in the North China plain's breadbasket is threatened by groundwater depletion. These are indications that future food security in India and China will primarily depend on how their surface water and groundwater irrigation is managed. A similar picture is emerging in Pakistan.

In which case how has the irrigation sector faired so far as a foundation for sustainable development? It is generally accepted that about 40 percent of the worlds food production is obtained from only 17 percent of the agricultural area due to the yield increases made possible by irrigation. However, it is also clear that there have been many cases where irrigation development and management interventions have not achieved the sustainable increases in productivity and improvements in rural livelihoods expected.

SUSTAINABLE OR INCREMENTAL DEVELOPMENT

Although the title of this paper is Sustainable Irrigation Development, the focus on sustainability has misguided the water sector in recent years. This is partly because sustainability has not been adequately defined. Is an intervention that continues to have impacts for 20 years sustainable or is it sustainable only when the impacts last 50, 100, or 1,000 years? In some cases sustainable development is said to have been achieved when infrastructure continues to be maintained at or close to the design conditions. However, this does not recognize that the requirements placed on the infrastructure may have changed dramatically and maintaining the *status quo* is actually restricting rather than promoting development.

When we focus on the sustainability of a project, the longer-term objectives of development can become lost in the need to justify the interventions and investments made. Yet if we focus on sustainable improvement of people's livelihoods, which implies more than just increasing agricultural and/or water-productivity but includes minimizing disruption to the environment and society, then the success (or sustainability) of irrigation interventions can be measured in terms of the contribution made to improving livelihoods.

Rice has been cultivated in Asia for a long time, extending over thousands of years. Can we consider that this system of agriculture is sustainable? I believe we can, but we must not be misled into believing that rice cultivation now is unchanged from that practiced a thousand or even a hundred years ago. For example, rice cultivation is important in Japan and Sri Lanka, for both food security and cultural reasons. And yet, in the majority of cases, the traditional forms of cultivation are becoming impractical for farmers if they are to feed and clothe their families. Farmers have changed their practices, adopting new technologies and in many cases, in Japan, becoming part-time farmers in order to adapt to the realities of the socioeconomic conditions in which they live. Farmers and society respond flexibly to changing circumstances, leading to what we can consider as sustainable. But these changes are often slow with longer time frames than development projects that seek to make changes in relatively short periods of 3-5 years.

If we look at the large irrigation schemes of North India and Pakistan, developed during the 18th century and now with about 150 years of operational experience do we see a sustainable system of irrigation? Well it is certainly true that the semiarid regions of the Indo-Gangetic plain have been a major source of food and fiber production that has sustained the economic development of the region. However, the management of the supply-based irrigation systems implemented during the 18th century has continued to develop and change as the aspirations and opportunities for the population have changed.

While the large-scale surface irrigation distribution system is still in place, and broadly functions as originally intended distributing a scarce water resource as equitably as possible, the role of groundwater has grown dramatically over the past 20-30 years providing a farmer-controlled water resources allowing for crop intensification and diversification. Groundwater development initially released farmers from the constraints imposed by restricted surface water resources and also helped control the elevated groundwater tables that had resulted from over 100 years of irrigation and increasing impeded drainage due to road, railways and other developments. However, in recent year's rapidly falling groundwater tables, resulting from unregulated exploitation is threatening the high levels of production achieved under the conjunctive use of surface and groundwater. Furthermore, the extraction of poor quality groundwater has resulted in increased soil salinity in many areas – severely reducing productive potential and requiring remedial action to keep the lands in production. What those changes will be is perhaps uncertain at present, but the search for solutions continues.

So, although each of the interventions made at various times in the management of water for agriculture are done with the objective of achieving sustainable increases in production, in reality sustainability is achieved by continuous changes in management and infrastructure designs. It is by being flexible and responding to changing conditions and opportunities that agricultural production can be maintained and rural livelihoods can be sustained and improved. In many cases the interventions are, in themselves, not sustainable but rather a stepping-stone that helps the transition from one form of management to another.

Often the conditions in which development interventions are made are not static. This is ever more the case – the impacts of WTO on local economies and sectors are not yet clear. But the long gestation times for some projects certainly mean that the interventions are addressing a situation that may well be significantly changed from when the project was appraised and approved.

The logical framework form of project design does provide a mechanism to enable the redefinition of project components. In this form of project management the goals and outcomes of a set of intervention are defined in both the short and longer term. A set of activities and outputs are defined to achieve the outcomes that are, with a number of assumptions, expected to lead to achieving the overall goal. Should the assumptions about external conditions change, the project activities can, in principle, be changed to address these changes. By focusing on the longer-term objectives and defined goals, short-term planning can be better focused towards interventions that move the irrigation sector towards achieving those goals in the actual socioeconomic environment in which the targeted community operates.

Incremental improvements and development of system infrastructure, management methods and cropping systems will be more likely to be accepted and maintained rather than major changes forced onto the community within the project timescale.

IRRIGATION DEVELOPMENT – SOME RECENT EXPERIENCES

This section presents examples from irrigation developments and management interventions observed in a range of countries in Asia and Africa. At each site the interventions were intended to provide the basis for sustainable increases in food production aimed at improving the socioeconomic status of the local farming population. And in each case, although the objectives were achieved to some greater or lesser extent, changing socioeconomic, agro-hydrology, or institutional settings made the interventions as designed less sustainable than envisaged when the interventions were designed. In some cases the interventions implemented were inappropriate and effectively doomed to fail, however in some the design was appropriate for the time but circumstances changed. Further changes to the design and/or operational objectives were required to achieve the, revised, targeted impacts.

Observations are from large- and small-scale irrigation systems in many different countries and are based on personal experience. For this discussion green-field development of new irrigation schemes and rehabilitation or management interventions are taken as development. Interventions designed as a "blueprint" almost inevitably will miss important constraints that become evident during and after the original interventions are implemented. The case studies are used to illustrate, how assumptions made during design of an intervention often fail to address the full range of conditions in which the intervention will ultimately operate and how an incremental strategy may be more appropriate model for development.

Irrigation Development Ignoring Local Practices

In many parts of Asia there are long traditions and experience of irrigation development and management. These are often small-scale systems based on *ad hoc* diversion structures, from small or large watercourses, constructed by the farmers benefiting from supplies from the diversion. These structures may be simple brush weirs to more substantial stone and rock barriers diverting available flows into earth canals, distributing to areas of a few hectares to many hundreds. There is often little in the way of formal regulation of the intake, although the sharing of water between farmers within the system may be policed rigorously to ensure the locally accepted concept of equity is maintained. Although water diversions from the channel may exceed crop water requirements during much of the season, the excess water returns to the river system and is captured by similar structures and farmer groups downstream.

While the irrigation service provided may be perfectly adequate and satisfactory to the community served, the structures and distribution system frequently do not match the perceptions of engineers and development agencies of what “modern irrigation” is supposed to be. In the case considered here about 20 of these informal weirs and small distribution networks were replaced with a large concrete weir upstream of the first structure. Two long distribution canals, with gated turnouts to serve the former irrigated areas were constructed high on the ridge with potential to bring more land into irrigation. Well-designed sediment traps were constructed in the head-reaches of the distribution canals to simplify operations and to reduce maintenance requirements for the benefitted communities.

Construction of the new infrastructure was a mix of contractors and volunteer labor. The contractors also obtained labor from the local communities in return for payments, contributing to short-term increases in income.

Following construction the new diversion structure and distribution system was put into operation and the existing local weirs abandoned. Irrigation diversions and security of supply were improved and labor requirements for reconstruction of the local weirs after the frequent flash floods were reduced.

Yet within two seasons the majority of local weirs were back in operation and the large weir upstream was serving a fraction of the intended area. Why?

Farmers in the area were used to diverting water in excess of their requirements, and allowing the excess to return to the river. The new distribution canal meant that once water was diverted from the river and applied to the first few fields, there was insufficient water remaining in the canal to serve the lower users. However, flows in the lower reaches of the river remained largely unchanged from the conditions before the project so farmers simply reverted to the tried and trusted practices.

Would it have been possible to change farmers’ practices to achieve more effective use of the infrastructure? Possibly, however this would inevitably require farmers to spend more effort in supervision of field irrigation that would detract from opportunities for alternate productive activities. Furthermore, increasing the effectiveness of the distribution would require greater cooperation between multiple village communities served by the canals, rather than in the local groups served by the local weirs. Thus achieving the project objectives of improving irrigation distribution and apparent productivity would potentially reduce farmers’ potential income; and possibly leading to greater conflicts between villages served by the new infrastructure.

In the subsequent developments by the same agency in similar conditions elsewhere in the country greater attention was paid to the traditional irrigation practices. Rather than replacing traditional weirs with a single concrete structure, lower cost gabion structures were used to improve the existing structures. The construction was within the capacity of the local community, the existing irrigation practices were maintained maintenance was reduced and farmers gained opportunities to increase their livelihood activities. Thus adapting proposed interventions to the local conditions and management capacities led to achieving the development goals where less well-tuned interventions failed.

Mismatch of Technology and Management Capacity

In this case a development agency was requested to assist a medium-sized irrigation scheme (about 5,000 ha) planned and partially developed 20 years previously to secure a reliable water supply and to expand from the existing 3,000 ha service area to the intended 5,000 ha. When initially planned and developed, the supply was obtained from a diversion weir constructed some 15 km upstream of the command area and delivered by a transfer canal. A flood destroyed the original weir within a few years of construction. Informal diversions from the river provided restricted supplies to the lower parts of the command area, however these were erratic and required frequent reconstruction of the in-river brush and rock weirs.

The command area is close to an international boundary, making the development of the area a high priority for the national government in order to attract the support of the local population. Consultants were appointed to design a new water intake and to redesign the distribution and management system for the scheme. The country had begun a program of management transfer and therefore the post-project responsibility for Operations and Maintenance (O&M) was to be adopted by the farmers. This transfer of responsibility was to be achieved by organization of the farmers into water user organizations at field canal level, with these organizations federated to scheme level for overall O&M.

The chosen water supply was by multiple electric pumps in a pump-house located on the outside of a river bend, approximately one-third of the distance down the main canal. New high and low level transfer canals were constructed from the new pump-house to the main canal. Water was to be divided between the upper canal reaches, in which the direction of flow was to be reversed, and the lower reaches served by the low-level canal. The river has a high sediment load, particularly during the monsoon season and therefore a complicated arrangement of sedimentation tanks were constructed immediately downstream of the pump-house to capture sediment for flushing back to the river. Flushing of sediments to the river would require operation of the pumps.

In an attempt to match the operations of the distribution system to the management capacity of the farmer groups expected to take over full O&M responsibility a form of variable proportional distribution was introduced in the main and distributary canals and to turn outs to field units. This approach is broadly similar to that adopted in other more traditional, farmer-managed systems upstream in the same catchment although the technology adopted in the weir structures in the case study scheme was considerably more “high-tech” than elsewhere in the country. At the case study scheme the weirs being prefabricated steel units with drop-gates of different widths to achieve the required range of flow rates.

To help the farmer organizations manage the distribution system effectively the consultants provided a computer-based irrigation-scheduling model that computed irrigation water requirements at each offtake for each irrigation delivery. A monitoring module with associated field observations, again nominally to be implemented by the farmer organizations, was provided to help the organization bill users for water supplies. Accurate estimation of demand and delivery was an important management concern given the intention the farmer organization would be paying full operations costs for the pump-house.

During the development phase of the project a mid-term review identified a number of existing and potential problems with the interventions being implemented. These included concerns about:

1. ***Performance of the Installed Pumps***

In the first few months of operation each of the pumps had shed impeller blades frequently requiring the pump-house operators to shut the pump down, drain the pump well, retrieve the shed blades, rework the mountings and rebuild the pump. This was resulting in pump down times of over 15 percent seriously reducing the water availability to the scheme. The warranty period was over before the pumps became operational and the manufacturer was understood to be in liquidation. Fortunately a renowned electro-mechanical workshop is located in the district capital about 30 km away and a service agreement could be negotiated between the farmer organization and the workshop. The funding agency provided a subsidy for the first five years of operations to enable the farmer organization to build up a cash reserve to cover unscheduled maintenance costs.

2. ***Availability of Water During Critical Periods of the Dry Season***

Water levels during the dry season fell close to the minimum operating level of the pumps in most years, restricting the capacity and increasing pumping costs. The supply to the full-expanded command area was rejected due to concerns over water availability.

3. ***Costs of Desilting the Sediment Basins***

Although designed for hydraulic flushing the costs of operating the pumps for this task was considered to be too great for the farmer organization to consider. This proved to be the case very soon after the farmers took over operations and realized the full cost of operations.

4. ***Reliability of Water Supply***

The electrical supply to the relatively remote area was subject to frequent "blackouts" and "brownouts" resulting in the pumps tripping offline and thus interrupting water supplies. Furthermore, the continued problems with the pump impellers also resulted in frequent supply interruptions.

5. ***Sustainability and Capacity of Water User Organizations***

These had been established in most turnout service areas and the system level federation was observed to be working effectively with the project implementation consultants. However considerable doubt was felt about the capacity of the organization to take over the O&M duties after project completion. Also the federated body was largely dependent on the initiative of one highly motivated farmer who had taken a lead from early in the project, few others demonstrated his commitment to the project goals or grasp of the responsibilities to be shouldered.

6. ***Computer Software and Hardware***

No one in the farmer organizations had received any form of training in the use of the software. Also the software was in English and, although local language interfaces were available, no attempt had been made to tailor the software to the local capacity. The sustainability of the hardware in the harsh environment in the remote location, the nearest computer service center was over 20 km distant, was thought to be unlikely.

7. ***Practicality of the Drop-Gates and Proportional Weirs***

Although similar in principle to local practice, the formalized scheduling intended in the design of the system was not adhered to even during the development phase whilst the design consultants were still on-site. Farmers in the lower zone quickly established a more or less equitable distribution by removing gates during periods of shortage and replacing them with rocks and sticks when surplus water was in the canal. However some locally powerful landlords and political elite secured preferential supplies by damaging the weirs to by pass the proportioning system.

Following the completion of the development phase, during which of the problems described above were addressed the system O&M was turned over to the farmer organization. The computer-based scheduling and monitoring system was abandoned; water charges continued to be based on cropped area rather than water use; problems with electrical and mechanical reliability at the pump-house continued to cause supply problems; and the farmer organization reduced pump operational hours to minimize power costs. The farmer organization failed to develop a cash reserve and the maintenance agreement with the workshop is understood to have lapsed when external support was withdrawn. When desilting is required the farmer organization mobilizes farmers served by the pump-house to help remove the silt from the basins.

The designed intervention did not match either the physical conditions or the management capacity of the organization expected to take over the O&M of the scheme. Therefore the interventions proved to be unsustainable, although the scheme continues to operate but with a command area below that expected and with less reliable supplies than intended.

Mismatches between Technology, Hydrology and Supporting Infrastructure

This case study is about green-field development of new irrigation infrastructure where the chosen technology did not match the agro-hydrological conditions encountered. The feasibility study, executed over 40 years ago, focused on bringing reliable irrigation to a new command area of over 10,000 ha to be supplied from a cross-river barrage on one of the countries major rivers. Construction of a pilot area, in excess of 40,000 ha, started in the late 1950s and became operational in the 1960s. A major pumping station provided water supply by lifting into the main canal system at the proposed weir site. The distribution infrastructure was designed for automatic downstream control, enabling users to draw water as required.

Within a short period of beginning irrigation in the pilot area it became clear that serious problems existed with the downstream control. Specifically, power supply to the electric pumps in the main pump station was erratic resulting in frequent water supply interruptions. When water supply was cutoff the canal regulator gates responded automatically by opening to match supply with the downstream demands. Thus left influential farmers in the upper reaches out of command. Shortly after these initial experiences, the downstream regulators to distributary canals from the main canal were removed and replaced with manually operated sluice gates. The automatically operated main canal cross-regulators were modified to convert each from downstream control to manually operated upstream control gates. Operation of the distribution system was therefore converted from an automatic system to one requiring 24-hour supervision in the main canal and daily attendance in the distributary canals.

Development of the balance 70,000 ha proceeded on the basis of traditional upstream, manually controlled, regulators still dependent on the pump-house for water supply. Power supplies remain erratic causing frequent water supply breaks, making difficult for operators to regulate distribution and for farmers to plan field irrigation.

However, by the 1980s, the full 120,000 ha was being irrigated during the monsoon season, and approximately 50-60,000 ha during the dry season due to the restriction on pumping capacity resulting from low water levels in the river. Plans to construct a diversion weir in the river had been abandoned due to cost and other considerations, including disputes with other riparian water users. In common with many irrigation departments in other countries, the agency was undergoing reforms to reduce the number of publicly funded staff and to transfer more responsibility for system O&M to the farmers. However, although numerous water user groups were formed at tertiary canal level, little success was achieved in formal transfer of O&M responsibility at distributary level, even though reductions in agency staff meant that the farmers were in *de facto* control. Recovery of O&M costs from the farmers, partly due to the use of water charges as an "election winner", and partly due to the poor service levels achieved by the system.

The command area had a high potential for groundwater extraction, no formal strategy had been established and farmers were discouraged from private developments which limited the cropping intensity to about 150 percent, rather than approaching 200 percent which would be feasible with groundwater use in the dry season.

The scheme has made a great contribution to improving the livelihoods of the rural population in the command area and in the towns and villages of the districts. However, the objectives of providing a demand responsive irrigation service could not be achieved, even at pilot scale, firstly because the electrical supply was too unreliable to enable supplies to match demands – the supporting infrastructure was not adequate for the task. Secondly, although power supplies were improved in the early 1990s, the changed hydrological conditions in the river, due to upstream developments, restricted water availability during the critical dry season months. Thirdly, a policy of restricting groundwater development in the command area left the farmers exposed to the unreliable water supplies from the main river source, which restricted the cultivation of alternate, higher value crops.

LESSONS FOR THE FUTURE

What lessons can we take from these three case studies? These were selected from a number of similar cases that differ in location and in specifics but which show broadly similar characteristics. Interventions are designed with sustainability of impact in mind, but which frequently do not capture the full dimension of the problem being addressed. As a result the interventions have to be revised, either during the period of implementation or afterwards.

Where the agencies, implementers and beneficiaries are able to respond to the changing circumstances during and after the development initiative then sustainable impacts can be achieved. However, where the project package is taken as a blueprint, to be inflexibly applied, the potential for sustainable impacts are greatly reduced.

The need for flexible response to changing circumstances and demands is widely recognized in many commercial fields. In the past, product development was based on a careful analysis of markets, production levels and product characteristic, which led to tightly defined life cycles. However the demands of rapidly changing markets and technologies have made flexible development models essential resulting in incremental product development strategies becoming widely adopted.

It is clearly not practical to adopt a rapid prototype and application development strategy, such used in the software industry, for the construction of reservoirs irrigation systems, the investment and development times are too great. However, for many other elements in irrigation and rural development, there are useful parallels where the approaches being adopted to reduce development times in industry can be used in the development and management of the irrigation sector.

Specifically, the definition of short-, medium- and long-term goals for the agriculture and irrigation in a country provide a framework for the sectors to work towards achieving. Individual development initiatives can be designed to address the short- and medium-term objectives, recognizing that short-term objectives will change quite frequently. When designing an intervention the objectives are to identify which initiatives will contribute the greatest amount towards achieving the long-term objectives, thus focusing what are increasingly restricted development budgets on the interventions with the greatest return.

A good example is the use of asset management plans for irrigation systems. Rather than using available annual maintenance funds to maintain the system in the design conditions, a proportion of the funds are set aside each year for incremental replacing infrastructure to enable the adoption of different management strategies, examples include:

* changing from open channels to pipelines to reduce seepage losses;
* encouraging farmers to adopt higher technology application systems to reduce water use; and
* introducing automated control of remote structures to improve service delivery to users.

In a traditional project-oriented management system, these changes would require a specific, often externally financed project. However, by setting a goal of reducing water use by some specified amount over a specified time allows system managers to prioritize the use of available funds to achieve those goals through better-targeted maintenance and replacement-planning. Where external funds become available these can be included into the long-term plans without disrupting the management strategy. A consistent strategy gives the irrigation system users greater confidence that the interventions are being made for their benefit than is sometimes the case with the current decision making norms.

CONCLUSIONS

Irrigation has played and will continue to play an important role in securing the food supply for the rapidly expanding population of the world. However, the irrigation sector must continue to develop approaches to the design and implementation of management and infrastructure interventions that provide flexible and responsive support to the agriculture sector. The need to increasingly consider the impacts of agricultural development on the broader environment, that have impacts on the livelihood systems of the intended beneficiaries will continue to constrain the freedom of movement available to the sector.

A major shift in thinking is required to move away from a distinction between the development and operational phases of a project life cycle. Rather the irrigated agriculture sector should assume that all irrigation schemes are in both phases at all times after initial completion of the infrastructure. The development plan for each scheme must focus on achieving the strategic goals set for the sector, and the surrounding community. This places the irrigation scheme in the broader context of the river basin and socioeconomic scene, whereby decisions on investment in the irrigation system are considered not only in terms of the improvements in system performance but also in the contribution to improving livelihoods and minimizing environmental degradation.

Thus sustainable irrigation development will involve:

i. identification and definition of medium- and long-term development goals for the sector and region. By necessity the long-term goals must be defined in consultation with civil society and the political groups in the country to minimize oscillations brought about by changing governments. The goals, and the movements towards achieving the goals, should be published widely.
ii. development of strategic management goals for the short- and medium-term planning of interventions to address short- and medium-term management objectives, responding flexibly to changing circumstances in the medium term. System managers and sector planners will need to keep an overview of the wider socioeconomic scene to ensure that interventions continue to address priority issues.
iii. shifting from a focus on short-term O&M planning to development of asset management plans focused on achieving given levels of water economy and productivity over the planning horizon of 10-20 years.
iv. using asset management plans to integrate recurrent and project budgets to achieve the strategic development goals, through incremental development.

v. recognition that sustainable increases in irrigation performance involve multiple partners in the government and private sectors and in society. Irrigation must play a responsible part in the use and protection of natural resources, most specifically land and water.

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5. ROLE OF PUBLIC AND PRIVATE SECTORS, NGOs, WATER USERS' ASSOCIATIONS AND OTHER STAKEHOLDERS IN IRRIGATION MANAGEMENT IN THE 21ST CENTURY

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INTRODUCTION

Irrigation management is a key to sustain the development of agriculture in many countries, especially because water is an increasingly vulnerable resource where population and economic growth compete for this limited resource to meet food requirements and other uses, and at the same time, problems of water quality are increasing, mainly due to the increased and diversified use of this resource. Rising demands for limited water supplies, from rural and urban sectors for agricultural, industrial and household uses, pose a formidable challenge. Even in areas where the annual aggregate availability is "high", spatial and temporal variability is threatening and characterized by severe flooding at certain times and droughts at others, and watershed degradation has exacerbated these effects.

In many countries in the region, agriculture sector in general, and irrigated agriculture in particular, has now entered a new phase of development. Breeding and the greater adoption of high-yielding varieties, especially rice, maize and wheat, coupled with irrigation development and the availability of nitrogen fertilizer had boosted crop yields, and the global food production "managed" to provide food to rising populations in the past few decades. Much of the production came from rising crop yields while the increase in area under cultivation was not significant. The average annual grain yields grew by 2-2.5 percent between 1950 and 1990. In the 1970s and 1980s, there was a shift in focus towards rehabilitation and improving management of existing irrigation systems rather than the earlier emphasis on constructing of new irrigation systems. This interest gathered momentum due to: diminishing land and water resources available for, and the increasing cost of developing new irrigation systems; demonstrated under-performance of the existing systems and comparative advantage of undertaking rehabilitation programs over new construction activities.

A marked decline in irrigation investment was evident in 1980s. For example, lending for irrigation development by four major donors – the World Bank, the Asian Development Bank, the US Agency for International Development, and the Japanese Overseas Economic Cooperation Fund – that reached a peak in the late 1970s reduced by half in the 1980s (Rosegrant, 1997). In the 1990s, the growth (of grain production) slowed down to less than 1 percent and a stagnating or declining trend in productivity has been reported for major food grains. Impact of declining productivity and profitability on the beneficiaries demands greater attention. Most of the farmers in the region are operating in small farm holdings. This condition is further aggravated because they have *limited "roots" in off-farm income sources*. The opportunities for conventional alternatives such as slash-and-burn (or shifting) cultivation are fast disappearing and many countries lack a strong sector of agriculture-based rural industries, which can act as the interface between the peasant farmer and the industrial world. In this context, it is suggested that most of the food requirement, and income for most of the rural people in many countries in the world should be expected from increase in productivity of existing cropland. This is crucial for our discussion because efficient water management enhances land productivity.

Scope of the Paper

In certain countries, irrigation dates back to several centuries if not millennia. However, in some other areas irrigation seems to be relatively recent, mainly a 20th century phenomenon. In addition, the type and quantity as well as the reliability of different sources of water, climate and other environmental factors, socio-political conditions, status of agricultural and non-agricultural development, etc. are not homogenous across the countries. Consequently, there exist a significant degree of inter-country as well as intra-country variation in regard to physical structures and institutional mechanisms (or "hardware" and "software") related to irrigation. Therefore, expectations as well as the potential for change during the 21st century may not necessarily be the same for all areas. However, a country-specific analysis is beyond the scope of this paper.[1] Instead, the paper is concepts- and issues-oriented.

Irrigation management is a multifaceted, multidisciplinary affair and it is *difficult to separate* the roles of different stakeholders. For example, it is hard to separate the roles of different stakeholders in strengthening Water Users' Associations (WUAs). In order to strengthen the capacities of WUAs, the paternalistic role of the state need to be removed and farmers' capacity and attitudes should be changed so that the institutions would become independent farmer-owned and -financed businesses. As such a catalytic function could not be expected from within the community and, as such expertise may not be available with the government, NGOs may fulfill that role. At the same time, effective partnerships between the organized private sector (OPS) and WUAs (or other forms of multifunctional users' organizations, such as farmer companies [FCs]) should be evolved. Hence, a variety of stakeholders will have to *work collaboratively* and share responsibilities. Therefore, the paper will first address the *challenges* faced by "Irrigation Management in the 21st Century – Tasks and *Shared Responsibilities of Stakeholders*". This will elaborate on the shared goals and responsibilities. Topics covered in this section include: a) role of agriculture and new challenges; b) role of irrigation production systems and the *need for focusing on profits* rather than only on physical production; c) water markets and pricing of water; d) the need for multifunctional Farmers' Organizations (FOs); e) modernization of irrigation; f) improving "*effective irrigated area*", "*time productivity of water*", and managing beneficial as well as non-beneficial water; and g) watershed/river basin management. Subsequently, the paper will briefly examine the specific roles of the public sector, WUAs, OPS and the NGOs. In addition, the paper will comment on the role of research, technology and funding agencies. Conclusions are presented in the final section of the paper. Throughout the discussion, the focus will be on: a) roles/functions of different stakeholders at present; and b) how these functions could be changed or enhanced in the future.

IRRIGATION MANAGEMENT IN THE 21st CENTURY – TASKS AND SHARED RESPONSIBILITIES OF STAKEHOLDERS

The growing scarcity and competition for water intensify uncertainty about the "future directions for agriculture and irrigation development". This is true for many Asian countries that experienced rapid agricultural growth from the mid-1960s to the mid-1980s (Barker and Samad 1998). In general, agriculture in many countries has now entered a post-Green Revolution era. In this paper we suggest that, in order to take off from present stage of stagnation and, especially to enhance the economic conditions and general well-being of farmers, it demands new strategies and procedures. Moreover, globalization changes the pattern of development of the agriculture sectors of respective countries. So the role of irrigation would depend on how this scarce resource is managed to achieve the expected pattern of agricultural development in a sustainable manner.

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[1] A diagnostic learning process involving the comparison of well-managed and poorly-managed systems under similar conditions could be a practical and a more beneficial way of identifying performance gaps and for designing strategies to bridge those gaps. Such analyses would prove that a significant portion of the "*performance gap*" in many systems could be reduced by management improvements. In an earlier Seminar sponsored by the APO, such an analysis has been presented (Wijayaratna, 1991).

Role of Agriculture

Declining "share" of agriculture in the GDP has been a "common" characteristic of economic development. In the process of economic development, usually the role played by agriculture is replaced by the industry and services. However, this should not imply that weakening of agriculture is a healthy phenomenon. On the contrary, the evidence to date suggests that rapid growth in agriculture supports the growth of non-agriculture sectors and accelerates overall economic growth.

It has been "predicted" that in the future, Asian countries would largely become the exporters of industrial products and net importers of food from the Western World (Carruthers, 1993). However, this trend was not clearly evident in the past few years. In addition, such a massive transformation of rural-based agricultural societies to urban-based industrial ones would require huge investments on human and physical capital and socio-cultural reorientation, and based on historical evidence; past investments in agricultural infrastructure, including irrigation;[2] and in the context of perceived socio-political and economic needs, one would conveniently argue that agriculture would *continue to play a significant role* in many countries in the region. Here, the agriculture sector would continue to help achieve national objectives such as achieving food security[3] by ensuring the uninterrupted supply of food in sufficient quantity and quality. Moreover, in many of the countries in the region, at least for few more decades, the sector will remain as a significant source of income for rural people. Hence, the *strength* of agriculture is important at any stage of development. And, in a typical process of economic development of a country, the *scale* of agriculture would not be reduced. It is in this context that this paper would examine the role of public and private sectors, NGOs, WUAs, and other stakeholders in irrigation development in the 21st century.

New Challenges

Increased scarcities of inputs and poor performance in their utilization have already caused problems in food production. For example, in many parts of Asia, most of the economically promising sources of irrigation appear to be already fully developed. In addition, in many countries, the sector has to face with new challenges of structural adjustments towards liberalized markets. This implies that the sector has to face with local demands such as achieving food security, poverty alleviation, environmental concerns, income and employment generation, etc., and at the same time, compete in export markets (and in the local market with imported products), based on comparative advantage. Hence, it is argued that, sectoral policies must be revised, the infrastructure as well as the selection and adoption of technologies should be adjusted and organizations and institutional arrangements should be restructured to cater a "market-oriented" growth. For example, adoption of appropriate technology and capturing economies of scale through new institutional arrangements would be necessary for the commercialization of irrigated agricultural production systems where a large number of small farmers operate on tiny holdings. *By looking into the future, the remainder of the paper attempts to address these themes*.

Performance of Irrigation Systems – From Physical Productivity to Profitability

Means and Ends: Irrigation systems are agricultural production systems and the overall performance of these systems depends on a large number of non-water factors as well. There are on-farm and above-farm levels of activity; cross-cutting water and non-water factors. For example, at farm level the combined effects of water, high-yielding varieties, fertilizer and other inputs influence the crop yields. There exist complementary relationships between these inputs in terms of their effects on crop yield. For instance, improved water availability to crops, through efficient irrigation, may result in an upward shift in the fertilizer production function and *vice versa*. In other words, returns to fertilizer (or water) are more when it is properly combined with adequate levels of water (or fertilizer).

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[2] Nearly 60 percent of the area irrigated is in Asia (with China and India covering almost one-third of the global extent).

[3] For example, the importance of addressing the issue of food security was evident in the recent Asian financial crisis. At the same time, the role of government was prominent and the inability of "market mechanisms" in handling the food crisis was also evident.

Also, improved water availability and more reliable distribution may lead to increased application of fertilizer by farmers. Thus, *the influence of irrigation management on the application of other complementary inputs is not merely technical, but also behavioral* (Wijayaratna, 1986). These physical and behavioral relations are important because performance ratings, based on land productivity, could be significantly different from that of water productivity. Also, because irrigation water is not the sole input used in the production process, water productivity measured by crop weight per unit volume of water could be misleading at times when the effect of complementary inputs such as fertilizer varies across the sample. Hence, *improving physical productivity of water should not be considered as an end itself.*

On the other hand, price policies, input supply services, support services (including agricultural information, credit, marketing) and the like that are at "above-farm" level may interact with farm-level factors – such as the ability and willingness of the farmers – to determine the level of contribution of inputs to the production process. Thus, it becomes prudent to consider irrigation system operation in the context of three categories of influencing factors, namely; a) irrigation management distributing water throughout the system, b) non-water factors influencing the productivity of farms, and c) interactions between the two. These interrelations between factors involved in the irrigation process suggest the need for making a distinction between ***means** and **ends*** of system performance. The performance of irrigation need to be evaluated against the "ends" or the ultimate goals of improved well-being of farmers and increased food production. It is suggested that the performance of activities such as operation and maintenance (O&M), or other physical and organizational events affecting an irrigation system should be viewed as "means" rather than "ends" of productivity and distribution, which constitute major criteria that can be reasonably well measured and interpreted (Wijayaratna, 1986). Such measures of productivity, equity and profitability may constitute the (relatively) short-term objectives of irrigation systems. However, these will also influence the longer-term goals such as sustainable well-being of beneficiaries and environmental concerns.[4] *In this context, it is proposed to consider irrigation systems as business entities, with due emphasis on interrelated concerns of sustainable well-being of farmers and environmental stability.*

Managing Irrigation Production Systems as Profitable Business Entities: Need for Multifunctional, Business-oriented Organizations

Improvements in irrigation management alone may not generate adequate incremental benefits for them to be financially viable. A better alternative would be to utilize the established organizations and enhance their scope of work to adopt a *business approach*. In this, the WUAs will have to deal with the OPS, in a business mode, for irrigation-related as well as non-irrigation services. It is proposed that, while the countries are increasingly embracing open market policies, the small farmers in irrigated agricultural production systems should be "equipped" to become active partners in *markets* and to benefit from this ("globalization") process. In this context, the remainder of this section is devoted to a discussion on emerging market trends and to suggest ways and means that would enable the water users to utilize the globalization process positively.

Tradable Water Rights/Water Markets

In many developing countries, it would take many more years to fully establish market mechanisms in the water sector.[5] There exist a tendency to ignore equity in judging the efficiency of markets. At the same

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4 Small and Svendsen (1990) suggested a similar concept and framework involving a "series of means and ends" at different levels. In this framework, "a narrow purpose is seen as the means for achieving some specified end, which is the broader purpose within which the narrow purpose is **nested**. This end, in turn, becomes the means for achieving another end reflecting a still broad purpose. Thus, beginning with the narrowest, or proximate purpose of irrigation, one moves outward through a series of broader purposes, the achievement of each is partly dependent on attaining the purpose of the previous level. This process continues until one arrives at the ultimate purpose" (Small and Svendsen, 1990).

5 It is interesting to note that in a recent workshop, when a group was asked to make recommendations about strategies of river basin management, for achieving the twin goals of poverty alleviation and agricultural growth, the group, among other things, came out with the following recommendations: "developing country (continued...)

time, in certain markets, due to the inadequacy of effective mechanisms to ensure the active participation of the poor and disadvantaged people, such segments of the society do not benefit much and are lagged behind. More often than not, small farmers fall into this category and in such circumstances people's organizations are increasingly being treated as indispensable tools for enhancing the economies of scale and bargaining power. Many WUAs have fulfilled this role, not only in water markets, but also in other arenas such as in the supply of other agricultural inputs and in output marketing. They are also being seen as useful social mechanisms for ensuring social harmony.

There are examples of enhancing water use efficiencies through tradable water rights and water markets. For example, in Chile, market-oriented water policies and tradable water rights have improved the efficiency of agricultural use of water and this has resulted in higher agricultural productivity. Mexico and California also provide "guidance in resolving the complex issues that arise in the process of implementing a system of markets in tradable water rights ..., (however) even comprehensive water law reform allows a phased approach to implementation, which can begin with regulated markets that are progressively opened up as market experience gathered" (Rosegrant and Schleyer, 1994, pages ix and xi). Palanasamy, in a comprehensive analysis of water markets in India, reports that many farmers in Tirupur, Coimbatore district, are selling water for non-agricultural purposes because it is more profitable in the context of unfavorable crop prices and rising costs of agricultural inputs. Some farmers switched on to crops with low or no irrigation demand, such as coconut and other perennials, to save water and sell it (Palanasamy, 1994 in Rosegrant and Schleyer, *ibid*.)

In certain countries, the ownership of different forms of irrigation water (such as ground, surface, etc.) and that of irrigation facilities is retained by the government, even after the Irrigation Management Turnover (IMT). However, WUAs are vested with rights to use water. They are not allowed to sell, transfer or rent out facilities. Individual use of water is granted through a licensing system; however, it is both sellable and transferable.

There are different opinions about the possible impact of this "lack of perfect markets" on water use efficiencies and productivity. Usually in developed countries the markets are based on individual rights. However, in many developing countries in Asia, there exist difficulties in creating water markets based on individual rights. In these countries there are a large number of small farmers operating on tiny smallholdings. They do not have irrigation infrastructure (and it may not be profitable) to cater to the individual farmer. For example, it would be impossible to deliver exact, predetermined volumes of water at a given price to individual farm plots. It would be costly and also these countries cannot afford at this stage of development, to provide such facilities at the farm level. Moreover, reuse patterns in water basins (and even within micro-watersheds) make it nearly impossible to measure the exact amounts of irrigation water utilized by individual farmers operating tiny smallholdings, often scattered in a locality.

If one expects land consolidation to occur in the process of development it is not logical/rational to incur such expenditure at the present stage of development. In addition, implementation of a costing mechanism based on volumes delivered to individual farms becomes irrational due to excessive reuse pattern as the drainage and reuse patterns in a typical river basin/watershed aggravate this situation. Also, water quality becomes an important determinant of water pricing process. And, it is difficult to conduct detailed Environmental Impact Assessment (EIA) and Initial Environmental Evaluation (IEE) according to a set of

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[5] (...continued)
river basin management regimes can use water allocation and pricing mechanisms to generate resources for *supporting smallholder communities and other poorer groups*. Economically dynamic sectors – such as commercial farming, mining, electricity companies, and industry in general – which use water intensively in wealth creation, should contribute a development levy, which would be used to create social infrastructure for poor communities. ..... While poorly designed subsidies can be dysfunctional or counterproductive, carefully designed 'smart' subsidies can provide powerful incentives. For example, in societies that lay great emphasis on privatization of service provision, dispersed poor communities may prove costly to serve, and therefore, it may take generations before they become viable demand systems for privately delivered services. In such situations, smart subsidies can create the required incentives for private service providers to serve dispersed poor communities" (Abernethy, 2001).

criteria and for each base unit. In many systems, the base unit is usually a small farm and thus the quality assessment based on individual "private units" would become a difficult task. *Further, one should not ignore the historical evidence exist in many countries that local organizations could enhance the efficiency of irrigation management sustainably*.

On this basis, it is suggested that, in certain situations, *group water rights may be the logical mechanism* in minor as well as major irrigation systems for some time. Multi-tier systems are useful to accommodate different interest groups or users with different privileges, such as those cultivating at head, middle and tail areas.

Multifunctional Organizations

In many irrigation systems, it is clear that unless farmers enhance their incomes through increased productivity – both land and water, their organizations will not be in a position to undertake O&M functions of irrigation in a sustainable manner. Also, in some countries (where agriculture sector still plays a dominant role as the provider of food and employment), the "takeoff" from agricultural base to achieve the industrialization goals should rely on rural agricultural diversification, specialization, market-oriented modernization and promotion of agro-industries. Hence, it would be prudent to expand the scope of work of WUAs to include non-water functions, including the integration of water and other factors of production, diversified cropping, value addition and enhancing the bargaining power. In this, it is imperative that FOs establish business links more with the OPS for services, including input and output marketing. In that strategy, *the management of irrigation, including O&M responsibilities would become an integral task of such business organizations*.

Modernizing Irrigation Systems to Match with Future Needs

Obviously this is a prerequisite for successful production in many irrigation systems. Irrigation systems need to be rehabilitated and *modernized*, not only to suit the present day needs, but also to face with future challenges. The needs of farming communities are fast changing. Agricultural development programs (including irrigation development), which were largely geared towards the achievement of self-sufficiency in staple food, have now been reoriented. As repeatedly suggested in this paper, there is an increasing need for diversified cropping, commercial production of high-value cash crops and intensification of production using advanced irrigation and production technologies. Hence, it is argued that the restoration of irrigation systems to original design status or effecting *ad hoc* improvements may not be productive enough to meet the new demand and challenges. Some of the original irrigation system specifications may even be inappropriate for the changes demanded in the cropping patterns, cropping intensities, etc.

Moreover, irrigation system modernization should be a process of making appropriate changes/ improvements in the physical, institutional and socioeconomic objectives of irrigation systems. It is argued that the projects and other opportunities for "rehabilitation of irrigation systems" should consider hydrological and other linkages between the subsystems of the main irrigation system as well as interactions among different segments (micro/sub-watersheds) within the river basin/watershed. Also, projects and programs should take a much more holistic approach and integrate irrigation system modernization with the adoption of novel production technologies and marketing of agricultural products. Such a strategy would *enhance farmer profits and this in turn will enhance their capacity to manage their systems, including self-financing*. What is needed then are irrigation betterment or modernization programs and not just simply to rehabilitate or restore the systems (see the section on technology at the end).

Shifting to High-value Crops and Diversification

Water used by a given crop and the dry matter produced per unit of water would depend mainly on the type of crop, location and conditions under which it is grown, climate, season and other factors. For example, a crop grown in a drier climate will transpire faster than that of a humid environment. And, the profit per unit of water would depend on the price of the product. Hence it is obvious that the rational selection of crops, cropping patterns, timing of cultivation, etc. would enhance water use efficiency and profits. A great deal of development outside the traditional mono-crop farming is necessary not only to optimize the financial and economic returns to investment made in the irrigation sector, but also to improve the living standards of the growing populations. Recently, crop diversification has gained popularity, mainly as a "response" to the declining trend in the growth rate of "new areas irrigated" and the declining profitability of mono-crop culture, approaching self-sufficiency in basic staple goods and growing demand for different types of food crops and crops with industrial potential.

In many countries diversification can be promoted while improving the production of basic staple food. For example, a limited water supply condition, which is inadequate to meet the requirements of rice during the dry season, is experienced in many irrigation schemes with favorable soil conditions. At the same time, the distinct unimodal dry season rainfall pattern would make it possible to have a well-aerated favorable environment for irrigated crop diversification with high-value short-age crops. Hence, both land and water productivity may be enhanced and the limited water available in the soil may be better utilized. Economic viability of such systems, therefore, may be maintained by diversification. At the same time, adopting water-saving technologies and improving the production process of widespread major staples like rice crops would improve irrigation efficiency and profits. In this regard, the System of Rice Intensification (SRI) provides an ideal example. SRI package includes transplanting of younger, smaller plants, fewer plants per hill and per m^2, less water per season, less purchased inputs. Moreover, it yields added environmental benefits (Uphoff, 1999-2002, various papers on SRI).

The progress in a program of diversification depends on a variety of factors: a) compatibility of the selected crop mix and land, water, climate, etc.; b) expected fluctuations of profits due to price shifts and other market factors including problems associated with respective markets and risks; c) farmers resource endowments; d) incidences of pest and diseases; e) irrigation requirements of individual crops in the mix and the feasibility of system-wide efficiency in water use,[6] etc. This latter may call for a certain degree of *specialization or zoning* at some level within irrigation systems.

"Effective Irrigated Area" and "Time-productivity of Water": For areas where further expansion in the irrigated land frontier is constrained due to financial problems and limits in water sources or supply, it is useful to examine the technical and economic feasibility of expanding the "*effective irrigated area*" by increasing cropping intensity (number of crops per unit area per unit time), and enhancing the "*time productivity*" of water (Wijayaratna, 1991). It has been suggested that crop output/income/profit per unit of water per unit of time is a better measure of water use efficiency. Increases in cropping intensity can be done effectively in several ways: a) introducing early maturing crops, thereby increasing the effective area planted to those crops per unit of time; and b) multiple and relay cropping and cultivating 2-3 crops per year by adopting water-saving techniques. Similarly, profit per unit of water per unit of time may be improved through rational and efficient use of irrigation methods, improving cropping intensity, and shifting to high-value crops and crop diversification (Wijayaratna, 1991).

Managing "Beneficial and Non-beneficial Water Use" – Real Losses of Water

For many years, scientists examined water balance in farms, irrigation systems and watersheds/river basins, examined *productive and unproductive uses of water*, developed water use equations and suggested measures to improve water use efficiency in basins. For example, Micklin (1991), analyzing the water management "crisis" in Soviet Central Asia, examined several interesting studies on water balance at different levels. In one study, the authors (Vol'ftsun, Sumarokova and Tsytsenko, 1988) had developed and quantified (using real world data) water use equation as follows:

$$W_{\{withdr\}} = W_{\{prod\}} + W_{\{ret\}} + W_{\{unprod\}} + W_{\{drain\}}$$

where $W_{\{withdr\}}$ is water withdrawn at the head works for irrigation; $W_{\{prod\}}$ is the amount of withdrawn water used productively by crops; $W_{\{ret\}}$ is the volume of return flow from irrigated areas that "reenters" the river network by surface and groundwater flow; $W_{\{unprod\}}$ is the quantity of withdrawn water that is "lost" to unproductive evaporation in unirrigated lands within irrigated areas that have groundwater lying at shallow depths and in the "transit zones" that lie between irrigated areas and the rivers from which water is taken and to which it is returned; and $W_{\{drain\}}$ is the amount of irrigation water collected in and evaporated from

6 For example, *flexibility* in adjusting irrigation interval or total duration of irrigation may be limited if a large number of crops with different water requirements and different age groups are included in the same turnout.

lowlands and irrigation drainage water lakes formed around the periphery of irrigated areas (quoted in Micklin, 1991, pp. 15-16).

In this case, potential for "*future water savings*" have been estimated and measured, which could be employed to deal with water problem in Central Asia. These included: *greater use of groundwater* to enhance replenishable water supplies; *reuse of irrigation drainage; more regulation of river flow, reduction of flood plain water losses*; and the *use of water collected in small natural basins and ephemeral streams*. In addition, it has been suggested that *trans-basin diversions* could provide solutions, depending on the technical social and economic feasibility (Micklin, 1991).

Similar concepts can be found in recent literature and it has been suggested: "ecological concepts of sources, sinks, and recycling provide a useful means of understanding water basins" ..... "better conjunctive use of surface and sub-surface water supplies, water conservation techniques, small and large dams, and possibly, trans-basin diversions to areas of high future potential are needed" (Seckler, 1996). In this context, let us consider the scope for river basin/watershed management.

1. ***Efficient Management of Rainfall in Irrigated and Non-irrigated Areas***

Nearly two-thirds of the cultivated area is in the world is rainfed and usually, water used by rainfed crops are not counted as "agricultural water use", because that water is provided by rainfall and not by irrigation. More often than not, rainfall is not efficiently utilized (in both irrigated and non-irrigated areas) within irrigation systems. While recognizing the importance of further improvements in irrigated areas, it can be argued that returns to efficient management of rainfall in these areas could be even more beneficial in the future. Therefore, integrated resource management in watersheds becomes important (see below). There are additional benefits – good vegetation could favorably influence downstream flow and reduce erosion.[7]

2. ***Water Quality***

Water quality, including groundwater contamination, too is reported as a serious environmental concern. According to Bradley, *et al*. (1987), agriculture's contribution to groundwater contamination is primarily from pesticides and nitrates. And, in general, irrigation "motivates" farmers to use more chemicals. Such contamination of wells and aquifers generally is difficult and costly to correct, and it may be easier to control the application of those chemicals at farm level. For this, the availability of profitable and acceptable alternatives is important.

3. ***Watershed[8]/River Basin Management/River Basin Management***

The watershed/river basin is a physical entity geographically defined by an important natural resource, water. The ways, in which the land and water in the upper parts of the watershed/river basin are used, affect the ways in which the downstream can be used. Thus, the various parts of the watershed/river basin are physically and operationally linked in important ways, and the potential benefits from integrated use can be large. The people in the different components of the watershed/river basin having access to different aspects of the natural resources base may be engaged in different economic activities, and may be of different social and/r cultural backgrounds. Therefore, the social and economic interests in the different areas do not necessarily coincide, introducing problems for planning and implementation.

Moreover, the physical boundaries of a watershed/river basin are rarely congruent with the boundaries of the administrative or constituent political entities. This situation complicates the processes of planning and implementation. As people are the final decision-makers regarding the use of land and water resources, they not only influence these linkages and relationships but also can change the production potential of land and water resources either favorably or adversely. Hence, watershed/river basin development should be user-

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7 Soil erosion annually takes 5-6 million ha of cropland out of production (Doos, 1994) and salinization adversely affects nearly 2 million ha of irrigated land annually (Umali, 1993).

8 In the watershed literature there is some confusion about the usage of terms such as "watershed", "river basin", "catchment" or "drainage basin" (Pereira, 1989). In this paper, the term *"watershed" is used as "the area of land surface that drains water into a common point along a stream or river"*. Hence, the river basin is considered as the highest order watershed. Areas that generate separate streams/tributaries within a larger watershed (or a river basin) can be conveniently defined as "sub-watersheds" and "micro-watersheds".

oriented and participatory. Moreover, most of the watersheds/river basins are degraded mainly because they are "being used". And, because the resources can be used profitably if due consideration is given to conservation concerns, watershed/river basin management should be considered as a process of participatory planning/formulating, implementing, and monitoring/adjusting and evaluating a course of action involving natural, human, and other resources.

Despite the fact that there is continued interest in comprehensive river basin/watershed planning and studies, implementation of such "plans" or what is "recommended" by studies, with the participation of a full range of concerned stakeholders, is lacking. A participatory watershed management approach should internalize, in a watershed/river basin context, a combined strategy of effective application of already known and new technology, strengthening/forming appropriate organizations to take advantage of scale, pooled resources, securing credit from banks, secure assured markets and schedule production, add value to agri-products, acquire appropriate managerial competence, etc., for profitable production and conservation (Wijayaratna, 1995).

ROLE OF THE PUBLIC SECTOR

Traditionally, water was considered as a public good and there were norms and regulations to ensure that everyone could benefit from water. In the recent past, however, use of this resource (especially for irrigation and domestic use and related services) had been moving from being a "public good" towards a "private good". It is believed that this trend would continue. It is with this assumption that this section would examine the role of public sector in irrigation management.

Participatory Irrigation Management and Irrigation Management Transfer (PIM/IMT)

In many countries, the governments find it increasingly difficult to maintain even the minimum levels of support to the rural communities, mainly because of budgetary constraints and also due to other pressures. And, following the global trends in "privatization", there has been a growing tendency for respective governments to adopt participatory or shared management processes as well as "privatization" of government undertakings. Relative inefficiencies in the government bureaucracies in improving infrastructure (such as irrigation) and delivering support services to the rural sector as well as the increased evidence of success of programs and projects involving beneficiaries in managing rural development have also motivated the respective governments, donors and pressure groups to look for participatory and joint or collaborative processes. There is, however, a need for continued government involvement in irrigated agricultural production systems, but it should be different from the approaches and strategies adopted in the past. As the individual farmer's access to the required services and supplies cannot be assured through bureaucratic modes, the evolution of new forms of organized service delivery is imperative. Therefore, governmental support *in facilitating a process* of more intensified and strengthened organizational activities on the part of the small farmer, needs special emphasis.

The governments of many countries worldwide have already recognized the need for transferring management responsibilities to water users. The major reasons for PIM/IMT are: improving irrigation system performance and productivity; responding to the advice/pressures of external funding agencies; reducing government expenditure on O&M of irrigation systems; responding to broader democratization and privatization policies and programs; enhancing the sustainability; and reducing detrimental environmental impacts (IIMI and FAO, 1995).

Several countries have had varied measures of success in cost and management transfer. The countries in the region which had launched IMT programs in mid-1970s (such as the Philippines) and in the early 1980s (like Sri Lanka) have adopted a participatory "learning process" approach while certain other countries like Nepal, based on such experience and due to external (donor) pressures adopted a "blueprint" approach in certain donor-funded projects. Probably, out of the developing nations in Asia, the Philippines provides one of the best experiences relevant to the IMT process in many other countries in the region. While the concept and principles seem to be generic in nature, the strategies and procedures may be country specific. *Countries could "exchange" experiences and lessons learned*. The tradition of government involvement in irrigation management, however, has been so strong in many countries and the dependency syndrome cannot be easily broken and the government funding and patronage extended to irrigation O & M cannot be suddenly withdrawn. *The experience suggests that it would be necessary for these countries to follow a gradual process of withdrawal of funding through the adoption of management transfer*.

It is important that the respective governments facilitate the PIM/IMT process to evolve effective mechanisms to ensure active user participation (and WUA responsibility), not only in the day-to-day O&M of irrigation systems, but also in the formulation and implementation of relevant policy, as well as in legal and institutional arrangements indicated above. In general, the conditions necessary for successful PIM/IMT program are: a recognized and sustainable water right, appropriate infrastructure relative to local management capacities, clear designation of responsibility and authority for all essential management functions, supportive accountability and incentive mechanisms, and adequate resources (financial and human) for sustainable (IIMI and FAO, 1995). It is the responsibility of respective governments to initiate an effective institutional arrangement for the success of an IMT process. Such institutions could be under shared management at the initial stages and gradually hand over to WUAs. The functions of institutions would include:

* deploying mechanisms to ensure active and productive participation of water users;
* planning and conducting O&M and Rehabilitation and Modernization (R&M);
* administer water rights;
* resolution of conflicts, and implementation of regulatory and control mechanisms;
* Irrigation Service Fee (ISF)/revenue collection, budgeting, and financial management;
* providing/coordinating irrigation and agriculture-related services; and
* managing information, M&E and research.

Based on our experience and analyses the following process is proposed for effective PIM/IMT:

1. Strengthen the managerial capacity of FOs or WUAs;
2. Facilitate the establishment of multifunctional business organizations like FCs, with irrigation management as an integral part of the overall business;
3. “Full transfer” of responsibility and authority to “rehabilitate, own and operate”;
4. Financial support, technical assistance and skill development; and
5. Assist initially in feedback and self-correcting mechanisms, establishing transparency through the establishment of a people-centered M&E system based on a set of objective verifiable indicators.

Policy and Financial Support

Government commitment is a necessary condition for the sustainability of PIM/IMT in general, and WUAs in particular. Enabling policy environment and legal conditions are necessary for genuine and sustainable people’s participation. While many governments voice strong public support for decentralization and people’s participation in decision-making, the policies and laws of many often do not reflect that position. In certain areas, sustainability of organizations is restricted due to inadequate policy support. In certain other areas, different perception on participation by different actors, chiefly the bureaucrats, including policymakers hinder the development and sustainability of organizations. As Korten correctly stated “... *Closing the gap between bureaucracy and the poor poses formidable requirements for the reorientation of the organizational structures and management systems of large public bureaucracies*” (Korten, *et al*., 1981).

Our experience suggest that certain policymakers and bureaucrats view participation or local management merely as a process of mobilizing rural labor and investment for grassroots level tasks, which would otherwise borne by the government while for some others, participation mean manipulation and regimentation. The latter tend to have a rigid “control” over local organizations. The policy support mechanisms to sustain local organizations should include legal and financial support, especially at the initial stages of development. An efficient and carefully designed legal framework is essential, especially in areas where the procedures and structures of the decision-making process of the public service are oriented much more towards control than to innovative and creative work. For instance, it may be prudent to provide local organizations with legal rights to participate in decision-making bodies at higher levels. However, it should be noted that a participatory system could not be brought into being by legislature alone.

Further, in certain countries, there is no guarantee that enacting a procedure or legalizing something would ensure the implementation of the same. On the other hand, once specific mechanisms or strategies of participation are identified and agreed upon, the legal support to facilitate their operationalization may be helpful to sustain such practices. It should also be noted that all the operations of a participatory system need not be supported by the legislature. Certain operations may occur on the basis of mutual understanding, norms or through informal agreements. In other words, the law can lay down a number of fundamental rules and rights of respective parties involved in specific aspects, e.g., forward contract for the sale of produce or in obtaining a service.

In addition to legal support, financial investment by the State is a necessary condition in organization building, especially at the early stages of development. At initial stages, financial assistance may come in the form of employing the correct type of NGOs/private sector/government agencies for catalyzing the development of local organizations, training and skill development and to meet the operating costs of establishing the correct "institutional home". *Investing in organization building should be considered as an effective form of investment in enhancing the human capital stocks*.

INSTITUTIONAL MECHANISMS: ROLE OF WATER USER'S AND WATER USERS' ASSOCIATIONS

Like all institutions, WUAs are creatures of their past. Their organization, orientation, efficiency and "role" in general, reflect the organizational environment, type and efficiency of irrigation as well as the economic and socio-political contexts in which they were born and evolved. So one could argue that they should be and will be shaped, especially by global trends, and also based on the learning experience. Hence, strengthening and "structural and functional adjustment of irrigation institutions building" will be a central task in irrigation development process in the 21st century. This section examines emerging challenges and future directions as well as expected role of WUAs as we move into the 21st century.

In Asia, developed countries such as Japan, Republic of Korea and Republic of China (Taiwan) have relatively advanced WUAs with strong bargaining power. The WUAs in these countries manage irrigation systems. They employ technical staff and hire the services of the private sector (firms) for certain function related to O&M and agricultural production. Such modes of management provide good examples for effective partnerships with the OPS. In China too, local responsibility for water facilities and irrigation development and management is clear. As the countries in the region are having varied experience and are at different stages of management transfer, the experiences could be shared and the "learning processes" may be expanded to achieve the goals of complete transfer.

In many developed countries, agricultural cooperatives are most visible "farmers' organizations". In certain sectors of developed countries (such as dairy), agricultural cooperatives hold significant market shares. For example, within the dairy sector, cooperatives control a significant share of markets in such counties as New Zealand, Netherlands, Denmark, Finland, France, Germany, Norway, Sweden and USA. In many developing countries, however, the existing top-down attitudes towards cooperative management of many existing cooperative managers and government cooperative officials need to be changed. In addition, the weak member capital base and low sense of "member ownership stake" in agricultural cooperatives need to be rectified. Developing countries may examine the rich experience of the developed countries and based on this, the scope of WUAs may be broadened or diversified and strengthened to enhance farmer profits in irrigated agricultural production systems (see below).

It is important that the leaders/farmer representatives as well as the members of organizations have a clear understanding on such aspects as: the need and basis for collective action in irrigation management, rules governing collective action, the "Reward-Punishment" mechanisms and other responsibilities of irrigation management.

The major irrigation management functions of the organization/company would include: deploying mechanisms to ensure active and productive participation of water users; planning and conducting O&M and R&M; administer water rights; water supply/delivery mechanisms (under normal conditions as well as under the conditions of scarcity); water requirements for planned cropping patterns at different places of the command area and at different times, resolution of conflicts, and implementation of regulatory and control mechanisms; ISF/revenue collection, budgeting, and financial management; providing/coordinating irrigation and agriculture-related services; and managing information, M&E and, at advanced stages, research.

Further, the modes of ordinary farmers' participation in decision-making at different levels and procedures ensuring accountability of higher level decision-making to ordinary farmers should be clear and transparent.

Institutional Building as a Dynamic Process

For many years to come, the major issue in economic development in many countries will be the adaptation of national economies and national institutions to global change, while protecting the needs of local people. Irrigation sub-sector is no exception. Multifunctional WUAs, FCs, cooperatives or other forms of federated FOs would be the most appropriate organizations for small farmers to coexist with free market forces. Such organizations would also help reach economies of scale and enhance the bargaining power of producers and may sustain as strong and viable production and marketing organizations which will be responsible, not only for irrigation management, but also for primary production, collection, storage, quality control, value-added production and marketing.

In this context, we suggest that the matured organizations/institutions would benefit if federate upwards and expand their scope, for instance by expanding their area of work to cover main irrigation system, the watershed/river basin, and most importantly, enter into other economic activities. Thus, new activities, roles and functions will be added and new skills will be required. Then the organizational structure should be adjusted for efficient handling of these new tasks and roles; it may be diversified and division of management and labor may be necessary to undertake special functions.

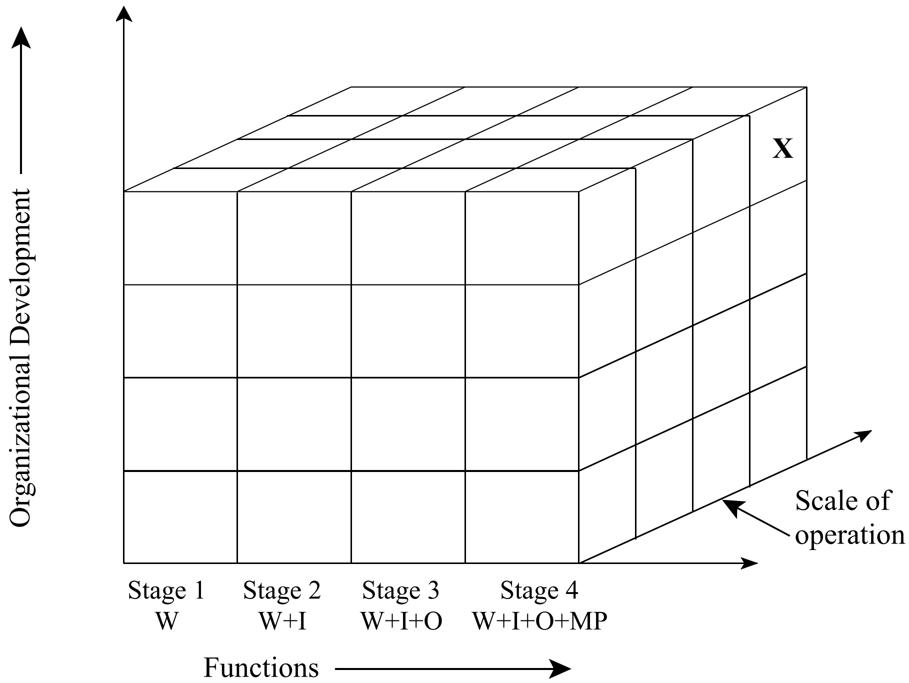
One alternative may be to form task-based groups within a single organization to handle different tasks. FCs or similar (multifunctional business) organizations, once they gain economic strength and management capacities, would become the appropriate organizations for "self-managing" irrigation systems. They could take the responsibility of managing the "agricultural production system" as a whole within which irrigation remains as an integral component.

The basic conditions that are necessary to achieve the goals of irrigation management in the future could then be defined as: a) a multifunctional business organization; b) suitable irrigation infrastructure/ physical system; c) change agents/facilitators, with changing roles at different stages of FO/FC development; d) self-correcting mechanisms and M&E; e) information systems (knowledge) and skill development; f) policy support, including legal and financial; and g) increased benefits/profits to individual members, through collective action.

Farmers' Companies: Certain FOs established under the various legislature and institutional reforms have emerged as forceful pressure groups and they manage to organize water distribution, input supply, and, in a limited way, sale of production. The fact remains, however, that a major breakthrough was not seen to ensure small farmer's economic and social well-being through profitable economic ventures. The absence of a combined set of interventions to promote year-round cropping, crop scheduling, value-added production and other agro-industries, market links in the form of forward contracts of sufficient scale as profitable business, the absence of procedures for decision-making in the implementation of trade policy sensitive to farmers, promoting partnerships between FOs and the OPS as well as between State and FOs – all these remain as obstacles. On the other hand, FCs could be helpful in overcoming at least some of these obstacles. FCs or similar institutions should operate as independent business organizations, which could avoid political and other problems. *Investments through FCs can produce competitive economic ventures for which a necessary condition will be the partnerships with the OPS and the State*.

It might be possible that WUAs/other FOs and FCs perform different roles at different levels. FOs (such as field channel water user groups or distributary canal organizations) as the "base units" can justify their existence within a company framework. These organizations are crucial as base and intermediary units for collective functioning. Usually such institutions are characterized by attributes like: one vote for each member; device for collective operation rather than an economic organization; and largely dependent for success on the maximum participation of a great majority of (if not all) members.

FCs on the other hand, can take the other forms of capital – physical, natural and human – and technology into consideration in an economically and socially optimal manner; can go for relatively large-scale investments; can establish voting rights depending on the ownership of shares; can invest in capital-intensive service functions yet offering equitable opportunities for a given member to benefit; operate as an economic organization, matching with the market economy; and can afford to bargain at the market. FCs, or similar (large-scale) business organizations of farmers/water users, in collaboration with their base organizations/groups (such as field channel groups, distributary-level organizations), may organize production and establish partnerships (e.g., through forward contracts) with the OPS, nationally and internationally. This will reduce government's direct involvement in production and marketing. Moreover, it will no longer be necessary to provide subsidies.[9] It is clear from this discussion that role of WUAs is an evolutionary and dynamic process. Different stages of this process are illustrated in Figure 1. For a typical WUA, the target for the 21st would be to reach a position like "X".



<Legend>
W = water, W+I = water plus production inputs, W+I+O+MP = water, inputs, output and market-oriented production, value-added production, other business

Figure 1. Different Options for Managing Irrigated Production Systems

ROLE OF THE PRIVATE SECTOR

We have already discussed some areas where the OPS could play a productive and mutually beneficial role in irrigation management. These include: a) providing catalytic services for creating and/or strengthening WUAs and other FOs; and b) providing/selling services such as inputs for R&M, irrigation (including modern technology) and for crop production, mainly through formal contractual agreements. As mentioned elsewhere in this paper, developing effective partnerships (in a business mode) between farmers and the OPS is a "prerequisite" for small farmers to become active partners of a market economy. And, it is also an effective way of reducing government expenditure and involvement in irrigation management.

Facilitating the formation of strong FCs and "privatizing irrigation" would be an acceptable mode of transferring management responsibility and at the same time, reducing the burden to governments. Obviously, the present users would then become the "Private Sector". When such a novel "Private Sector" is emerged from within the small farmer sector, it would be profitable for the OPS to establish mutually beneficial business links with farmers.

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9 For a detailed discussion on this subject (of FCs), refer Wijayaratna, 1992, 1997, 1999 and 2000.

There are other ways of private sector participation. For example, the OPS may undertake R&M and even post-R&M management of irrigation systems under different modes of operation, depending on specific conditions and acceptance by the present users. In certain cases, the OPS may involve in infrastructure development (e.g., R&M) and establish "joint ventures" with the present users (usually, small farmers). More often than not, small farmers may find it difficult to share capital in required amounts. In such cases, land may be considered as farmers' share and the government may contribute capital and become a shareholder. In certain cases such an involvement of the State would be necessary only at the initial stage and farmers could gradually buy this "share". The private company could contribute the balance or undertake the responsibility of R&M and become a shareholder. Another alternative would be for the OPS to undertake R&M under "own and operate" basis. A third alternative would be for the OPS to undertake R&M, and sell water to farmers. In this case, farmers may not benefit in the long run unless the R&M process undertaken by the private sector does not improve water availability and yield adequate profits to farmers. In certain other cases, the OPS may undertake new constructions on their own. Then they would own and operate irrigation systems.

In general, in areas where government had played an important role, the reforms or the "adjustment and stabilization programs" have introduced private sector participation for increased efficiency and to reduce the burden to government. However, in certain cases rural people may not have the access or cannot afford the prices of such services offered by the OPS. Therefore, in such cases, it would be beneficial if the communities utilize social capital in developing and managing such services and related infrastructure. This would "create" a healthy competitive environment in which both the newly emerged private sector and the OPS could grow, side by side.

ROLE OF NGOs:[10] FACILITATING INSTITUTIONAL DEVELOPMENT

To achieve sustainability, the challenge is to facilitate and institutionalize a process through which water users/farmers themselves would evolve local organizations to satisfy their own local needs. For this, a catalytic process or a "planned intervention" into the community is required. *Such a catalytic effort should be strong enough to generate the internal dynamism of the community and controlled enough not to dominate it*. The intervention methodology requires potential members (of the rural communities) to promote association, interaction and cooperation with each other; develop their perception of problems and needs; and then begin a process of exploring how these needs could be met. In effect, what needs to be done is to make a planned intervention into the community. Carefully selected and well-trained catalysts or change agents could make such interventions (Wijayaratna, 1985). Our experience with small FOs suggests that these "ideal" features are not found frequently in State-sponsored organizing processes. Instead, local organizations are "formed" (and not "evolved" from within the communities) by field officials not to fulfill people's needs, but merely to follow the orders of the superior officials or to satisfy the politicians. *And, experienced and effective NGOs could bridge this gap and play a catalytic role*.

Facilitating the Evolution of Self-Correcting Mechanisms

To attain self-reliance, local organizations need to adopt self-correcting mechanisms on a continuous basis. An experienced and committed NGO could help WUAs or FOs or FCs to internalize participatory self-assessment procedures to measure and monitor the performance of the organization as well as the development and management processes. In collaboration with the members of other participating organizations, local officials of relevant agencies, resource persons such as technical experts, the NGO could *pave the way for participatory M&E and Management Information Systems (MIS), especially at the planning and initial stages of adoption*. Such a planning process and M&E would help the membership to articulate a possible future vision for their organizations.

It should be noted, however, that in some cases, due to the relative inefficiency in government agencies or due to the lack of effective community organizations at the grassroots level, funding agencies have tended

[10] Usually, NGOs are different from rural people's organizations in that they are generally not grassroots organizations or community organizations. And, in general, the NGOs are funded from outside.

to load new tasks onto NGOs, whether or not they are suited to such tasks. Looking ahead, and in the context of "reduced role of governments", the NGOs will come under increasing pressure as alternatives, especially to government agencies.

The Need for Dynamic and Forward-looking NGOs

It was evident from earlier discussion that, with the diversified and expanded functions expected from the WUAs/FOs/FCs, the role and functions of the change agency/agent or facilitator/catalyst should also be changed. The added roles of a facilitator/catalyst in such situations would include:

i. *identify and estimate market potential* for selected agricultural enterprises and agro-processing, assist in the scheduling of production in a given user company/organization area; inform the company/organization and other technical officers (such as the extension and credit, input supplies) of the availability of markets for enterprises that would match with the agro-climatological and socioeconomic conditions of the area and for the selected processed products;

ii. *estimate the production* of these selected enterprises *jointly with the rural people* and then arrange for *forward contracts with identified markets/buyers*. In this way, the facilitator/NGO would link the producer groups/companies/organizations with potential markets/private sector firms;

iii. *assist the rural community in monitoring the feasibility of meeting the contractual agreements*: For this, the catalyst/NGO would join the local staff of government agencies and other staff of the company/organization and assist the organization/company to monitor, whether there are any constraints faced by the rural community in the water markets, production and processing, etc., which may affect the quantities and quality standards included in the forward contracts or other agreements;

iv. *arrange for expert advice* as well as *other needs* of the organization/company. These will include all aspects of water markets, marketing and processing farm products, storage, packing, transport, etc. The objective is to help evolve the required business mode of operation within the organization/company; and

v. *be accountable to the FO/FC.*

A MODEL FOR SHARED MANAGEMENT OF IRRIGATED PRODUCTION SYSTEMS

In the context of above concepts and procedures, a model aimed at transferring the irrigation management responsibility to farmers and to achieve the goals of sustainable farmer income, is proposed (Figure 1).[11] It should be reiterated that, sustainable farmer income (through commercialized production) is considered as a prerequisite for achieving sustainable irrigation management.

Different actors/stakeholders (farmers, OPS, government and the NGOs) may participate and collaborate with each other in different ways (and at different levels) by providing or receiving one or more of the inputs/services such as the following:

- Managing the main source of water supply/reservoir, including the pricing and selling of water
- Managing canal system and downstream water distribution
- Decision-making in relation to other aspects of irrigation and crop scheduling
- Primary production: high-value crops
- Providing/selling technological and other production inputs
- Purchasing/selling produce through forward contracts
- Processing, value addition
- Policy and regulatory mechanisms
- Handling disputes.

[11] This is a modified version of a model developed for Mahaweli Restructuring and Rehabilitation Project, on behalf of Mihidiya Foundation, Sri Lanka.

Different combinations of stakeholders, primarily WUAs/FOs/FCs, government, NGOs and the OPS (private firms), may undertake R&M and post-R&M activities (like managing irrigation and the production processes) at different levels of intensity using different technologies. It is suggested that, in general, different models for managing irrigation production systems can be specified on the basis of three variables, namely; a) type or the nature of improved water resource utilization (mainly technology and method of irrigation), including R&M; b) post-R&M management of irrigated production system – mainly the type of production process including the selection of crops and cropping patterns, methods of production; and c) the degree of participation by different "actors" or the stakeholders in "a" and "b". Obviously, the type and number of functions undertaken by any user organization and the scale of operation would directly related to its organizational strength or the stage of organizational development. This latter has been illustrated in Figure 1. Figure 2 illustrates the process and the respective roles of stakeholders in managing such an irrigated production system.

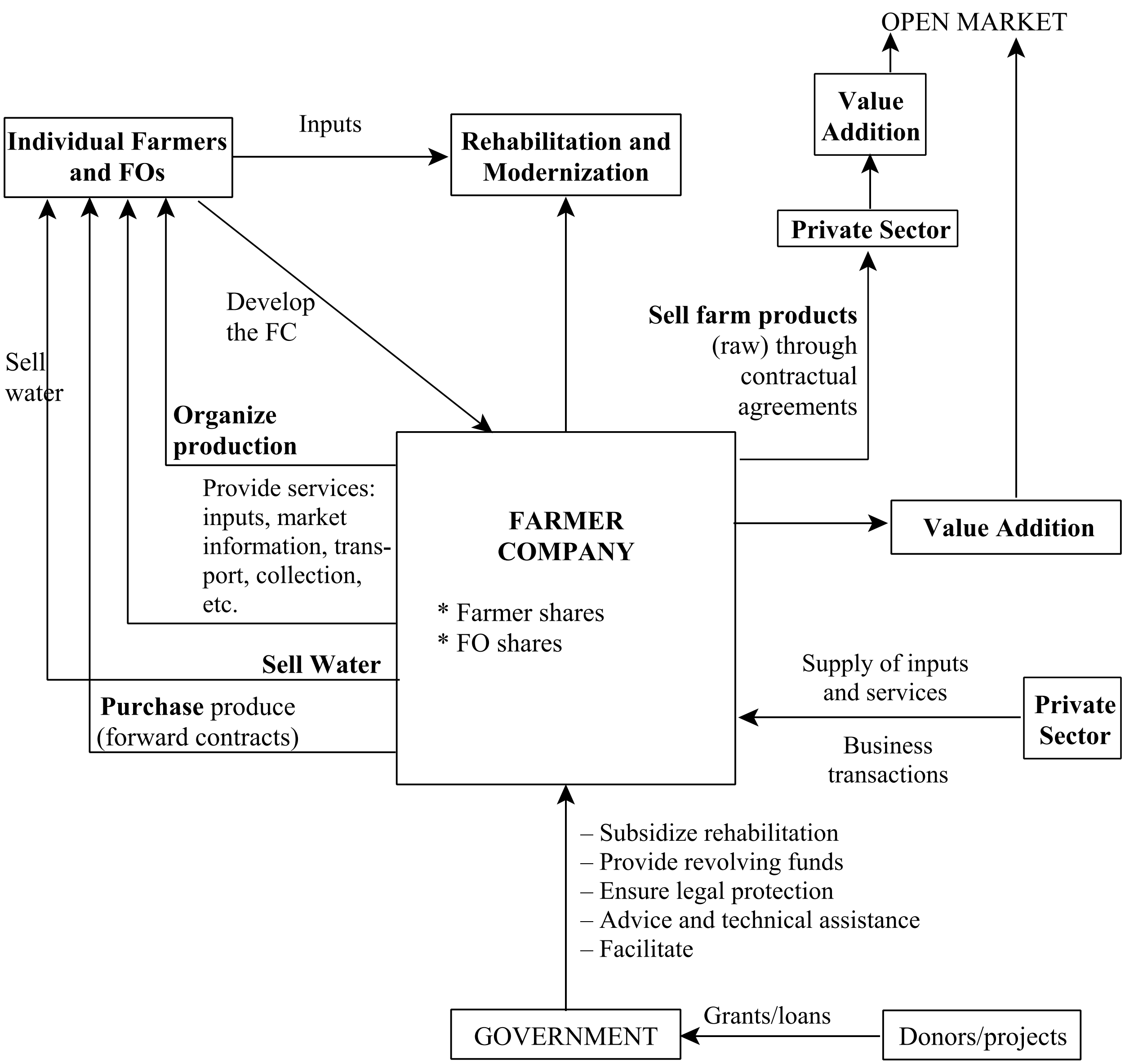

Figure 2. Roles of Stakeholders in Managing Irrigated Production Systems[12]

[12] This is a modified version of a model suggested earlier (refer: wijayaratna, 1999 and 2000).

OTHER ROLES AND FUNCTIONS

Role of Research and Technology

Research has contributed to modernization and, undoubtedly the "modernization" of agriculture has improved the quantity and quality of inputs, including irrigation; enhanced methods of production and the ways of combining inputs; and raised productivity and total production. Also, better technology has contributed to enhance the potential for diversification, and contributed significantly to postharvest improvements. A vast array of technology is now available for irrigation management, extending to the use of satellite information systems, other wireless technologies and electronic methods. These are being used to collect data on many variables related to crop water use, including rainfall, air temperature, soil conductivity, soil and leaf moisture levels, relative humidity, wind velocity, solar radiation, etc. Such data are processed by computer software and recommendations such as quantity and timing of irrigation are made accordingly. *However, analysis itself is not useful to improve water use efficiency. Based on such (socioeconomic, biological and physical) analysis, policy directions and work plans may be formulated. Research outcomes need to be translated into action plans. A more practical strategy would be to employ a "Learning Process Approach" and "Participatory Action Research".*

More efficient methods of irrigation, usually associated with more advanced technologies, could improve the productivity of water. For example, under certain conditions, sprinklers, drip systems, and other methods of delivering irrigation water more closer to roots of crops can control unproductive evaporation. Cost-effectiveness of such methods would vary under different conditions. While the small farmers could organize themselves to benefit from such technology, they need to be encouraged, catalyzed and assisted by the respective governments, funding agencies and the NGOs.

Although certain advanced technologies could be used as "public goods" and extend the use to benefit the vast majority of small and resource-poor water users, there is a tendency for certain technologies to favor the large-scale farms in both developed and developing countries. The other notable trend is that "agriculture" is being transformed into "agribusiness". One may argue that such a transformation that would combine activities to form a "chain" – from input supply of agricultural production inputs to processing and distribution/marketing – may capture economies of scale and enhance overall efficiency. However, if farmers fail to organize, expand their role beyond primary production or strengthen their bargaining power and become an important elements in this chain, they may not get their due share from such developments.

Role of the Financing Institutions

The donor financing for new constructions has declined in the recent past, mainly due to price signals. Price fluctuations induced shifts in investment decisions. A major shift in the supply function of food occurred when the global production of food grains dropped due to unfavorable weather that prevailed in major grain producing areas. Consequently, grain prices – notably rice – rose sharply in the mid-1970s.

Naturally, this signified a situation in which irrigation investments appeared to be "*profitable*". And in response, major donors increased the level of lending for irrigation development. These investments were biased towards "*hardware elements*" of irrigation development; new constructions were initiated and more and more lands were brought under irrigation. In the late 1970s, the reverse occurred. Food grain supplies increased and, consequently, a sharp drop in grain prices was experienced. This in turn led to a notable reduction in investments on irrigation by the major donors (Azarcon, 1990; and Rosegrant and Pingali, 1991). The rationale for making investment decisions in irrigation development (which usually yields benefits over a longer period of time) based on market price fluctuations (which, more often than not is short term) is questionable. Significant "*time lags*" exist in the decisions between price shift and investment decisions, and investment decisions and the realization of "*output*" (e.g., construction of irrigation systems).

A deviation from such a "top-down" and "donor-driven" approach and a more careful decision-making process would be required in financing irrigation management in the 21st century. Also, as it would be beneficial if financing institutions invest more on integrated projects that would combine irrigation, agricultural production, value addition and marketing, etc., with due regard to environmental concerns and sustainability.

Information Systems and Skill Development

To assist in the identification of potential opportunities, the information must encompass a wider range. Information on water resources, irrigation and production technologies, and infrastructure as well as on value-added production and marketing, etc., becomes important when attempting to discover new economic potentials. The objectives of the information systems are manifold. First, the information on new and sustainable technologies, relevant to the activities undertaken by the local communities, should flow down from appropriate sources to the local organizations. Such technology should be affordable by the respective communities and viable. Second, information on opportunities available for local users such as banking and credit facilities, market and processing, etc. should be made available to the local organization. Third, the flow of information on policy, legal and regulatory aspects and information on relevant government or private sector collaboration/assistance and on the work of other relevant user groups/local organizations is of significant importance for pronounced growth and sustainability of local organizations.

A continuous flow of information is required to enrich the implementation process facilitating interaction, debate and resolution. The prudent use of information technology (IT) in the generation, process and analysis of information needed is crucial to support the planning, implementation and evaluation of PIM. For this, the organization may use a MIS and a rigorous self-monitoring and evaluation (M&E) activity through a participatory procedure. It may review the progress and employ a feedback/correcting/warning mechanism to ensure that inputs, work schedules targeted outputs and other related actions are proceeding according to plan.

Similarly, the training and skill development needs of organizations that are engaged in new tasks are of different types and are of continuous in nature. Changing technology and the expansion of activities of the local organizations with their maturity will call for new kinds of training and skill development. Also, the matured organizations will enter into transactions and business with outsiders such as the OPS. Therefore, the sustainability of the organizations will depend, among other things, on the knowledge and skills of their managers and those who are entrusted with specific functions. For example, training on financial management, acquiring skills in managing different types infrastructure, etc., are essential, especially for a multifunctional organization.

CONCLUSIONS

Irrigation management is a multifaceted, multidisciplinary affair that demands collaborative action, and it is difficult to separate the tasks and responsibilities of different stakeholders. Despite the enormous progress made by many countries over the past few decades, irrigation management in the 21st century is faced with many challenges. Rising demands for limited water supplies from rural and urban sectors for agricultural, industrial and household uses pose a formidable challenge. Agriculture will continue to play a significant role in many countries and it demands new strategies and procedures. Hence, irrigation management strategies should be adjusted and organizations and institutional arrangements should be restructured to cater a "market-oriented" growth.

In this process, special emphasis should be given to new institutional arrangements that will be necessary for the commercialization of irrigated agricultural production systems and there is a need for economies of scale to make agriculture profitable. Therefore, it would be prudent to expand the role of WUAs to include non-water functions, including irrigation system modernization, diversified cropping, value addition, etc. In this, it is imperative that strengthened FOs such as FCs establish business links with the OPS for services, including input and output marketing. In that strategy, *the management of irrigation, including O&M responsibilities would become an integral task of such business organizations.*

Hence, it is suggested that the matured organizations would benefit if federate upwards and expand their scope, for instance by expanding their area of work to cover main irrigation system, the watershed/river basin, and most importantly, enter into other economic activities. Multifunctional WUAs, FCs, cooperatives or other forms of federated FOs would be the most appropriate organizations for small farmers to coexist with free market forces. Such organizations would also help reach economies of scale and enhance the bargaining power.

When such a novel "Private Sector" is emerged from within the small farmer sector, it would be profitable for the OPS to establish mutually beneficial business links with farmers. The primary role of the

OPS would be: a) to provide/sell inputs and services for R&M, irrigation, and crop production; and b) purchasing outputs, mainly through *formal contractual agreements*. The OPS may also undertake R&M, and even post-R&M management of irrigation systems under different modes of operation, depending on specific conditions. It may even involve in infrastructure development (e.g., R&M) and establish "joint ventures" with the present users.

For such an institutional transformation, a catalytic process or a "planned intervention" is required. Such a catalytic effort should be strong enough to generate the internal dynamism of the community and controlled enough not to dominate it. And, experienced and effective NGOs could play this catalytic role. Capacity building and a continuous flow of information are required to enrich the implementation process facilitating interaction, debate and resolution. The prudent use of IT in the generation, process and analysis of information needed is crucial to support the planning, implementation and evaluation of PIM. For this, the organizations may use MIS and a rigorous self-M&E activity. In the end, organizationally and financially fully autonomous business organizations should emerge and they should be accountable to membership, be dynamic and responsive to changes and maintain effective business partnerships with the OPS. Governments could then perform facilitating and regulatory functions and conflict resolution related to competing uses and users. An improved dialogue between governments, NGOs, people's organizations and the OPS as well as effective coordinating mechanism would be crucial for the sustainability of such partnerships.

Irrigation systems need to be rehabilitated and modernized, not only to suit the present day needs, but also to face with future challenges. R&M should consider hydrological and other linkages between the subsystems of the main irrigation system as well as interactions among different segments (micro/sub-watersheds) within the river basin/watershed, adoption of novel production technologies and marketing of agricultural products. Such a strategy would *enhance farmer profits and this in turn will enhance their capacity to manage their systems. Effective irrigated area and the time productivity of water* would be enhanced through the rational selection of crops, cropping patterns and timing of cultivation; diversified cropping, including high-value crops; application of appropriate technology; and maximizing the utilization of rainfall in both irrigated and non-irrigated areas.

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INTRODUCTION

Irrigation can be defined as the practice of applying water to soil to supplement natural rainfall, in order to provide moisture for plant growth. It is considered as the leading input in the Green Revolution technology. It is the prime mover of growth for Bangladesh agriculture. The rapid growth in irrigation, especially minor irrigation made it possible for Bangladesh to make a progressive shift from a high-risk monsoon-dependent agriculture to lower-risk agriculture. But still it is characterized by low irrigation coverage and low-level capacity utilization.

The net cultivable agricultural land in Bangladesh is about 9.03 million ha of which 7.5 million ha are suitable for irrigation (Jaim, 1993). At present 4.48 million ha (49 percent) is under irrigated condition out of which about 3.4 million ha land are being irrigated by an existing 0.629, 0.025 and 0.063 million of shallow tube wells (STWs), deep tube wells (DTWs) and low lift pumps (LLPs), respectively. But the total operational capacity of this equipment is equivalent to about 8.8 million liter per second, capable of irrigating over 6.4 million ha. STWs account for 72 percent of total capacity, and DTW and LLP for 14 percent (Ministry of Agriculture, 2001).

A World Bank report shows that, in the future at least another 2.6 million ha of land can be brought under irrigation through groundwater utilization and an additional 1.2-million ha through surface water development (Ghani and Rana, 1992). Thus, a total of up to 6.8 million ha could be brought under irrigation. Out of 2.6 million ha, 40 percent of the area is suitable for DTWs and 60 percent area for STWs (Department of Agricultural Extension, 1992). Hence, a long-term national policy for both vertical and horizontal expansion of irrigation should be under taken to achieve the target food production of the country.

This paper assesses the chronological development and impact of irrigation systems for crop production in Bangladesh. The paper also identifies the constraints and suggests policy implication for irrigation development in Bangladesh.

HISTORY AND POLICY FOR MINOR IRRIGATION DEVELOPMENT

The development of irrigation in Bangladesh passed through a series of phases. These are: (i) public sector initiation phase; (ii) public sector rationalization phase; (iii) private sector expansion phase; (iv) return towards public sector control; and (v) private sector liberalization and expansion phase.

Public Sector Initiation Phase (1951-74)

Before 1950, irrigation was done using manually lifted devices like dooms and swing baskets drawing on surface water sources as well as dung wells to tap shallow ground aquifers. In the 1950s, the then East Pakistan Government attempted to modernize irrigation with the creation of Water and Power Development Authority (WAPDA) in 1959 and the East Pakistan Agricultural Development Corporation (EPADC) in 1961. WAPDA was primarily involved in developing canal irrigation projects but from 1962-68 it also launched a tube well project in the northwestern part of the country using 380 four-cusec DTWs. EPADC started minor irrigation through a LLP system in 1961 and DTW program in the following years. In 1969 EPADC started renting the LLPs on a yearly basis and the farmers had to pay for fuel themselves. The DTW program of EPADC began with 200 two-cusec wells installed in the Comilla area on an experimental basis between 1962 and 1970. These DTWs were about 75 percent subsidized and were rented to farmers' cooperatives

(*Krishak Samabaya Samiti* [KSSs]) organized by the Integrated Rural Development Program (IRDP). After the independence of Bangladesh in 1971, Bangladesh Agricultural Development Corporation (BADC) (former EPADC) expanded its LLP and DTW rental programs and started to include STW rental in the early 1970s. The STW rental program was converted to a sales program after 1974-75.

Public Sector Rationalization Phase (1974-79)

In this phase, the Government of Bangladesh attempted to rationalize its minor irrigation program to lighten the budgetary and management burden for running an expanded number of pump schemes. By 1980 there were about 10,000 DTWs, 35,000 LLPs and 22,000 STWs in operation BADC maintained its control over DTW and LLPs procurement, installation and rental. STW subsidies dropped to a very low level and a credit program for STW purchase was put in to place through the Bangladesh Krishi Bank.

Private Sector Expansion Phase (1979-84)

There was a continued government effort to decrease the role of public sector involvement in minor irrigation and increase private sector activity during the late 1970s through to the early 1980s. The irrigation equipment rental programs were recognized as too expensive and insufficient incentives existed for farmers to improve capacity utilization (Government of Bangladesh/World Bank, 1982). As a result there were simultaneous moves to discontinue LLP and DTW rental programs and shift to selling both new and old LLPs and DTWs to groups in the private sector. BADC continued to control sitting, installation, spare parts and mechanic services for DTWs through the late 1980s. For STWs, liberalized credit, decreased import duties and the involvement of the private sector in equipment importation, led to a rapid increase in the number of wells. By 1983-84 the number of STWs increased to 120,000 as compared to 22,000 in 1980 (International Irrigation Management Institute [IIMI], 1995).

Return Towards Public Sector Control (1984-87)

In the 1983 dry season, a greater than expected drawdown of groundwater was reported in the northern districts of Bangladesh. The alarm that this event seems to have caused triggered a response from the public sector that may have been partly a reaction to the corrosion of agency control of minor irrigation during the previous decade. Actions taken by the government in 1984 and 1985 included: a ban on STW sales in 22 northern sub-district areas; an embargo on the importation of the small diesel engines used in STWs; standardization of engine brands; and formation of the Groundwater Management Ordinance imposing a mechanism of spacing requirements on all tube wells. In addition, agricultural loan disbursements were decreased following prior irregularities and large loan repayment defaults. STW engine distributors and importers were also vilified. As a result STW expansion slowed in 1984 and practically stopped during 1985 through 1987 (IIMI, 1995). Meanwhile, the groundwater level in the northern districts affected in 1983 had returned to normal in 1984 before any of the changed policies had taken effect.

Private Sector Liberalization and Expansion (1987 onwards)

Due to the slow growth of irrigation during previous years the government removed the restrictions imposed earlier in 1987. In this year the ban on importation of small diesel engines was removed. Simultaneously, import duties on irrigation equipment, engine standardization and tube well sitting restrictions were eliminated during 1988-89. Private importation and sales of STWs and LLPs picked up sharply, though there was a temporary slow down following a doubling of diesel fuel prices at the time of the Gulf War (1991). BADC started clearing its equipment stock. There has been a maturing equipment market, spare parts shops, repairing workshops and private mechanic services are available at district, sub-district and even the local level.

IRRIGATION DEVELOPMENT AND FOOD OUTPUT GROWTH

In Bangladesh agriculture sector, food output growth rates in excess of 3 percent must be maintained and sustained if the needs of the population are to be met domestically. With an estimated population increase from 132 million in 2000 to about 169 million in 2005, food grain output must grow at the rate of 4-5 percent to achieve food grain self-sufficiency targets (Sarker, 2000). Similarly, production of pulses must grow at 3.8 percent. Since the mid-1970s, growth in food grain output has been closely correlated to increase in irrigated area: studies show that for every 1 percent increase in irrigated area, food grain production increases by 0.6 percent (Sarker, 2000). However, because some of the increased production can be attributed to better management, fertilizer use, high-yielding variety (HYV) rice and flood protection of irrigated area, the irrigation-specific increase in production is about 0.4 percent.

Minor irrigation projects in Bangladesh comprise LLPs, DTWs, STWs and manually operated pumps (MOPs) (IIMI, 1995). Since 1973 the area under irrigation has expanded from 0.5 million ha to 4.48 million ha in 2000 (National Minor Irrigation Development Project [NMIDP], 2001). Over 92 percent of this area is irrigated by various modes of minor irrigation and about 8 percent by major surface water canal schemes. The contribution of different irrigation technologies to total irrigated area has changed considerably over time. STWs have increased in importance, from 24 percent of total area in 1982-83 to 60 percent in 2000, whilst the total irrigated area has also increased rapidly. After many years of contributing to about 15 percent of the total irrigated area, DTWs have started to decrease in recent years, to 11 percent of total area in 2000. Manual groundwater systems contribute about 1 percent of the total. LLPs show a long-term relative decline from 22 percent to 13 percent of total area between 1982-83 and 2000. Traditional systems have declined considerably, from 27 percent to 5 percent (Figure 1). The contribution of groundwater to total irrigated area has increased from 41 percent in 1982-83 to 75 percent in 2000 and has gone up each year. The contribution of surface water has declined from 59 percent in 1982-83 to 25 percent in 2000.

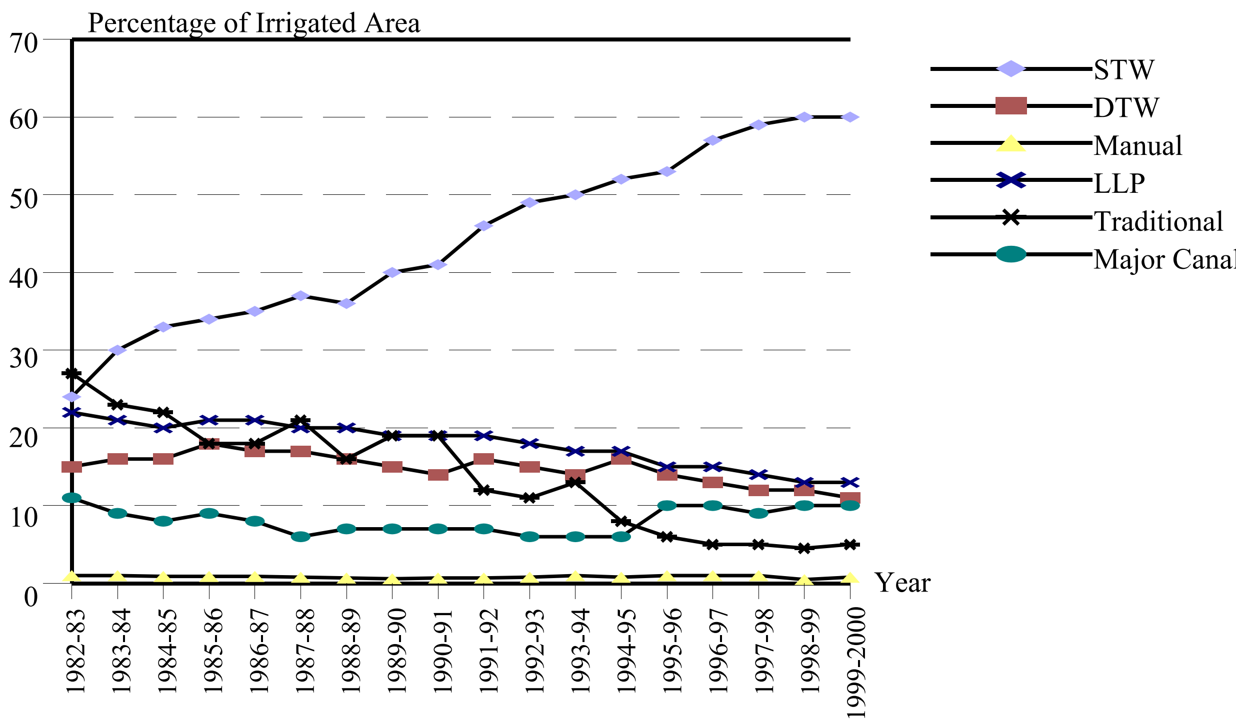

Figure 1. Percentage of Irrigated Area under Different Modes of Irrigation

IRRIGATION DEVELOPMENT AND CROPPING PATTERN

The *rabi* season cropping pattern is dominated by HYV *boro* rice with 82 percent of the total and wheat (10 percent). *Kharif* cropping is only a small proportion of the *rabi* area (6 percent) and is dominated by T. Aman rice.

HYV *boro* rice always dominated minor irrigation and the proportion of rice has tended to increase, it was 82 percent in 2000. Wheat area was 10 percent of the total area in 2000, but still below its peak of 12 percent in 1986-87. Other crops showed a small increase to 8 percent in 2000 (Figure 2).

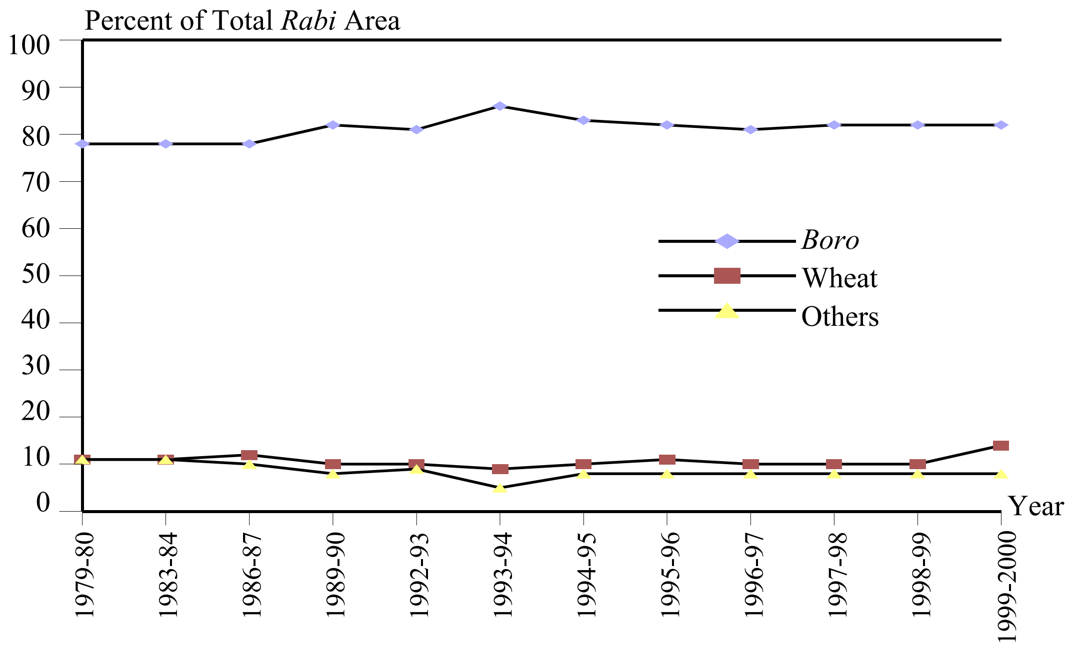

Figure 2. Trends of Crops to Total Irrigated Area

IRRIGATION WATER MARKET

The cropping pattern in Bangladesh has shifted from the traditional variety of Aman to the HYV *boro* variety, which requires intensive irrigation; hence, the demand for irrigation water is increasing. There has been a rising dependence on groundwater, mainly because surface water sources become silted up. The tube well owners pay the costs of fuel, lubricants repairs, canal repair and salary to the pump operators or lineman, and charge the farmers a fixed fee per hectare of land for supplying water within the command areas. Repairs and spare parts costs sometimes appear to be critical factors affecting tube well owners returns from selling water, which also influence productivity. Expansion of the spare parts markets and development of private workshops and mechanical services have the potential for improving irrigation markets in Bangladesh.

The water market has a profound implication for tube well capacity utilization as well as for returns to tube well owners and farm households as the amount paid for irrigation determines both the returns of the tube well owners and the profit of the farm households from irrigated crops. About 79-86 percent of pumped water is being sold.

LINKING MAIN IRRIGATION SYSTEM MANAGEMENT TO FARM LEVEL MANAGEMENT

The Water Resources Planning Organization (WARPO) is charged with overall integrated water sector resources allocation and macro level planning while Bangladesh Water Development Board (BWDB) is the principle agency responsible for carrying out those plans into action after conducting micro level planning. Water sector development strategies and policies have undergone numerous changes overtime and consequently the medium- and short-term plans had to be modified and guided by these policy objectives. For example, minor irrigation which covers about 90 percent of the total irrigation areas, was gradually privatized and now it is entirely operated by the private sector. Necessary policy measures have been taken to reduce the capacity gap between big and small farmers through formation of water users groups and by providing technical services and credit to small farmers.

IRRIGATION PROJECTS IN BANGLADESH

Major Irrigation Projects

In these systems, water generally flows from the source as gravity flow through main, secondary, tertiary and field canal to the plot. Sometimes it requires double lifting. Initially water is lifted from the river to the main canal, then, it is allowed to flow through canals by gravity or again lifted by LLPs. The projects are: Ganges Lobadak, Tista Muhuri, Chandpur, Barisal, Bhola and Meghna Dhounagada, etc. BWDB manages all major irrigation projects. A recent study shows that major surface water irrigation projects achieved 54 percent of their potential capacity. So they have the capacity to increase their potential command area.

Minor Irrigation Projects

Minor irrigation projects comprises of LLPs, DTWs, STWs and MOPs. The capacity of the devices varies 1 liter per second (l/s) to 56.6 l/s. At present 528,335 STW, 32,135 DTW and 62,341 LLPs are used for irrigation. There is scope to increase the number of devices to increase the command area and also to increase the productivity of crops.

WATER MANAGEMENT TECHNOLOGIES

Field Level Water Management

How to apply irrigation water in the field is one of the important factors for water saving and crop production. Irrigation interval for rice irrigation is one of the technologies available for this. Experimental results showed that irrigation at five days interval and 10 days interval could save about 25 percent and 40 percent of irrigation water than continuous 5-7 cm standing water in the rice field. Another experiment showed that irrigation water application three days after disappearance of water from the rice field could produce optimum yield of rice. The farmers can adopt the technologies in major and minor irrigation system.

Water Distribution System Management

* ***Earthen Channel Management***: The farmer generally uses earthen channel. About 40-70 percent of water could be lost through the earthen channels. This system may be improved by compaction of channel and using low cost lining materials. The lining materials may be heavy clay, rich husk and clay mixture and sand cement plastering of the channels.
* ***Pipe Irrigation Systems Management***: GI, PVC, CC and plastic pipe are available in Bangladesh. The pipe irrigation systems consist of buried pipes, or semi-buried pipes and/or surface laid pipes. In these systems, there is no conveyance loss. Water is delivered in the field. GI pipe is costly than PVC and the latter is costly than CC and plastic pipes. Plastic pipe is cheaper than any other pipe. This is one of the best methods to control water loss with low cost. For STW plastic pipe of 3” and 4” diameter may be used directly from the delivery point to any plot. Inland Water Management Division of Bangladesh Rice Research Institute demonstrated the use of plastic pipe in the farmers’ fields.
* By introducing the pipe distribution systems, about 37-41 percent command area can be increased. The Benefit cost ratio (BCR) of the pipe irrigation system varied from 2.74 to 1.43 on the basis of 15-45 percent discount rates. Pipe distribution systems were found to be highly economical, based on the BCR and internal rate of return (IRR) analysis.
* ***Supplemental Irrigation Using Irrigation Devices in T. Aman Rice***: In the T. Aman rice season, most of the time rainfall ceases around first and second weeks of October. As a result, rice crops suffer from moisture stress and yield is reduced drastically. In such situations, supplemental irrigation can minimize the yield loss. Therefore, irrigation devices like DTWs, STWs, LLPs and indigenous devices may be used for supplemental irrigation to sustain rice production.

CONCLUSIONS AND POLICY IMPLICATIONS

* Major and minor irrigation projects have the potential to increase their command areas. These have positive effects on cropping patterns, cropping intensity, agricultural productivity, farm income and employment. Therefore, the government should continue to maintain a policy environment that favors private sector investment and operation of major and minor irrigation equipment.
* BWDB manages all major irrigation projects. Recent study shows that major surface water irrigation project achieved 54 percent of their potential capacity. So they have the capacity to increase their potential command area.

* A total of up to 6.8 million ha could be brought under irrigation. Out of 2.6 million ha, 40 percent of the area is suitable for DTWs and 60 percent area for STWs. Hence, a long-term national policy for both vertical and horizontal expansion of irrigation should be undertaken to achieve the target food production of the country.
* Supplemental irrigation should be done in T. Aman season with the existing minor irrigation devices to increase and sustain crop production.
* Irrigation scheduling with the 5-10 days irrigation and irrigation after three days of disappearing water from the field could save irrigation water and increase command area. Therefore, steps should be taken to improve on-farm water management practices. To ensure a regular water supply to crops, it requires an improved irrigation plan (i.e., when to irrigate and how to apply). Agricultural extension workers can assist in this regard. In general, policies should be taken to promote water management training to farmers for better understanding of on-farm water management.
* In minor irrigation systems, command areas could be increased through introduction of PVC and plastic pipes. The system can save about 83 percent water compared to the earthen channel. Further the command area could be increased by about 40 percent. The system becomes highly economical considering the BCR and IRR analysis up to the discount rate of 45 percent. But the initial investment cost of the system is high. Therefore, individual farmers or tube well owner may not be interested to install the system. In other words, installation of the system becomes a precondition for deriving benefit from the improved distribution system. Thus, the government or NGOs should take the necessary arrangement to promote the system. If the system becomes more effective and popularized among the farmers, existing command area of DTW would be increased sharply and consequently national production and income would also be increased.
* Irrigation technologies developed by research institutes should reach the end-users (farmers) through GO and NGOs. Therefore, the government should continue to maintain a policy environment that favor and strengthen research and extension linkage.

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2. REPUBLIC OF CHINA

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INTRODUCTION

Irrigation in Taiwan

Food production was traditionally the only and most important objective of agriculture in Taiwan. Exports of produce earned a significant amount of foreign exchange that became the solid foundation for today's industrial development of Taiwan. The origin of irrigation practices in Taiwan can be traced back hundreds year ago since the Ching Dynasty. Some farsighted farmers assembled local farmers, gathered their own money and land for their own irrigation needs. Some famous historical irrigation canals in Taiwan were named after these founders. Canals and ponds were constructed by the farmers themselves for better food production. Organizations were also formed by the farmers for management of these irrigation facilities. These farmers' groups were transformed into more consolidated unions under Japanese governance. Today, irrigation associations, which are evolved from the former farmers' organizations, are the basic irrigation management institutions in Taiwan. Currently, the irrigated farmlands occupy 685,221 ha (Table 1).

Table 1. Irrigated Areas in Taiwan

(Unit: ha)

Year	Paddy	Upland	Total
1992	448,944	219,265	668,209
1993	463,557	206,552	670,109
1994	421,595	226,020	647,615
1995	452,486	220,149	672,635
1996	425,352	200,376	625,728
1997	429,306	231,666	660,972
1998	429,328	244,137	673,465
1999	425,510	210,258	635,768
2000	403,467	222,977	626,444
2001	430,147	255,074	685,221

Organization of Irrigation Associations

As shown in Tables 2 and 3, there are now 17 irrigation associations in Taiwan with comprehensive irrigation network and facilities as well as staffs and budgets of their own.

Some irrigation associations even own their reservoirs. The irrigation association collects membership fees from its members and supplies water to them for their farm irrigation needs. The associations build and maintain their distributing infrastructures and manage the irrigation practices with their own personnel as private sectors. The membership fee is collected on area basis. The president of the association is elected by the farmers and is responsible for all the administration and the management of the association. A legislative body consists of councilors also elected by the farmers supervising the operations of the association. The candidates for the president and the councilors should hold memberships to be eligible being elected. The collection of membership fee has been discontinued since 1990. The government subsidizes this financial deficiency by its annual budget. This change increases the government subsidiary to the irrigation operations (Table 4).

Table 2. Total Command Area of Irrigation Associations in Taiwan

Year	Command Area (ha)	Members	Average Farm Area (ha)
1999	382,918	1,116,505	0.34
2000	381,810	1,189,307	0.34
2001	380,901	1,107,973	0.34

Table 3. Statistics about the Irrigation Associations

	Unit		Percent of Total
Number of association	Number	17	
Employee	Number	2,994	
College education		1,278	42.7
Graduate		47	1.6
Workstation	Number	292	
Working group	Number	3,469	
Irrigation canal	meter	45,756,943	
Main line		3,833,249	8.4
Secondary		4,552,877	9.9
Sub-secondary		4,829,202	10.6
Tertiary/quaternary		32,541,615	71.1
Drainage	meter	22,072,936	
Tunnel	meter	99,233	
Dike	meter	17,842	
Annual budget	US$000	408,597	

Table 4. Government Budget for Irrigation

Year	Budget (US$ million)	Percent of Total Government Budget
1986	20.4	0.10
1987	21.3	0.10
1988	45.8	0.18
1989	60.5	0.15
1990	92.5	0.24
1991	113.2	0.24
1992	145.4	0.26
1993	156.1	0.25
1994	172.7	0.27
1995	184.1	0.27
1996	191.5	0.29
1997	180.7	0.26
1998	180.9	0.25
1999	227.9	0.26
2000	249.6	0.27

The irrigation association in Taiwan is not a governmental agency. It is an autonomy formed by the farmers more or less like a water users' association in other Asian countries. The organization and administration framework has been formed during Japanese governance. The staff in the association may be regarded as technicians or engineers employed by the farmers.

The organizational chart of a typical irrigation association is shown in Figure 1. There is a chief engineer and a general manager under the president of the association. The Engineering Division does all the engineering works to keep the irrigation system functioning. These include designs, construction and maintenance of distribution canal system and related control structures. The Management Division is responsible for the irrigation planning, scheduling, operation and management. The Financial Division handles the budget and accounting red tapes and manages the properties of the association.

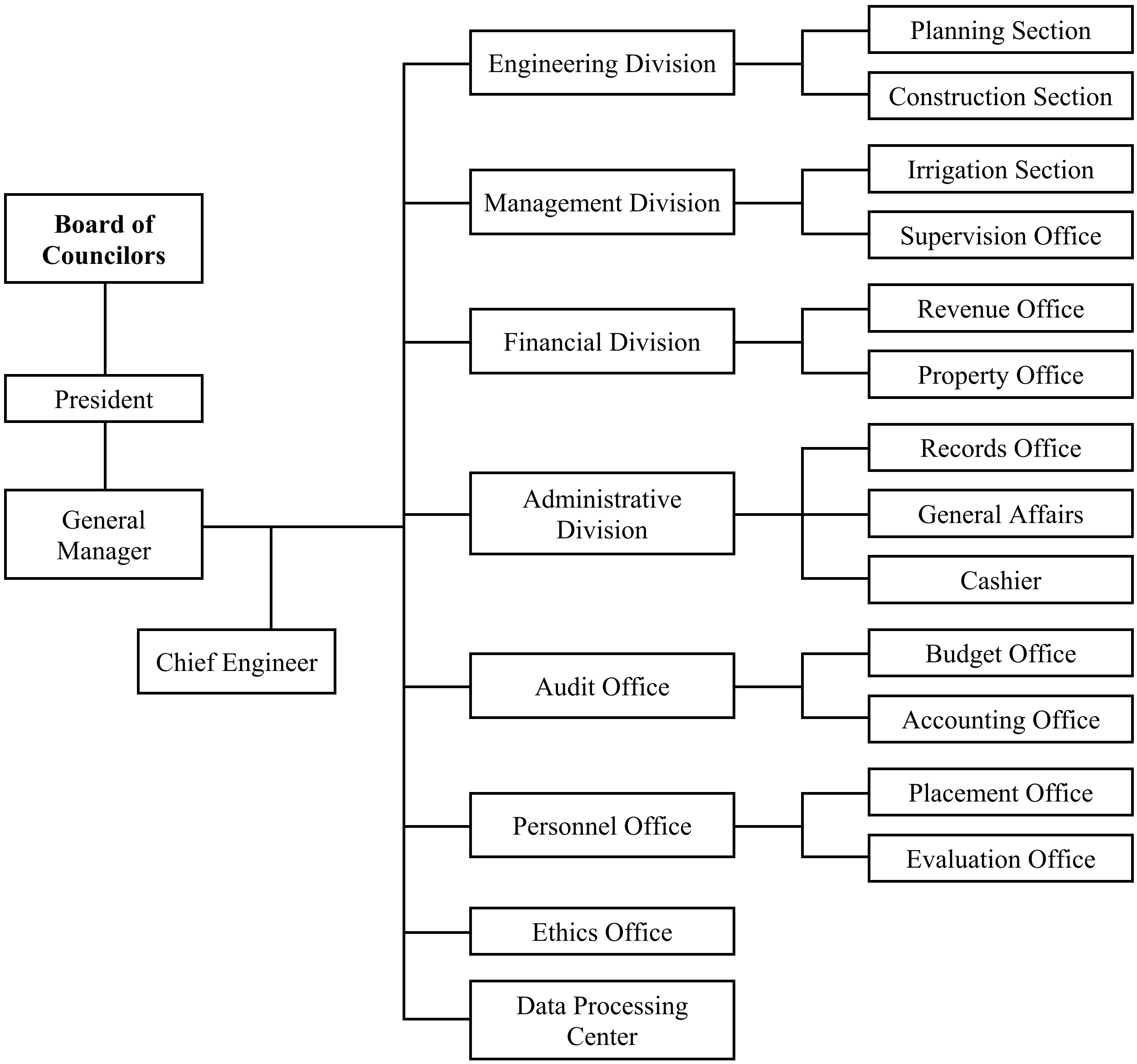

Figure 1. Organization Chart of Irrigation Association in Taiwan

FRAMEWORK FOR IRRIGATION MANAGEMENT

For efficient distribution and management of irrigation water, the command area of an irrigation association is divided into workstations with an average area of 1,500 ha. The workstation has its own administration housing furnished with staffs and facilities to perform such official business as engineering and management. For irrigation associations with larger command areas, 10-15 workstations are grouped as a management section. There are several irrigation-working groups with an average area of 150 ha under each workstation. The group is the basic operational unit of the irrigation association. Each group is subdivided into three or more "Rotational Units" with about 50 ha in area each. In area without enough water supplies, these rotational units take turns in growing paddy. For example, the *two crops in every three year rotation* means two rotational units in paddy and the other in upland crop such as corn each year.

The staff delivers water to the check gate of the working group and the farmers themselves take the distribution jobs from there. Hierarchical structure of the irrigation management framework is shown in Figure 2. The divide of the main system and the farm level system is the check gate of the irrigation-working group (Figure 2).

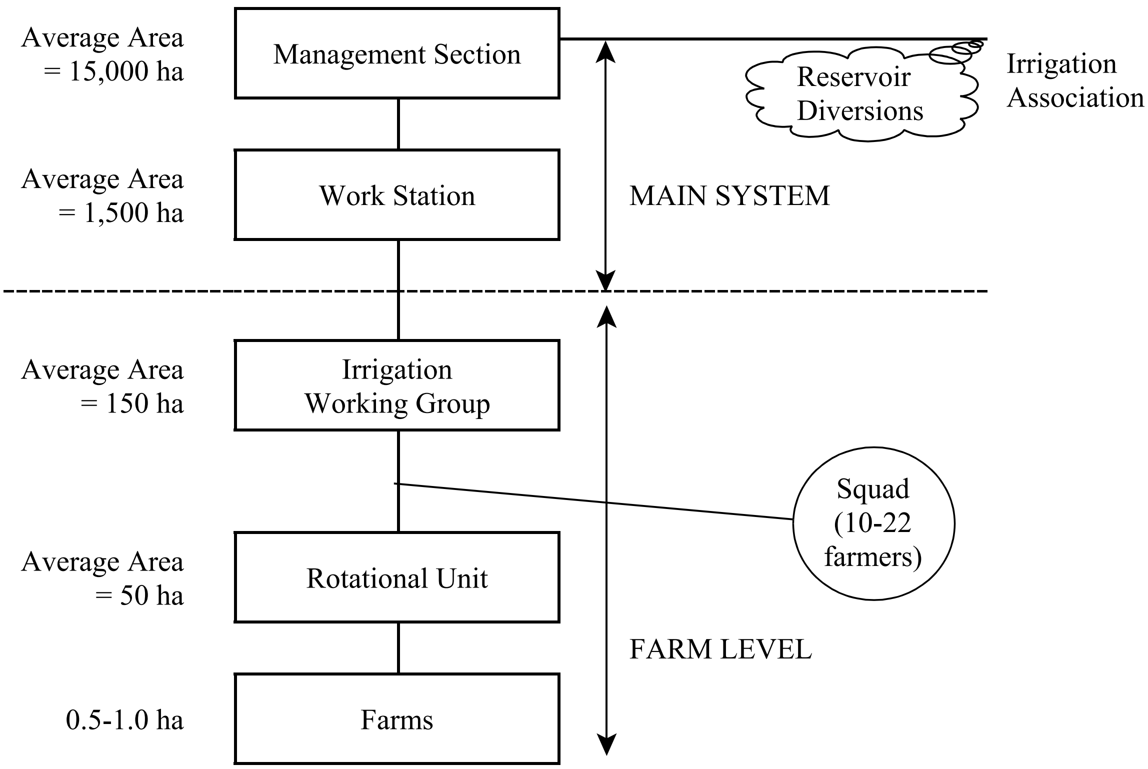

Figure 2. Hierarchical Structure of the Irrigation Management Framework

The Irrigation-Working Group

An irrigation-working group covers an area of about 150 ha. It is further divided into three or more rotational units. Each unit has its own irrigation manager who patrols the irrigation canals, distributes the irrigation water among farms, and conciliates disputes of water distribution. To act as the irrigation manager by turns is the obligation of the farmers. Otherwise, an irrigation manager may be hired and paid by the farmers for the work. Each irrigation-working group has a chief who is elected by the farmers in that working group. He/she is the connection of the farmers with the irrigation association, which manages the sources of irrigation water and main irrigation systems. The missions of the irrigation-working group are as follows:

* Distribution and management of irrigation water;
* Maintenance of the farm irrigation systems and facilities;
* Monitoring the water quality in the irrigation canals;
* Management of the irrigation ponds;
* Dispute conciliations;
* Collections of irrigation fees; and
* Dialogue with the Irrigation Association for regional affairs.

Because of the small farm size, an irrigation-working group may consist of hundreds of farmers. According to the rule of irrigation autonomy, 10-20 farmers may be formed into a squad. The chief of the irrigation-working group assigns a squad representative to help him/her for better administration and to facilitate communications with his/her fellow farmers. A meeting of group members will be held at least once annually for discussion of related issues in the groups and to set up plans for irrigation.

ISSUES AND CONSTRAINTS OF IRRIGATION MANAGEMENT

The irrigation management framework of Taiwan as described above has been functioning well for long time in the last century and made remarkable improvement in the agricultural production system. But in the last decade, the irrigation management system has confronted with some difficulties and challenges. Because of the rapid development in industrial and commercial sectors, the share of agricultural production in the GDP has declined and is relatively insignificant. At the same time, there is a growing competition for resource allocation among sectors. Consequently, the agricultural use of considerable amounts of land and water resources had become contentious. Besides, the decline in importance of and profits from agricultural production resulted in a decline in government support and farmer participation. This creates the following problems:

Water Supply Shortage

Paddy is the most important cash crop in Taiwan. Most of the paddy fields are located within the command areas of irrigation associations and are irrigated by the associations. Reservoirs, diversion weirs, and wells are used for water supplies. For the farms outside the command areas, groundwater is usually used for irrigation. The irrigation associations have served the agricultural production for decades but are now facing a major challenge of water supply shortage.

The water supply in Taiwan becomes more and more deficient than ever, mainly due to the rapid growth of population as well as due to the increased commercial and industrial activities. As it is more difficult nowadays to develop new sources of water supply due to the lack of dam sites and the environmental concerns, there is an urgent need for higher water use and improving management efficiency. By nature, the water supply in Taiwan is not steady and water shortages do occur from time to time. Since the agriculture sector holds the major portion of the total water right (about 78 percent in Taiwan), others such as municipal, commercial and industrial sectors usually turn to agriculture for temporary water loans during the drought. It is then necessary to increase the efficiency of irrigation management or even to stress the crops to cut down the irrigation demand during the drought. This makes the role of irrigation management more important.

As the food supplies become more sufficient, food production will no longer be the single purpose of irrigation for this century in Taiwan. The food production will be limited to the amount required for self-sufficiency. As a consequence, the irrigated area and irrigation demand are decreasing. For future development, the agriculture must be balanced among the triad of food production, environmental protection and improvement of everyday living of the society. For example, canals would be integrated with the regional drainage systems, and esthetics would be an important issue for the reformation of the canal network.

Budget

Traditionally, the financial sources for irrigation management came from irrigation fees collected from the beneficiary farmers as well as from the government subsidies. As mentioned earlier, the irrigation fees are no longer collected from the farmers since 1990. The government compensates these financial losses by increasing subsidies to the irrigation associations. These amounts of subsidies remained the same as they were in 1990. Most of the irrigation associations suffer from these financial deficits and have to sell some of their land to meet these urgent needs. Some irrigation associations that are near to the urban area do not have problems as they gain benefits from the increase in land values, but those near the rural area may confront with such severe problems as bankruptcy.

Willingness to Participate

Most of the rural areas in Taiwan suffer from the problem of manpower shortage. Young generation leave for urban area seeking better job opportunities. This is mainly because of the low financial reward in agricultural production. Most of those stay in rural areas and in agriculture are elderly farmers. The revenues from farming activities take a relative low percentage of household incomes. All these factors reduce the farmers' participation in farm irrigation management. Usually, less than 10 percent of the farmers attend working group meetings. The irrigation management today is totally carried out by the excellent staff and administration of the irrigation associations. In order to cut down the cost of maintenance and to reduce conveyance losses in tertiary canals, most of the unlined canals have been replaced with pre-casted concrete u-type canals. And the irrigation association is also dealing with regional drainage and water quality monitoring jobs.

CHALLENGES AND FUTURE PROSPECTS FOR IRRIGATION MANAGEMENT

Demand-driven Irrigation Management

Because of the food consumption habit, farmers in Taiwan traditionally consider that growing paddy as the first crop option. As Taiwan participates in the World Trade Organization (WTO), in the future the agriculture sector would confront severe competitions from foreign produce. The subsidy for agricultural production would not be possible then, and it is predicted that the agricultural activities would decline rapidly. Some of the paddy fields would then be converted into other more profitable crops such as fruits, flowers, and vegetables. This change in cropping patterns would create new challenges to irrigation management. The scheme of rotational irrigation may no longer be suitable for this more dynamic irrigation needs.

In the old irrigation scheme, water has been distributed to farms by the irrigation association on schedule. As the diversity of crop in the farm level increases, this irrigation scheduling may not be appropriate. The irrigation service may have to resemble that of municipal water supply. The farmer may wish to irrigate, as they demand it, instead of as scheduled by the irrigation association management staff. An ongoing research program studies the possibility of using storage ponds to save water as the irrigation association distributes it and when the farmer is not in need. In addition, the potential for using pipelines for saving water is also being investigated. This might replace the open channel for saving water losses and increase farm irrigation flexibilities.

Dynamic Regional Water Planning and Management

The shrinkage of paddy fields would produce some environmental and social impacts. The abolishment of farming would bring about the release of the farmland and desuetude of irrigation canal systems. This released farmland would soon be converted into industrial, commercial or residential uses. This will bring more water demands in these sectors. The diminishing canal systems may cause some problems to regional drainage. Better and more flexible regional water demand planning model is needed for this rapid change in regional development.

As the water shortage becomes more and more severe, possibility of drought will become higher. As mentioned earlier, because the agriculture sector has more water right than others, it is most frequently asked to allocate and transfer water to municipal and industrial sectors during a severe drought. The irrigation management is then confronted with drought allocation challenge. A decision support model linking crop model and water allocation model would then become a solution to this complicated problem.

Application of Information Technology (IT) in Irrigation Planning and Management

The spatial variations of irrigation management-related information is multifarious and disorderly because of the vast extents covered. Paper maps and card system were used for handling these spatial/ temporal data. But the storage, search, edit, and update of these papers from records are difficult and inefficient. IT is introduced in irrigation management in Taiwan in the last two decades. Digital maps and database are used in the irrigation association for better irrigation planning and management.

3. INDIA (1)

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INTRODUCTION

Agriculture is of fundamental importance to India. It contributes 25 percent to GDP and generates 60 percent of employment. One of the major concerns in India today is to increase agricultural productivity, which is quite low compared to many Asian countries. For example, while Republic of Korea and Japan have cereal productivity level of around 6 mt/ha, the productivity level in India is only 2.2 mt/ha (Figure 1).

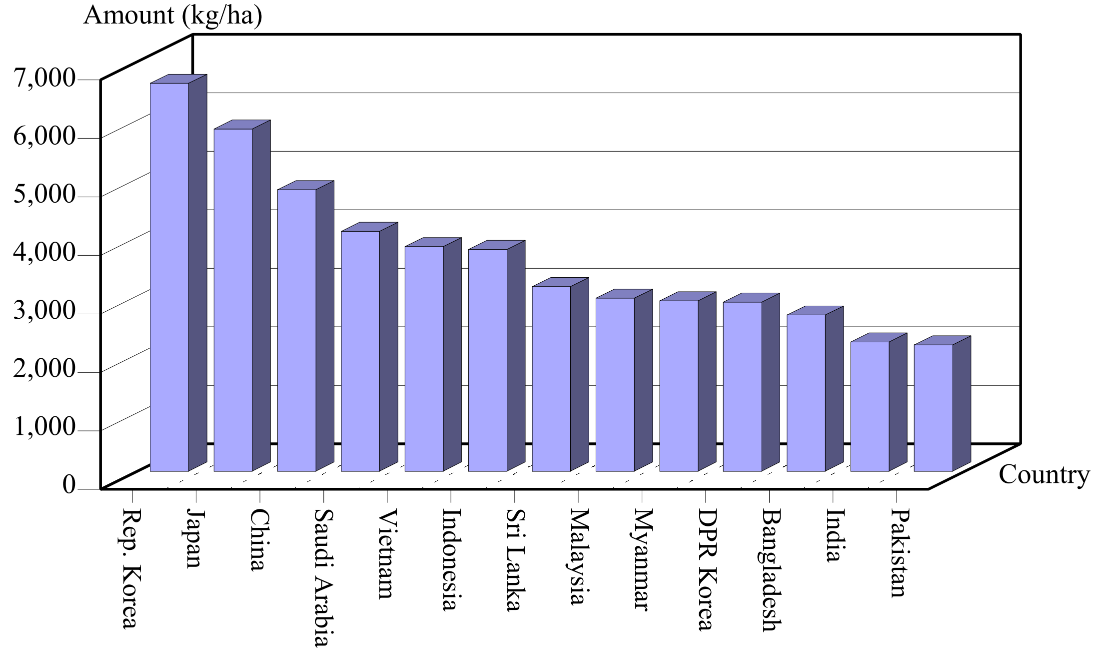

Figure 1. Productivity of Cereals (Total) in Asian Countries

Agricultural Productivity and the Importance of Irrigation Management

A major concern in India is to increase agricultural productivity in line with its population growth rate that is expected to stabilize at 1,500-1,800 million by the year 2050, while preserving land and water resources. Agricultural growth is the engine that will also provide momentum to growth in the other sectors through its backward and forward linkages. Irrigation, which has the potential for doubling the productivity of agriculture, therefore, occupies center stage.

The total ultimate irrigation potential of the country is estimated at 139.9 million ha (major and medium irrigation projects: 58.5 million ha; and minor irrigation projects: 81.4 million ha) with four States (Uttar Pradesh, Bihar, Madhya Pradesh and Andhra Pradesh) accounting for a little more than half share (Table 1). An irrigation potential of 93 million ha has been created out of which 83 million ha could be utilized up to 1997-98 (Table 2). Presently, nearly one-third of the gross sown area is under irrigation, utilizing 83 percent of the country’s available fresh water and contributing to around 66 percent of total food grain production.

Table 1. State-wise Ultimate Irrigation Potential

(Unit: 000 ha)

State/ Union Territory	Major and Medium (Surface Water) Schemes	Minor Irrigation Schemes		Total Irrigation Potential
		Surface Water	Groundwater	
Andhra Pradesh	5,000	2,300	3,960	11,260
Arunachal Pradesh	*	150	18	168
Assam	970	1,000	900	2,870
Bihar	6,500	1,900	4,947	13,347
Goa	62	25	29	116
Gujarat	3,000	347	2,756	6,103
Haryana	3,000	50	1,462	4,512
Himachal Pradesh	50	235	68	353
Jammu and Kashmir	250	400	708	1,358
Karnataka	2,500	900	2,574	5,974
Kerala	1,000	800	879	2,679
Madhya Pradesh	6,000	2,200	9,732	17,932
Maharashtra	4,100	1,200	3,652	8,952
Manipur	135	100	369	604
Meghalaya	20	85	63	168
Mizoram	*	70	–	70
Nagaland	10	75	–	85
Orissa	3,600	1,000	4,203	8,803
Punjab	3,000	50	2,917	5,967
Rajasthan	2,750	600	1,778	5,128
Sikkim	20	50	–	70
Tamil Nadu	1,500	1,200	2,832	5,532
Tripura	100	100	81	281
Uttar Pradesh	12,500	1,200	16,799	30,499
West Bengal	2,300	1,300	3,318	6,918
Total States	58,367	17,337	64,045	139,749
Total Union Territories	98	41	5	144
Grand Total	58,465	17,378	64,050	139,893
Percentage	56	71	71	65**

Source: Central Water Commission (P&P Directorate); and Ministry of Water Resources (Minor Irrigation Division).

Notes: * Included under Union Territories; and ** percentages of potential created up to the end of 1996-97 to ultimate potential.

"–" = not assessed.

The total food grain production which was only about 51 million mt at the time of commencement of the First Five-Year Plan (1950-51) has gone up to 200 million mt and at present, the country is self-sufficient in food grains. In addition, India exported 8.4 million mt during the year 2001-02. The availability of assured irrigation water made possible by the water resources projects has played a lead role in achieving this distinction. But it is also noteworthy that the competing demands for water for sectors other than agriculture and the limitations of horizontal expansion of net cropped area (143 million ha) due to rapid urbanization and catering to burgeoning population have set a compelling agenda for producing more and more with less and less water.

Major and medium irrigation projects are funded, planned, constructed, maintained and operated exclusively by the government and this sector is underperforming primarily due to inadequate maintenance of irrigation systems compounded by abysmally low level of revenue recovery and purely governmental management of irrigation systems, in spite of galloping establishment expenses. In addition, crop productivity level under irrigated agriculture is quite low compared to many other countries.

Table 2. State-wise and Plan-wise Achievements of Irrigation Potential Created/Utilized under Major and Medium Irrigation (Surface Water, Cumulative)

(Unit: 000 ha)

State/ Union Territory	Annual Plan		Eighth Plan (1992-97)		Annual Plan (1999-2000) (anticipated)	
	Potential Created	Potential Utilized	Potential Created	Potential Utilized	Potential Created	Potential Utilized
Andhra Pradesh	2,999	2,847	3,045	2,884	3,389	3,206
Arunachal Pradesh	0	0	0	0	0	0
Assam	176	111	197	138	202	141
Bihar	2,766	2,295	2,803	2,324	2,887	2,351
Goa	13	12	13	12	17	14
Gujarat	1,246	986	1,350	1,200	1,398	1,261
Haryana	2,035	1,791	2,079	1,834	2,091	1,842
Himachal Pradesh	8	4	11	6	11	6
Jammu and Kashmir	158	136	174	148	177	158
Karnataka	1,377	1,192	1,666	1,472	1,847	1,623
Kerala	416	367	513	464	590	539
Madhya Pradesh	1,962	1,395	2,318	1,621	2,398	1,668
Maharashtra	2,030	1,035	2,337	1,288	2,875	1,812
Manipur	59	50	63	52	80	67
Meghalaya	0	0	0	0	0	1
Mizoram	0	0	0	0	0	0
Nagaland	0	0	0	0	0	0
Orissa	1,409	1,326	1,558	1,443	1,695	1,728
Punjab	2,367	2,309	2,513	2,451	2,532	2,481
Rajasthan	1,999	1,887	2,274	2,088	2,363	2,261
Sikkim	0	0	0	0	0	0
Tamil Nadu	1,545	1,541	1,546	1,545	1,549	1,549
Tripura	2	2	2	2	205	5
Uttar Pradesh	6,789	5,751	7,043	6,114	7,409	6,297
West Bengal	1,353	1,258	1,433	1,315	1,564	1,419
Total States	30,709	26,295	32,938	28,401	35,279	30,429
Total Union Territories	15	7	19	9	22	10
Grand Total	30,741	26,314	32,954	28,410	35,102	30,439

Source: Planning Commission, Annual Plan Document 2000-01.
Note: Total may not tally due to rounding off.

Farm Size

Another major concern of this sector is an increasingly large number of small and marginal landholdings, where stand-alone agriculture is not economically viable and the task of irrigation water delivery, irrigated-area recording, revenue collection, day-to-day water distribution, conflict management, etc., also becomes extremely difficult and cumbersome for the government agencies. Unless the marginal landholders form some organization for adopting modern package of agricultural practices, irrigation and other input management; the productivity of marginal land holdings may continue to decline.

Need for Participatory Management

There is a growing concern and realization among the prime stakeholders, i.e., the farmers and the government, that old organizational setup on the pattern of early British India is no longer appropriate and a paradigm shift in irrigation management is needed.

Therefore, there is an urgent need to evolve a strategy for equitable and optimal utilization of canal irrigation water for better productivity through community participation and there is near consensus now that promoting community participation through Water Users' Associations (WUAs) can be the best strategy for long-term sustainability of irrigated agriculture. The gradual reduction of all pervading governmental presence and matching enlargement of farmers' role in irrigation management is, therefore, crucial to the better performance of irrigated agriculture sector.

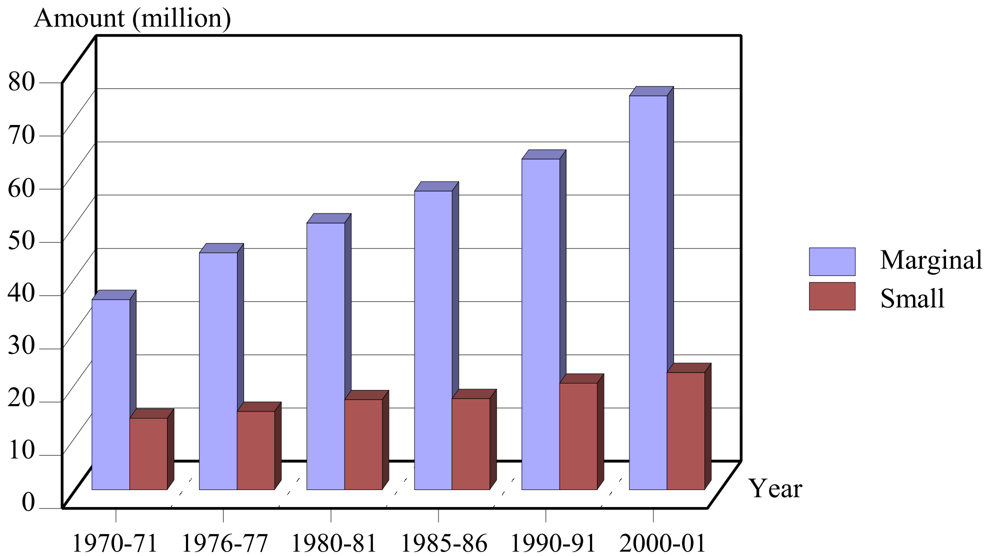

Figure 2. Operational Landholdings, 1970-71 to 2000-01

Purpose of the Paper

In the context of linking main system management for improved irrigation management, this paper will focus on Participatory Irrigation Management (PIM). The purpose of this paper is to suggest, in the light of the past experiences of decentralization and irrigation management transfer (IMT) in India, a strategy for implementation of PIM through formation of WUAs on canal systems.

In addition, the paper will examine the WUAs' linkages with State irrigation departments, *Panchayats* (the elected village body under the Indian constitution, responsible for administration and implementation of the development schemes), their potential strengths and limitations, the institutional requirements of irrigation departments as main system managers for their new role and the indispensability of major training programs for line agency officials and farmer representatives for the success and sustainability of WUAs. The present paper is intended to serve as a background material for finalizing definitive strategy by the State governments.

IRRIGATION MANAGEMENT IN INDIA: GROUND REALITIES

Water Is A State Subject

Presently, India is divided into 35 States and water being a State subject under the constitution; the State governments have the basic responsibility for developing, controlling and managing this resource.

Unutilized Irrigation Potential

At the onset of planned development (1950-51) in India, an irrigation potential of 12.9 million ha on Minor Irrigation Schemes and 9.7 million ha on Major and Medium Irrigation Schemes has been created. It rapidly rose to 37.26 million ha and 30.01 million ha, respectively by the end of the sixth Five-Year Plan (1980-85) due to thrust on construction and extension of irrigation facilities in order to achieve self-sufficiency in food grains production. However, utilization of created potential has lagged behind in all categories of government-owned irrigation facilities, particularly in the major and medium irrigation projects (Figure 3).

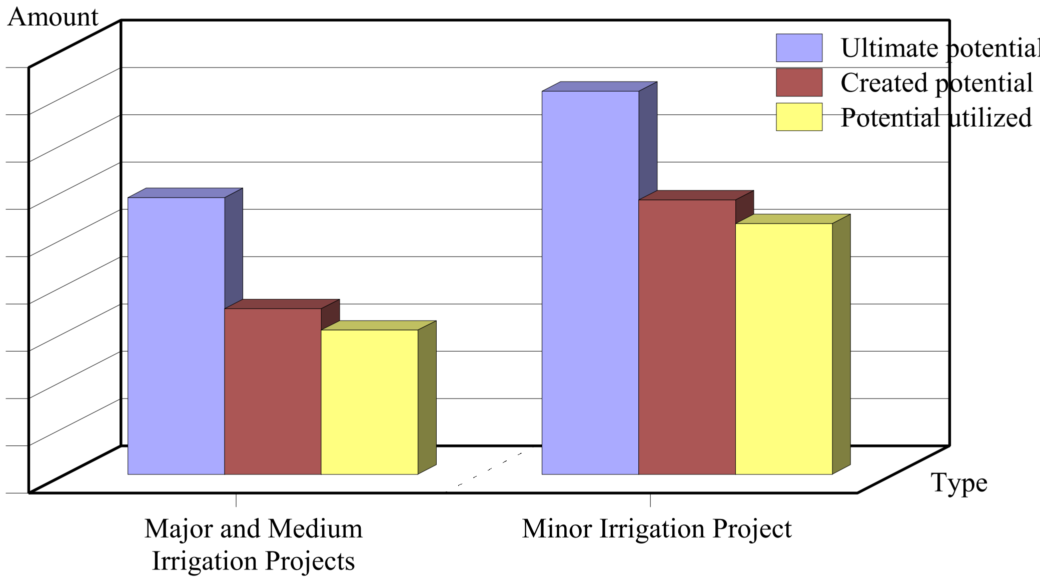

Figure 3. Status of Irrigation Potential in India

At the end of 1999-2000, unutilized irrigation potential on major and medium canal systems was around 4.5 million ha. At the current rate of creation of irrigation potential of about Rs.60,000/ha, government investments worth Rs.2,70,000 million (US$5,400 million) still remain unfruitful.

Irrigation Cost Recovery and Related Problems

One of the major worries in irrigation sector is related to abysmally low revenue collection due to highly subsidized irrigation rates. By tradition, irrigation facilities are considered as farmer-welfare schemes and any proposal to rationalize irrigation rates is considered as a critical political issue. On an average, gross revenue receipts are around 10 percent of working expenses (Figure 4 and Table 3).

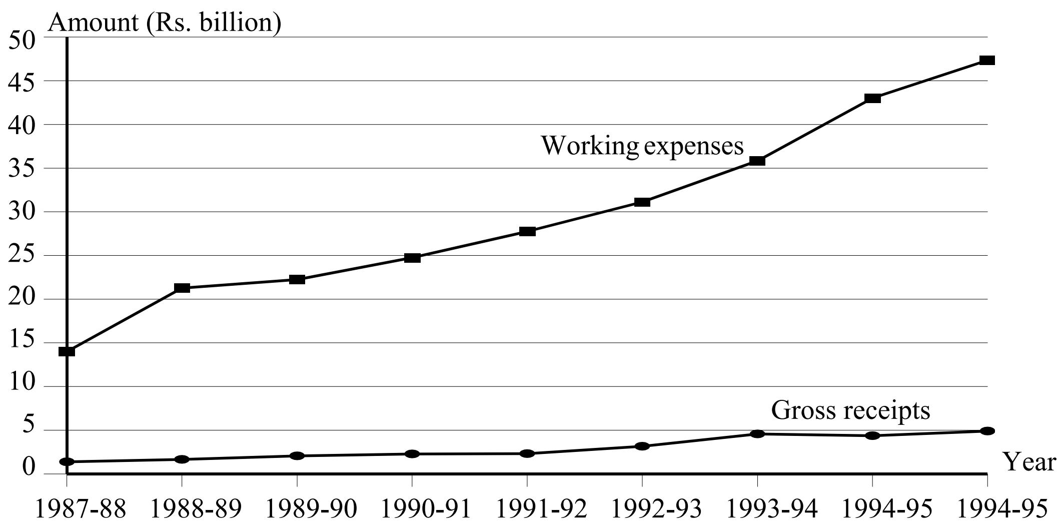

Figure 4. Financing of Irrigation and Multipurpose River Valley Projects (All India)

Unless the irrigation sector is pushed towards a more realistic cost recovery regime, State governments will find it extremely difficult to raise resources even for operation and maintenance (O&M) of irrigation systems. The paucity of O&M funds at state level has hastened the deterioration of canal systems. When the supplies are unreliable, the farmers act individually to protect their own interest and these results in unauthorized withdrawal of water at the cost of the tail-enders.

Table 3. Revenue Receipts and Working Expenses on Irrigation and Multipurpose River Valley Projects (Unit: Rs. million)

Year	Capital Outlay (cumulative)	Gross Receipts	Working Expenses
1976-77	51,378	1,047	1,128
1977-78	59,963	969	1,272
1978-79	69,664	1,081	1,552
1979-80	80,900	1,007	1,405
1980-81	93,467	1,034	2,257
1981-82	107,905	1,202	2,653
1982-83	123,423	1,171	2,377
1983-84	140,421	1,651	2,739
1984-85	159,297	1,297	334
1985-86	179,712	2,238	4,869
1986-87	202,343	1,667	4,896
1987-88	223,112	1,387	14,003
1988-89	246,080	1,664	21,280
1989-90	270,888	2,076	22,238
1990-91	305,691	2,289	24,763
1991-92	336,997	2,322	27,751
1992-93	361,927	3,161	31,132
1993-94	403,757	4,592	35,827
1994-95	447,964	4,378	43,015
1995-96	501,615	4,909	47,345

Source: Central Water Commission, *Pocket Book on Water Data*, February 2001.

Note: Working expenses for the year 1987-88 and onwards are inclusive of the interest on the capital at the end of the year.

Communication Gap between Irrigation Department and the Irrigators

The administrative character of State irrigation departments promotes highly centralized decision-making and emphasizes implementation of predetermined plans, with little scope for participatory planning and implementation. The Executive Engineer, as head of an irrigation division, is vested with enormous powers under the Canal Acts (some of which have been in existence since British India days). Therefore, his attitude towards farmers is paternalistic. The communication, trust and interaction between the Executive Engineer and the farmer-client, on the basis of equality, are practically nonexistent.

Under such a situation, Irrigation Officials often complain about the farmers' irresponsible behavior in tampering with canal structures and taking unauthorized withdrawals. On the other hand, farmers put the blame on to irrigation department and complain about poor system maintenance and irregular operation of canals, non-availability of irrigation officials, their paternalistic attitude and their indifference to irrigation needs of the area.

The notable feature is that the irrigation departments are construction-oriented and their priorities lie in implementation of predetermined plans according to budget allocations. Hence client-oriented PIM does not occupy a prominent place in their implementation plans. Moreover, their PIM initiatives are found more construction-centered than organization-centered, resting mainly upon the rehabilitation and modernization package for the canal system.

The Importance of Training/Capacity Building

The main issues that affect the irrigation sector have changed significantly. Today's irrigation environment is more complicated and dynamic than ever before. The canals were primarily constructed with the aim of providing protective irrigation to safeguard the farmers from recurrent drought and famines. The economic environment has changed as self-sufficiency in food has largely been reached and farmers now look for productive irrigation instead of protective irrigation which implies that they are not satisfied with bare minimum supplies to keep their crop alive but demand full supplies as per water requirements of their crops.

In this era of *Panchayati Raj* system where the constitution (73rd Amendment in 1992) provides for constitutional sanctions to the *Panchayats* as the institutes of local self-governance, the political environment has become more responsive to the demands farmers make on the department. A vigorous, need-based and sustained training effort is, therefore, required to help the Executive Engineers and other irrigation agency staff to change their traditional, administrative, self-centered and input-oriented work culture to their new role which demands increasingly a managerial content, organizational abilities to promote and support WUAs with a focus on the needs of water users and the productivity of their farms through irrigation management by WUAs.

PIM is a new approach which encourages the involvement of the users, viz., the farmers in all the decision-making and implementation process of irrigation water conveyance, delivery, application, utilization and drainage initially at minor canal level and gradually moving upwards in the canal system. This kind of integrated interaction and joint management is new for both the irrigation agency and the farmers. Such a change requires special skills and attitudes on the part of both the irrigation agency and the farmers in order to modify their present roles and responsibilities. Therefore, besides the Executive Engineer and other irrigation agency officials, farmers also require vigorous training/capacity building to adopt their new role.

Lack of Awareness of PIM Principles among Irrigation Officials

There is widespread misconception regarding PIM among all ranks of irrigation officials. Engineers often understand that their role ends with formation of WUAs (and even during the process of formation, their role is limited to rehabilitation and deferred maintenance of canal only) and WUAs, since their inception, are fully responsible for O&M and cost recovery functions, etc. An action research on *Basarahiya* Water Cooperative Society (BWCS) in Uttar Pradesh by the author has clearly brought out that the irrigation agency understood the process of 'handing over' five outlets on a canal to BWCS as an abrupt relinquishment of their role in irrigation management with appalling consequences. The irrigation agency officials have to be sensitized that there is a continuing and supporting role of irrigation agency, even in cases where WUAs have achieved sovereignty over all aspects of irrigation management. Normally, WUA ownership implies that they are responsible for O&M, user representation and other functions related with agricultural growth while irrigation agency and other line agencies continue to have facilitator and regulatory role.

A clear understanding of the principles of PIM shall be helpful in inculcation of right attitudinal and behavioral changes among the irrigation officials and it shall also be helpful in building up a working collaborative partnership between the water users and the irrigation departments.

AN OVERVIEW OF PIM INITIATIVES IN INDIA

In India, PIM is being pursued as a means to reduce financial pressure on the government, improve performance of irrigated agriculture, and ensure sustainability of irrigation systems (Ministry of Water Resources, Government of India, 1995). Irrigation being a State subject, the initiatives have been taken by the States in this regard although these initiatives vary in quality, quantity and according to the socio-cultural background, agro-climatological conditions, needs and interest.

The States differ widely in their approach to irrigation management, which affects PIM policies and activities. For major and medium canal systems, the approach includes rules/practices for supply of water to the outlets, water allocation between the farmers and system for collecting irrigation charges from the users.

The approaches by the different States are summarized below (Jeffery D. Brewer, 2000):

1. ***Warabandi***

In Punjab, Haryana, Uttar Pradesh and Rajasthan, the available water is supplied to all the farmers in proportion to their holdings through rotational operation of the canal system and *warabandi* (denoting time of supply to every farmer below the outlet). Irrigation rates are charged to each farmer on crop-area basis irrespective of the number of irrigations. *Warabandi* has legal sanction under the Northern India Canal and Drainage Act 1873.

2. ***Shejpali***

In Maharashtra, Gujarat and part of Karnataka, the farmers are required to apply for irrigation each season for specific crops and areas. The irrigation department sanctions those applications, it can satisfy and the supplies to those crops are given up to maturity. Farmers are required to pay crop-area based irrigation charges for sanctioned irrigation. Farmers below each outlet are expected to take water in turns. *Shejpali* has legal support under the Bombay Irrigation Act 1879, which remains the basic irrigation law for Gujarat. The Maharashtra Irrigation Act of 1976 recognizes *Shejpali* as the basic approach to irrigation management.

3. ***Land Classes***

In Tamil Nadu, Kerala, part of Karnataka and Andhra Pradesh, water rights are assigned to land. Some land is entitled to two rice crops per year; other land is entitled to only one crop per year. The irrigation department is responsible for adequate and timely supplies to bring the crops to the maturity. Fees are assessed based on water rights of the land and are collected as a part of land tax.

4. ***Satta/Assured Irrigation Area***

In Bihar, West Bengal and Orissa, farmers apply for water each season for an assumed crop. In Bihar, the requirement to submit application has been replaced by identification of most of the canal command as the "assured irrigation area". Within this area, the irrigation department is responsible for delivering water so to bring the assumed crop to maturity. Every farmer within the assured irrigation area has to pay the irrigation charges whether or not he takes water. The *Satta* system is based on Bengal Irrigation Act of 1876, which still remains the basic irrigation law for Bihar, West Bengal and Orissa.

Similarly, irrigation charges assessment and recovery agencies also vary in different States. In Maharashtra and Rajasthan, irrigation charges are assessed and recovered by the Irrigation Department. In Gujarat, Punjab, Haryana and Uttar Pradesh, the irrigation charges are assessed by the Irrigation Department but recovered by the Revenue Department. In Orissa, Bihar, Kerala and Tamil Nadu, assessment and recovery of irrigation charges are made by the Revenue Department.

While it is difficult to evolve a uniform national policy and approach in respect of implementation of PIM and mode of cost recovery there are some notable common features and variations, which when analyzed, indicate the direction of PIM movement in India.

PIM Status in the States

So far the Andhra Pradesh, Madhya Pradesh and Rajasthan are the only three States in India, which have formally passed their own acts exclusively taking care of the PIM implementation through the promotion of WUAs. Goa has also passed "Goa Command Area Development Act 1997" which has incorporated all the implementation aspects of PIM. The Andhra Pradesh Act was the first of its kind in the country and it has served as a good reference material for the other States that were keen to pursue legal reforms.

In Tamil Nadu and Orissa, the PIM Acts are already formulated and shall be enacted soon. The other States are also in the different stages of action for revising their age-old irrigation acts to accommodate new aspirations and paradigms in the irrigation management. In these States, notably Maharashtra, Gujarat, Uttar Pradesh and Bihar, the PIM implementation is being carried out through notifications and ordinances.
The status of WUAs in different States in India is given in Table 4.

Commonalities in the PIM Programs in Indian States

Almost all the States envision the transfer of operation and management responsibilities to WUAs organized on hydrological basis. However, the size and structures of the proposed WUAs, responsibilities transferred, etc. vary from State to State.

All States envision retaining ownership of the canal systems, retaining the State irrigation agency and maintaining its responsibility for O&M of the main/upper levels of the canal systems.

Table 4. Status of WUAs in India

Name of State	Umbrella/Statute	Implementing Agency	Status of WUAs		Cover (000 ha)	Remarks
			Level	Number		
Andhra Pradesh	Andhra Pradesh Farmers Management of Irrigation Systems Act 1997	Water Resources Department	Minor Distributory	10,292 174	4,800.00	Strong political will and bureaucratic commitment
Assam	Government notification	CADA[a]	Minor	17	6.00	
Bihar	Government notification	Water Resources Department	Distributory	1	12.2	Government decided IMT on distibutories up to 15,000 ha
Goa	Goa Command Area Development Act 1997	CADA	Distributory/ minor/outlet	42	5.0	In Goa, CADA is under Water Resources Department
Gujarat	Government notification	Water Resources Department	Minor	476	19.00	PIM being pursued on all projects. Sardar Sarovar Project shall supply water to WUAs only
Haryana	Haryana Canal and Drainage Act 1974/CADA Act	Tube Well Corporation/ CADA	Outlet	2,575	200.00	*Warabandi* system of management is functioning satisfactory
Himachal Pradesh	Government notification	Irrigation Department	Outlet	875	35.00	
Jammu and Kashmir	Command Area Development Act	CADA	Minor	1	1.0	
Karnataka	Government notifications/Karnataka Cooperative Societies Act 1959	CADA	Minor	760	138.38	
Kerala	Government notifications/Kerala Command Area Development Act 1986	CADA	Project Minor Outlet	9 112 3,372	148.48	Kerala gets great deal of rainfall and irrigation has developed relatively recently
Madhya Pradesh	Madhya Pradesh Ke Sinchai Prabandhan Me Krishkon Ki Bhagidari Act 1999	Water Resources Department	Minor	1,470	1,495.0	Undivided State: 2,416 WUAs with 2.83 million ha coverage
Maharashtra	Government notification	Water Resources Department	Minor	278	100.00	Started bottom-up approach quite early. Vide government resolution on 23 July 2001, WUCs formation mandatory

... To be continued

Table 4 (Continuation)

Name of State	Umbrella/Statute	Implementing Agency	Status of WUAs		Cover (000 ha)	Remarks
			Level	Number		
Manipur	Command Area Development Act	CADA	Minor	62	49.27	
Orissa	Government notifications (Pani Panchayat Act to be enacted soon)	Water Resources Department/CADA	Minor	201	84.00	Under OWRC[b] Project, 181 *Pani Panchayats* (WUAs) formed against a target of 726 WUAs
Rajasthan	Rajasthan Sinchai Pranali Ke Prabandh Me Krishkon Ki Sahbhagita Adhiniyam 2000	CADA	Outlet Minor	3,843 417	185.67	Informal committee at outlet level and at minor level under the Act
Tamil Nadu	Government notifications (Act to be enacted soon)	CADA/Tamil Nadu Agriculture Engineering Department (TNAED)	Minor Outlet	328 7,725	474.28	In June 1994, TNAED reported 3,300 outlet level and 118 distributory level WUAs but most of them are now dysfunctional
Uttar Pradesh	Government notification on 18 January 2001	Irrigation Department	Minor	8,387	30,000	Formed hastily. Efforts on to make them functional

Notes: [a] Command Area Development Agency; and [b] Orissa Water Resources Consolidation Project.

Implementation Strategy

1. ***Every State Shall Have to Evolve Its Own Strategy***

The situation in the States lying in the Indo-Gangetic plain (Northern States) is different from the Southern States. The Indo-Gangetic States are mostly served by run-of-the-river schemes where uncertainty of canal deliveries is far greater than reservoir fed systems of the Southern States. The water saved by a WUA in a particular season may be allotted to the WUAs in the next season as an incentive in the reservoir-fed systems but not in the run-of-the- river schemes. The problem of silt is far more acute in the run-of-the-river schemes. Another major difference lies in easy availability of groundwater in Indo-Gangetic States. Therefore, every State shall have to evolve its own strategy based on the nature of system, traditions, needs and feedback from the pilot projects.

2. ***The Nodal Agency for Implementation of PIM***

As WUAs are designed as social organizations; an external agent is needed to help establish them.

This could be an NGO or a government department such as the irrigation department, CADA, Land Development Corporation, etc. or a resourceful individual, say, a local leader or activist. In many States, the CADAs have the mandate to form WUAs under the Command Area Development Program. Many other departments also undertake pilot sub-project where WUAs are being formed.

It is obvious that, "dependable access to water" is the basic requirement for the sustainability of WUAs. Unreliable and inadequate availability of canal supplies negates the very purpose of group action. Since the irrigation departments are principal suppliers of water, the success and sustainability of WUAs largely depend upon their willingness and commitment to promote PIM. It is therefore more appropriate to designate irrigation agency/water resources department as nodal agency in the State for the implementation of PIM and organization and promotion of WUAs.

3. ***Models of Irrigation Management Transfer***

Irrigation management may be transferred to: (a) private development agencies (b) *Panchayats*; or (c) especially constituted WUAs. Since the basic philosophy behind IMT is that farmers (users) have largest stake in improved irrigation management, they have strongest motivations to distribute water and they have better local information on system performance and irrigation needs, it can be deducted that a local farmer organization would be more viable and sustainable than any private development agency. The *Panchayats* have a constitutional mandate for water management but they are already burdened with so many development activities.

It is, therefore, suggested that WUAs on pilot basis may be promoted for the specific purpose of handling irrigation management and a representative of *Panchayat* may be coopted as ex-officio member of the management committee of the WUAs.

Normally two models have been adopted by the various States. First model adopted by Andhra Pradesh and Madhya Pradesh was a "big-bang model", where a full-scale PIM program with political, legal and administrative backing has been started. The second model was based upon initiating pilot PIM projects and gradually extending their reach as more and more factors of sustainability are picked up through action research, process documentation and performance evaluations. While the success of the first model hinges on firm political will and bureaucratic commitment, the second model suffers from weakness of "too slow to be demonstrative and effective".

Those command areas of ongoing construction projects where water is to be delivered shortly may be ideal for promotion of WUAs and suitable training in participatory project planning methods may be given to irrigation officials to enable them to promote beneficiaries' participation right from the initial planning stage of location of masonry structures and outlet fixation.

The Selection of Systems for PIM

Experiences from many countries including India testify that WUAs can only be successful on those minors that are capable of providing reliable water delivery. It will be impossible to motivate the farmers to form a WUA on a system that is dilapidated, incapable of effecting designed discharges and requires huge money for rehabilitation. It is, therefore, advisable that the pilot WUAs are promoted on those systems that are in reasonably good condition or can be brought back to good condition in a reasonable time with little money and effort.

Organizational Structure of WUAs

It is appropriate that core objective of joint management with full beneficiary participation is gradually achieved by incrementally building up WUAs from minor to distributory and finally up to project level. However, in the first stage, a three-tier structure up to minor level is more participative in nature as it is easy to organize farmers effectively in smaller groups (8-15 farmers). Normally a *chak* of 5-8 ha in a canal command consists of 8-15 farmers and it is ideal as primary unit of organization (Sub-Outlet Committee). These "Sub-Outlet Committees" may confederate into "*Kulaba Samiti*" (Outlet Committee), which shall further confederate into WUA at minor level.

The WUAs Should Be Given Responsibilities Gradually

The WUAs cannot immediately take up the responsibility of O&M and cost recovery; as it requires reorientation, sustained training and perceptive assistance by the line agencies. It is, therefore, suggested that the change should be gradually introduced through well-planned phases.

OPPORTUNITIES AND THREATS TO THE WUAs IN INDIA

The greatest opportunity lies in making irrigation systems sustainable as ownership feeling among the farmers may lead to better O&M up to tertiary canal level and greater resource mobilization on one hand and efficient utilization of funds and natural resources, viz., water and land on the other hand.

It shall also ensure mutual accountability between irrigation agency and the WUA and shall enable irrigation agency to focus on technical input oriented main system management. Better management of resources will lead to increase in yield and irrigated area and ultimately help poverty reduction and improve food security.

The greatest threat lies in likely politicization of WUAs along with caste and political lines and the powerful farmers may utilize the WUAs as a tool to serve their self-centered goals instead of serving the poor and marginal farmers.

Moreover, the whole program in most of the States is donor-driven and the line agencies are not sensitized to the potential and indispensability of PIM. The proactive role of irrigation agencies is as essential as the participation of the farmers. The formation of the WUAs is the beginning of the PIM process but, presently, there is a tendency in the irrigation agencies to see it as an end in itself.

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4. INDIA (2)

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INTRODUCTION

Irrigation has played key role in the agricultural growth of India. The gross irrigated area in the country has increased from 22.6 million ha in the year 1950-51 to 71.3 million ha in the year 1995-96. The corresponding net area irrigate in 1995-96 has been 53.5 million ha. The area irrigated from surface irrigation water sources accounts for about 38 percent of the total irrigated area. The breakup of source-wise area irrigated (1995-96) is given in Table 1.

Table 1. Area under Different Sources of Irrigation

Source of Irrigation	Area Irrigated (million ha)
Canal	17.1
Tank	3.1
Well	29.8
Others	3.5
Total	53.5

Source: Central Water Commission, Government of India, Water and Related Statistics, 2000.

India, which was an importer of food grains in 1960s, has not only become self-sufficient now but also a marginal exporter of food grains in the recent years. The production of food grains has increased from 51 million mt in 1950-51 to over 200 million mt in the year 2001-02. It has been estimated that the increase in irrigation facilities alone has contributed to about 52 percent increase in food grains production. Improved input management and agricultural practices including use of high yielding varieties have contributed to 48 percent in increase in food grains production.

While the overall strategy of irrigation development has made the country self-sufficient in food grains production, management of irrigation system unfortunately has not received adequate attention. There has been lack of sufficient focus on water distribution and maintenance aspects, which has not only led to underutilization of the created irrigation potential but also contributed to inequitable distribution and less efficient use of available irrigation supply despite a number of interventions by the government from time to time.

The next section of the paper will present a brief account on the issues and constraints concerning the management of irrigation systems. This will be followed with an account on the measures for improving performance of irrigation management, with particular reference to the enhancing of linkage between main system management and field level management. Finally, the paper will submit future directions for irrigation management.

ISSUES AND CONSTRAINTS CONCERNING MANAGEMENT OF IRRIGATION SYSTEMS IN INDIA

Maintenance of the System and the Water Rates

Inadequate maintenance of irrigation systems, particularly the older irrigation systems, has resulted in reduction of canal capacity and higher seepage losses leading to problems of deficient water supply. Low water charges and low recoveries have led to insufficient revenue collection, which has made it difficult for the State governments to allocate sufficient funds for proper upkeep of the irrigation systems. According to the report of the committee on pricing of irrigation water appointed by the Planning Commission of India in 1992, the revenue realized from irrigation on an average worked out in 1989-90 to Rs.50 per ha, whereas the cost of maintenance was Rs.270 per ha, representing a gap of Rs.220 per ha in revenue collection and Operation and Maintenance (O&M) expenditure. The problem has been further compounded due to periodic revision of the salaries/wages of the government staff because of which funds provided for O&M are used up in meeting the establishment cost of irrigation departments. Table 2 shows the percentage of total O&M cost going into the establishment in various Indian States:

Table 2. Establishment Costs as a Percentage of Total O&M Costs

State	1986-87	1987-88	1988-89	1989-90	1990-91
Bihar	61	55	57	62	67
Haryana	52	60	64	70	67
Madhya Pradesh	25	25	25	25	-
Maharashtra	32	30	55	55	-
Punjab	68	69	73	75	77
Uttar Pradesh	19	54	38	47	-
Average	43	49	52	56	70

Source: *Maintenance of Irrigation and Drainage System* edited by Jurriens and Jain quoted in L. K. Joshi (ed.), *Management of Irrigation – A New Paradigm in Participatory Irrigation Management*, 1997.

Unreliability of Water Supply

In addition to the deferred/poor O&M of irrigation systems, there are various other reasons for unreliability of water supply. In some cases the volume of water available in the reservoirs is less than the volume computed at the time of completion of irrigation projects. At times, the storage capacity of reservoirs is reduced due to faster rate of siltation than assumed at the planning stage. It has been estimated that on major and medium irrigation projects India was losing a live storage capacity through sedimentation corresponding with a loss of amount for 0.28 million ha of irrigation potential per year. Evaluation of study of Giri Irrigation Project in the Indian State of Himachal Pradesh revealed that the weir pond meant for diverting supplies into the main canal had silted up reducing the pond capacity. Another study of Malaprabha Project in the State of Karnataka revealed that conveyance losses in both lined and unlined systems were generally 300 percent of those assumed which led to reduce availability of water at the outlet for irrigation purposes.

Inequity in Water Supply

In many irrigation projects in the country, rotational supply system of irrigation water to farmers has not been enforced effectively and as a result the farmers in the head reaches draw disproportionately large quantities of water, depriving the tail-end farmers of their due share. A study in the Sharda Sahayak command area of Uttar Pradesh State had revealed that farmers at the top end got five irrigations while the farmers in the low reaches hardly got one. In Tungabhadra Project in the State of Karnataka it was revealed in a study that the tail-end areas of a major distributory received only 20-40 percent of the designed discharge. Similarly a study under the Bhakra system in the State of Haryana revealed that the farmers located in the head reaches of the water courses were on an average receiving two times more water than the tail-enders.

Lack of Incentives/Disincentives/Motivation

At present there are no incentives for those who economize on water use and also no disincentives against those who may make excessive use of irrigation water and indulge in faulty and wasteful irrigation practices. Absence of night irrigation in many irrigation projects leads to excessive return of irrigation water back to the drainage system. Absence of awareness generation and motivational programs regarding efficient water management is the other contributory factor for the indifference of irrigators towards canal water management.

Lack of Legal Support

In a majority of States, existing Irrigation Acts do not have explicit provisions for farmers' participation in the irrigation management. These Acts need to be suitably amended to make provisions for setting up of Water Users' Associations (WUAs), devolution of powers to them, signing of Memorandum of Understanding between the WUAs and irrigation departments and other provisions necessary for enforcement of participatory management.

Resistance to Change

The mind-set of irrigation bureaucracy has long been conditioned to work in a particular mode where designing, planning, construction and O&M of the system get precedence over water management. They also perceive a threat to their own position and power in the switch over from existing unilateral management approach to the participatory approach involving the beneficiaries' intervention. The prolonged prevalence of government-managed systems has also made farmers dependent on government and they are reluctant to take up responsibilities of system management. They are also apprehensive that the irrigation departments may transfer the burden of O&M of the irrigation system, collection of water charges, etc., without adequate support in future. They also fear that the irrigation departments may not cooperate with them after actual transfer of O&M and other responsibilities has taken place. Obviously these apprehensions and misgivings on both the sides need to be overcome for fostering a sense of joint responsibility in the farming community and irrigation bureaucracy.

Sustainability of Water Users' Associations

The majority of the WUAs formed so far are in the irrigation projects covered under the centrally-sponsored Command Area Development (CAD) Program. These were mostly formed due to availability of one time functional grant from the government. However, once these associations were registered and targets for their formations completed, the government staff used to withdraw from the process leaving WUAs to fend for themselves. This coupled with lack of proper leadership has been a major impediment for the success of WUAs.

Big Farmers vs. Small Farmers

According to the Report of the Agricultural Census for 1995-96, about 75 percent of irrigated holdings are small and marginal (less than 2 ha per holding). However the area owned by them is much less than the area occupied by the large holdings. The findings of various scholars and the research studies have indicated that bigger farmers are greater beneficiaries of the canal irrigation facilities because of their influence over the irrigation bureaucracy.

MEASURES FOR IMPROVING PERFORMANCE OF IRRIGATION MANAGEMENT PARTICULARLY ENHANCING LINKAGE BETWEEN MAIN SYSTEM MANAGEMENT AND FIELD-LEVEL MANAGEMENT

Various State Irrigation Acts legally regulate the irrigation management in India. The Irrigation Acts enacted by the British administration did not incorporate the concept of beneficiaries'/farmers' participation in the management of irrigation system. During early 1970s, the Central Government launched the CAD Program which was primarily aimed at improving "On-Farm" physical systems with emphasis on construction of field channels, field drains, land leveling/shaping and introduction of rotational supply of water to the farmers.

The legislations for setting up CAD authorities enacted in 1970s and 1980s gave recognition to the concept of farmers' participation in irrigation management. The WUAs formed under the CAD Program were however required to function below the outlet and under the general supervision of irrigation bureaucracy. Gradually it has been realized that merely by building infrastructure below the outlet alone is not sufficient and it is necessary to improve the irrigation system as a whole and involve beneficiary farmers particularly in water distribution and management aspects of irrigation.

During the last two decades, the Participatory Irrigation Management (PIM) concept in India has passed through three distinct phases. Starting from 1975 and until 1985 the emphasis was on creating outlet-based farmers' organizations. During the second phase, 1985-90, the emphasis shifted to experimentation when a number of pilot projects on PIM were started. The third phase which started from early 1990s has seen the emergence of WUA that can take up the responsibilities for execution of improvements in physical infrastructure below the outlet and management of tertiary irrigation systems (minor/distributary) in case of major and medium irrigation projects.

The overall progress to date in various States of the country in terms of the formation of WUAs is given in Table 3 below:

Table 3. Number of WUAs Formed in Different States of India and Area Covered by Them

State	Number of WUAs Formed	Approximate Area Covered (000 ha)
Andhra Pradesh	10,292	4,800.00
Assam	17	6.00
Bihar	1	12.20
Goa	42	5.00
Gujarat	476	19.00
Haryana	2,575	200.00
Himachal Pradesh	875	35.00
Jammu and Kashmir	1	1.00
Karnataka	760	138.38
Kerala	3,930	148.48
Madhya Pradesh	1,470	1,495.00
Maharashtra	247	91.62
Manipur	62	49.27
Orissa	164	73.75
Rajasthan	417	185.67
Tamil Nadu	7,725	474.28
Uttar Pradesh	1	1.00
West Bengal	10,000	37.00
Total	39,055	7,772.65

Some of important milestones achieved in respect of PIM and linking main system management for improved irrigation management in some States of India are described below:

Andhra Pradesh:

The State government enacted "Andhra Pradesh Farmers Management of Irrigation Act" in 1997 to facilitate PIM. About 10,000 WUAs have been formed. There have been significant initiatives towards farmers' involvement in management of canal irrigation. The functions like collection of water charges and annual maintenance of physical system are gradually being taken over by the farmers. The State government has issued orders on water charges and sharing of water among the farmers' organizations at various levels. The farmers' organization below the minor level is known as 'Water Users' Association' and at the distributory level the 'Distributary Committee'.

Gujarat

The Gujarat State, with a strong tradition of cooperative movement, has accorded high priority to the policy of farmers' involvement in irrigation management. The State had taken 13 pilot projects to study the modalities of implementation of PIM. It has adopted a policy to accord priority to those schemes for rehabilitation where farmers were ready form associations and share part of the cost. In the areas to be commanded by the Sardar Sarovar Project it has been decided as a matter of policy to supply water only to water associations and not to individual farmers. The WUAs are being made responsible for the construction and O&M of tertiary systems.

Karnataka

The State government has decided as a policy to hand over management to Water Users Cooperative Societies. The responsibility of O&M as well collection of water charges would be transferred to these societies. The Karnataka Irrigation Act (2000) provides an enabling legal framework for PIM.

Madhya Pradesh

The State government has recently passed farmers' participation in irrigation management in 1999 on the lines of Andhra Pradesh which envisages transfer of power to WUAs for them to manage the system under their jurisdiction. The Act has come into force from September 1999 and elections of office bearers of WUAs have been completed.

Maharashtra

The State government proposes to amend the existing Irrigation Act. The State has however decided to supply water to water association on volumetric basis and to take up the work of renovations of irrigation subsystem before handing over to WUAs.

Orissa

The State government has decided to introduce the PIM in all the canals commands in major, medium and minor irrigation schemes. A new Act 'Orissa Farmers Irrigation System Management Act' to implement PIM is under consideration of the State legislature. In all, 164 water associations have been formed in the State and of these, 57 have already signed agreement and taken over the responsibility of O&M of the canal system.

Rajasthan

The State has passed a new Act "Rajasthan Farmers' Participation in Irrigation Management Act 2000" to give legal support to PIM. The State government took up a number of pilot projects with a view to improve the physical condition of the canal system and form WUAs. Eight projects have been handed over to WUAs.

FUTURE DIRECTION FOR IRRIGATION MANAGEMENT

It is now well recognized that proper management of main system is the key to improved performance of the system at the farm level. The Working Groups of the Planning Commission of India on 'Private Sector and Beneficiaries Participation in the Irrigation Water Management' and 'Command Area Development Program' in their reports for the 10th Five-Year Plan (2002-07) has offered a number of suggestions for accelerating farmers' participation in the irrigation system management including the main system management. Some of the important suggestions are given below:

Initiation of a New Command Area Development and Management Program

The centrally-sponsored CAD Program, which has been under operation for the last two and a half decades, has concentrated on on-farm development works below the outlet with no provision for taking up the management of the system above the outlet. The Working Groups of the Planning Commission have recommended that the scope of this program be expanded to cover both improvement of the physical infrastructure below the outlet and management of the main system above for improving performance and efficiency of the irrigation system. Accordingly the Union Ministry of Water Resources has proposed restructuring of CAD Program.

Organization and Structures of Water Users' Associations

In this context the Working Group on 'Private Sector and Beneficiaries Participation' has suggested that implementation of the PIM should be sub-divided into three phases:

i. ***Preparation and Assessment Phase*** – would involve a) institutional strengthening of organizations that will implement PIM; b) orientation training of farmers and irrigation staff about merits of participatory approach; and thereafter c) joint exercises with them to familiarize them with the system and identify minimum rehabilitation needs.

ii. ***Organizing Phase*** – in which farmers should be organized into WUAs for each outlet command and federation of WUAs at the minor/distributory level.

iii. ***Joint Management Phase*** – under which WUAs would learn to manage the water distribution and other functions like O&M, collection of water charges together with staff of irrigation departments.

Government's Role and Responsibilities

In case of major and medium irrigation projects, government's role in respect of O&M of tertiary system below the minor should end after the turnover. The department should however continue to discharge its primary responsibilities of delivering water at the designated points in accordance with predetermined time schedule from where the farmers' organizations should take over the responsibility of management. The reservoirs and main canals should remain under the ownership of the government and the irrigation departments should continue to operate and maintain the system.

Minimum Rehabilitation Before Turnover

The government should carry out "minimum rehabilitation" before turn over of irrigation systems to WUAs. The rehabilitation work should not be done before the WUAs are actually formed and have been operational for sometime. To enable WUAs to discharge the responsibilities of the maintenance and to make them self-sustaining, the government should allow them to collect water charges and retain 50 percent. And, where distributary level organization exists, additional 20 percent should be made available to the federations of WUAs.

Pricing of Irrigation Water

Pricing has a major impact on the success of irrigation systems. The government should therefore actively consider the raising of water rates appropriately. The ultimate aim should be to cover at least 10 percent of the actual cost in addition to full O&M.

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5. JAPAN

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INTRODUCTION

In Japan, as in the other countries in the Asian monsoon region, paddy rice agriculture is the mainstay for food and agricultural activities in farming villages. Japan's current prosperity was created and supported by lifestyles, cultures and customs that formed by food production systems of rice paddies. This evolution is a practical example of sustainable development over two thousand years. In this document, I would like to describe current state of managing irrigation water for paddy field irrigation that is 94 percent of agricultural water use in Japan.

The Historical Development of Paddies

It was approximately in 3 B.C. that the techniques for wet-rice cultivation were imported into Japan from the mainland Asia (Figure 1). Subsequently, up to 3 A.D. rice cultivation spread to northernmost Honshu Island where latitude was some 40º north. By the beginning of the 17th century, rice had become the basis of the economy and finance. In this process, paddy field development was actively conducted by a number of entities. During the period of about 100 years from middle 17th century, total area of rice cultivation in Japan doubled from 1.5 million ha to 3.0 million ha, and much of the present-day paddy fields in Japan were formed at this period.

The increase in population in Japan after 19th century was in direct proportion to the increase in the area under cultivation. It suggests that the population was largely controlled by agricultural production – in other words, controlled by the amount of food.

Role of Rural Communities

According to the development of farming in 17th century, technology of designing weirs, headworks and canals as well as paddy field itself developed. At the same time, rural communities had been formed to operate, maintain and rehabilitate irrigation facilities. It is well mentioned that the network of irrigation canals in rural areas historically possesses a role of not only production-washing and water for fire prevention, etc., but also providing irrigation water. Rural communities were a key factor to activate roles of agricultural water. The fact is that flow of agricultural water has been an important element for landscape of the rural areas owes the existence of the rural communities. Roles that the rural communities played in old days have been transferred to the current Land Improvement District (LID), legally authorized organizations in Japan.

THE CURRENT STATE OF WATER USE IN JAPAN

In Japan, the food self-sufficiency ratio and the area of agricultural land as well as the number of farmers have continuously been declined after the 1970s. Under these circumstances, limited quantity of agricultural land and the declining number of farm labor should be effectively utilized.

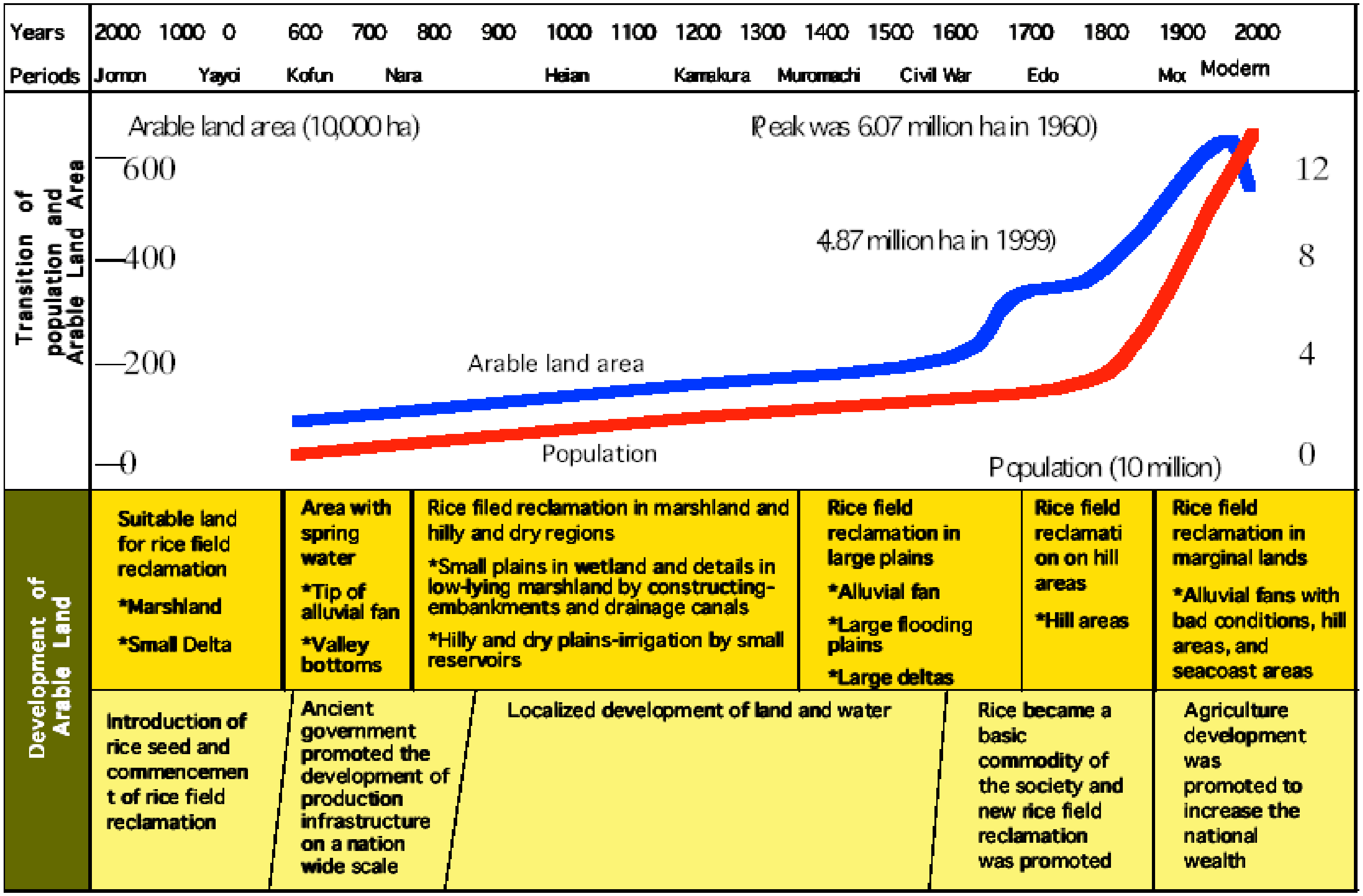


Figure 1. Historical Development of Paddy Fields in Japan (upland fields are included in "Cultivated Land")

Japan's water resources, calculated by substituting evapotranspiration from precipitation, are about 240 billion m^3 in an average year and about 280 billion m^3 in a dry year. Although the precipitation in Japan is about double the world average, the annual water resource per capita, about 3,360 m^3, is almost half the world average (7,100 m^3). The precipitation in Japan has wide seasonal variations by rainy season, typhoon and snowfall. The rivers are short and steep owing to the mountainous topography. Due to these climatic and geographical characteristics, water resources in Japan are different to use. Thus agricultural water has been developed throughout the country since ancient times.

The irrigation facilities at present include about 42,000 km of canals, more than 1,000 dams, about 2,000 headworks and about 2,500 pumping stations. Up to the present, approximately 60 billion m^3/year has been used for irrigation. This amount is two-thirds of Japan's total water use of 90 billion m^3, and one-seventh of Japan's water reserves (rainfall minus the evaporation volume) of 420 billion m^3 (Figure 2).

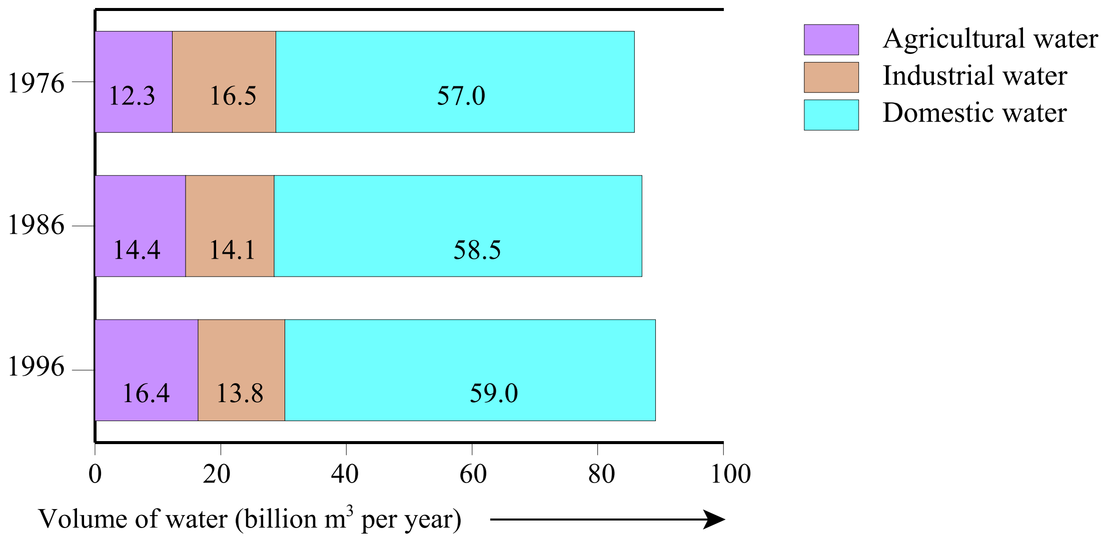


Figure 2. The Volume of Water Use in Japan

Source: National Land Agency, 2000.

About 94 percent of agricultural water is used for paddy field irrigation, while another 5 percent is used for upland irrigation and 1 percent for the livestock industry. Rivers are the main water source for irrigation, and supply about 88 percent of the total. Another 10 percent is supplied from ponds and 1 percent from groundwater. Counting only major facilities whose beneficiary area count 100 ha or more, the stock of agricultural water supply facilities and use facilities amounting to 42,000 km of water channels, more than 1,000 dams and some 2,000 headworks exist now.

Irrigation Systems in Japan

After World War II, scientific research was done and Ministry of Agriculture, Forestry and Fisheries (MAFF) formed planning standers. In which, concepts of planning irrigation projects followed historical rules of water usage in rural areas. New projects should have been designed considering the old design to maintain the functions. Also, development of technology on irrigation and drainage (I&D) helped managers or planners of agricultural water improve operation, enhance maintenance and keep effective provision.

Water Cycle on Paddy Field

The water balance in a rice paddy for one rice season (about 120 days) in Japan is schematically depicted in Figure 3. The total water supply for a rice paddy is 2,700 mm, of which 1,800 mm is supplied by irrigation and 900 mm is obtained from precipitation. The total water loss from a rice paddy is 2,700 mm, of which 1,440 mm is percolation, 600 mm is evapotranspiration and 660 mm is surface runoff. About 75 percent of percolation water, 1,080 mm goes to drainage canals near the paddy as return flow, and the remaining 360 mm goes into groundwater. These percolated waters as well as surface runoff water are effectively reused in the lower part of the basin or recharge the groundwater, as actual water consumption for rice cultivation at the district level is small.

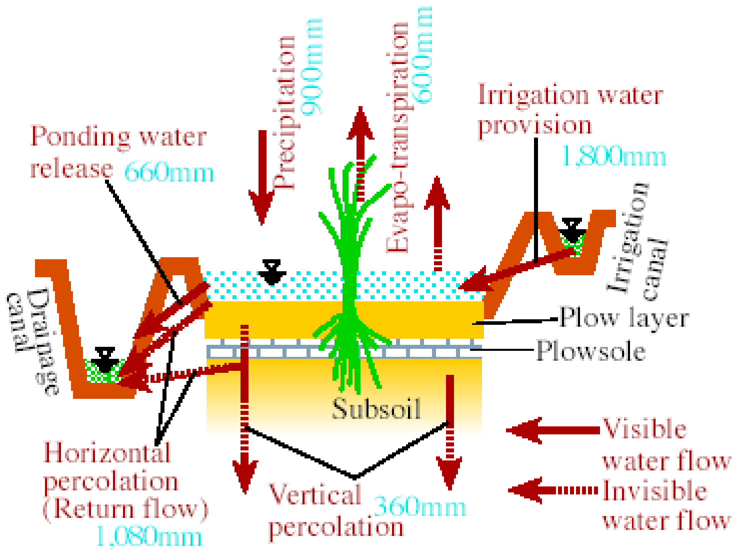


Figure 3. Water Consumption in the Paddy Field

Source: Maruyama, *et al*., 1986.

According to Kuroda, *et al*. (2000), water cycle on paddy fields is explained as follows: precipitation as well as irrigation water provided via irrigation canals is an input water flow to paddy fields. Water stored in paddy fields moves out by: (1) transpiration and evaporation to the air; (2) horizontal percolation through levee and occasionally; and (3) overflow through outlet. Evapotranspiration includes evaporation and transpiration. Percolation from plow layer includes vertical percolation through plowsole and horizontal percolation through levee. Horizontal percolation through the levee, it is invisible, includes inflow from upper paddy fields or canals and runoff to lower paddy fields or canals. Visible runoff through outlet includes: (1) lot-management water for the lower paddy fields; (2) ponding water release for managing plants growth; and (3) overflow in flood seasons (Figure 4).

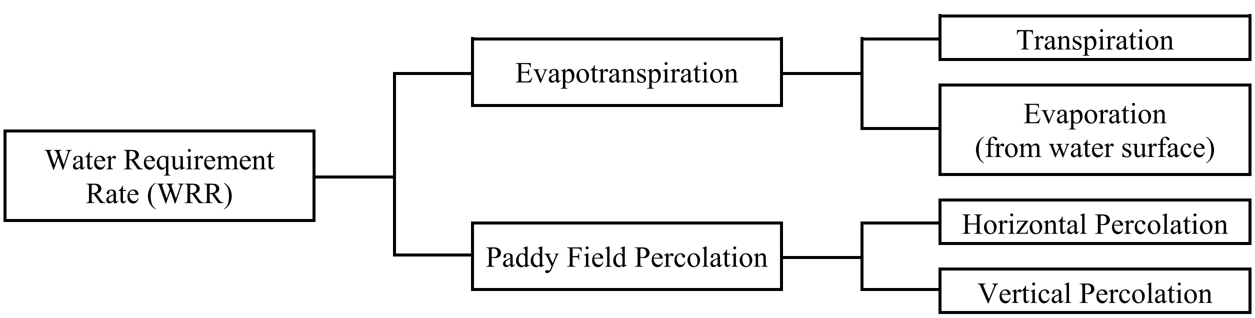


Figure 4. Aggregation of Water Requirement Rate

BASIC CONCEPTS OF IRRIGATION WATER PLANNING

When we plan an irrigation project, we firstly calculate water volume needed in a particular field inside a project area; if we cannot calculate it, we must assume it consulting experience of other projects nearby and/or similar to the project. The main purpose of irrigation water planning is to decide enough Irrigation Water Requirements (IWR) to provide appropriate volume of irrigation water to every paddy field within expected time and to consider functions of agricultural water that should be included in the project.

When deciding IWR, it is important to set Unit Water Requirement (UWR) first, then calculate other water requirement considering appropriate conditions for the project. UWR is decided by counting water balance for irrigation on each paddy plot or a small block, where farmer(s) manage irrigation water as the same schedule.

Water Requirement Aggregation

IWR consists of: (i) WRR; (ii) lot-management water requirement (LMWR); (iii) effective rainfall (ER); (iv) "canal-system-management" water requirement (CSMWR); and (v) usable water volume (UWV). Sequence of calculating IWR is done from right to left (Figure 5).

Sequence of Calculating Irrigation Water Requirement

The first step is to decide UWR after consulting WRR, LMWR and CSMWR based on data collected inside project area or nearby area.

The second step is to decide IWR considering water use priority and conditions of the blocks. In which, priority should be decided reflecting water use efficiency, economic efficiency and water quality:

$$\text{NWR (Net Water Requirement)} = \text{UWR} - \text{ER} \quad (1)$$

$$\text{GWR (Gross Water Requirement)} = \text{NWR} + \text{CSMWR} \quad (2)$$

$$\text{IWR} = \text{GWR} - \text{UWV} \quad (3)$$

Unit Water Requirement

UWR consists of WRR, PWR and LMWR. As a plan is made generally considering several stages of rice production, the project usually has two kinds of UWRs, such as early stage UWR and ordinary UWR.

$$\text{Early stage UWR} = \text{WRR} + \text{PWR (Puddling Water Requirement)} \quad (4)$$

$$\text{Ordinary UWR} = \text{WRR} + \text{LMWR} \quad (5)$$

In which, WRR, PWR and LMWR are described as follows (Otsuki, 2001):

1. ***Daily Water Requirement (Water Requirement Rate)***

The daily water requirement, which is the sum of percolation and evapotranspiration, ranges from 15 to 25 mm/day for most rice paddies. As the length of irrigation for rice cultivation is about 100 days, 1,500-2,500 mm of water is required.

2. ***Puddling Water Requirement***

The land preparation requires 100-150 mm of water. As the water requirement per unit time in this state is the largest during the rice growing season, the distribution of water from water reservoirs through rivers and irrigation canals is critically important.

3. ***Lot-Management Water Requirement***

Supplemental water is required to prevent cold damage, save labor of water management and compensate for intentional drainage such as mid-summer drainage and drainage after applying fertilizer, pesticide and herbicide. The amount of water required for this management is estimated to be 200-300 mm. Water volume is also different according to soil conditions.

ON-FARM WATER MANAGEMENT

According to Otsuki (2001), on-farm water management in Japan is described as follows: a typical large-scale I&D system in Japan is shown in Figure 6. Almost all I&D canals at all levels are paved with concrete or made of concrete flumes. Water reserved in a dam is released to a river. The river water is introduced to the main canal by weirs, and diverted to several lateral canals, tertiary canals and farm ditches. Water is finally conveyed to paddy fields through a long and complex irrigation network.

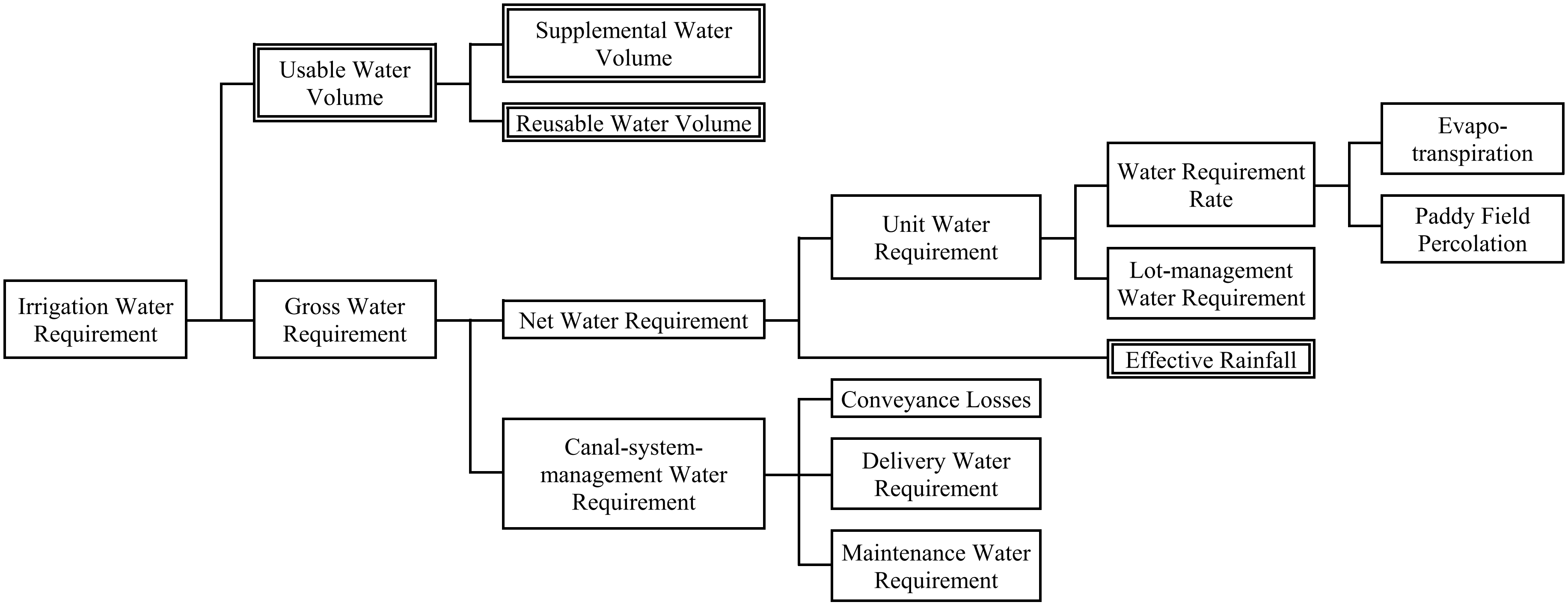


Figure 5. Aggregation of Water Requirement on Project Planning

Source: MAFF, 1993.

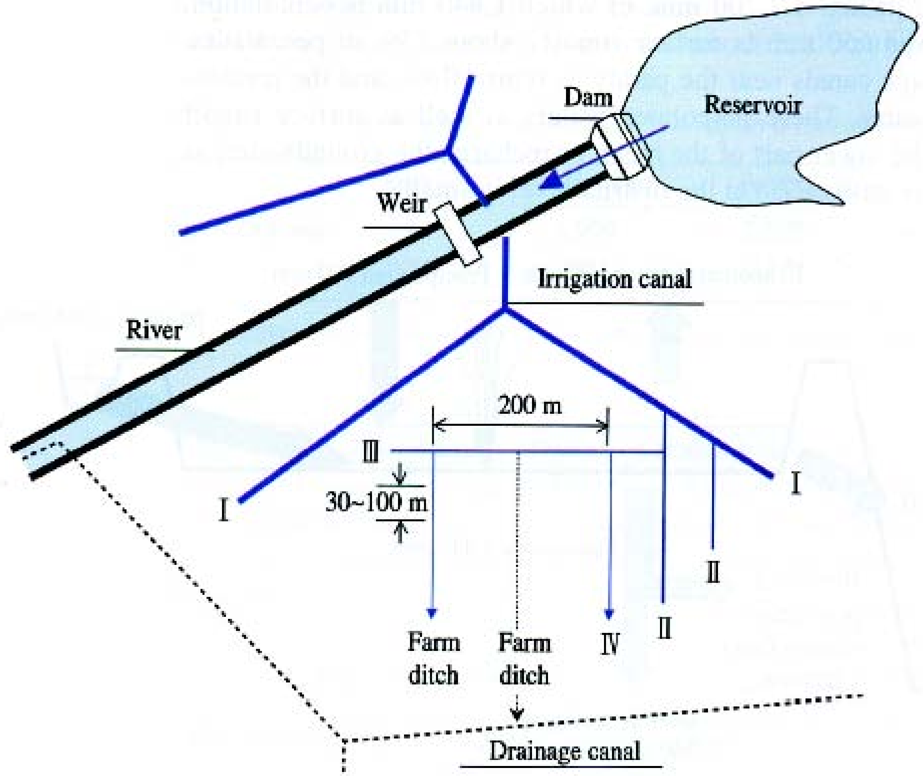


Figure 6. Typical Irrigation System in Japan

Source: Otsuki, 2001.

In some cases farm ponds are constructed to control water flow corresponding to the water use. Pipelines with pumping stations are also used. Subsurface drainage pipes are installed at a depth of 70-90 cm and with a space of around 10 m in rice paddies. They are employed to convert paddies into multipurpose fields by controlling soil moisture. Surface and subsurface water drained from paddies flows into farm drains and is collected in the drainage canals. Drained water is finally returned to the river and used again for rice paddies in downstream areas.

LAND IMPROVEMENT DISTRICT

Formation of a Water Use System

Control and management of water for rice cultivation has been an important issue since ancient days. Over a long period of time, water user groups have been organized in each region, and established a mechanism of water management for the entire region. Through frequent disputes among users over water distribution and allocation in the past, a system and rule of agricultural water usage was formed. Currently, agricultural water has been operated, managed and maintained by the LIDs (Table 1).

Executing Mechanism of Land Improvement District

LID is a party organized under the Land Improvement Law for the purpose of undertaking new construction/improvement/management of I&D facilities and land improvement projects. Since land improvement projects themselves are of highly public-purpose nature, LID is a party quite public in nature enough to be admitted of forcing farmers to become district members and then to pay necessary expenses, playing a central role in land improvement projects.

Table 1. Status of Management of Irrigation/Drainage Facilities Created Under Government-operated Projects, as of 31 March 1996

Manager, Controller, etc.	Dam	Head-works	Pumping Station	Gates	Sub-total	Canal	Total
Government	10	7	3	0	20 (1.4)	9	29 (0.3)
Prefecture	28	26	55	48	157 (11.4)	99	256 (2.6)
Municipality	7	7	81	35	130 (9.5)	2,457	2,587 (26.2)
LID	90	247	634	81	1,052 (76.6)	5,880	6,932 (70.2)
Agricultural cooperative	0	13	2	0	15 (1.1)	53	68 (0.7)
Sub-total	135	300	775	164	1,374 (100.0)	8,498	9,872 (100.0)
Commissioning under discussion (not entrusted yet)	3	0	14	0	17	113	130
Total	138	300	789	164	1,391	8,611	10,002

Note: Figures in parenthesis represents composition ratios.

LID members will be those farmers engaged in actual cultivation, namely; owners of owner-operate land and cultivators on tenant farmland. LID is required to elect its officers including directors and auditors for smooth execution of businesses. The number of directors will be five or more, while that of auditors will be two or more. In which, three-fifths or more of directors and a half of the auditors must be district members. A secretariat is also established for daily operation of businesses, as usually required by LID articles, together with business committees to assist the Board of Directors. Their systems, however, widely differ from each other, depending upon the size of LID and business contents.

Main Activities and Current State of LID

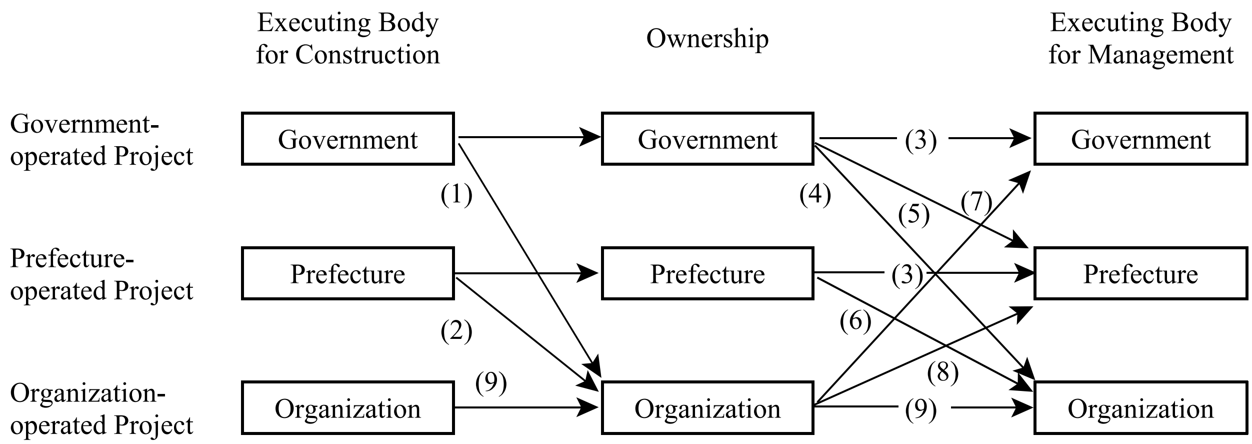
They are carrying out three main activities including management of water such as implementation of projects incidental to land improvement projects, petition for execution of national and prefecture projects and collection of expenses. The present number of LID is about 7,700 in Japan, with the area amounting to approximately 3.2 million ha and district members are some 4.5 million. Simple mean area is about 400 ha and members are about 600 for one LID. By scales area, LID of 100 ha or less account for a little less than 50 percent, while those of 1,000 ha or more account only a little less than 10 percent. In terms of district members in number, districts with less than 300 members account for a little less than 60 percent while those with 1,000 members or more, a little over 10 percent or so.

As for business types, with the progress of land improvement projects, those specializing in operation, management and maintenance (OMM) projects account for slightly 60 percent of the total and those under construct about 43 percent.

Operation and Maintenance and LID

The facilities created by I&D projects will be operated, maintained and managed by the LID at its own costs: water management system was legally converted to LID according to the Land Improvement Law in 1949 (Figure 7).

This is because I&D facilities must be managed not only by properly maintaining/managing the functions of a facility, but also by water management within the benefitted area through the operation of facilities. Moreover, it is considered more rational that these facilities should be managed and controlled by LID composed of benefitted farmers, since how they are managed is deeply associated with the interests of individual farmers within the benefitted area. Particularly in Japan, each area of a farm village has been on the base for an autonomous and voluntary agreement system established on the well-accepted community-first principle through the long history of a rice culture. Based on the above situation, the water management system has been formed.



(1) Assignment under Article 94-3 of the Law (Conditional Assignment)
(2) Assignment under regulations (Rules under the Local Government Law and Subsidy Budget Rationalization Act)
(3) Government-operated management by petition under Article 85 of the Law
(4) and (5) Entrusted management under Article 94-6, paragraph 1 of the Law
(6) Entrusted management under Article 94-10 of the Law or Regulations
(7) and (8) Requested management under Article 93 or 96-4 of the Law
(9) Management under Article 57 of the Law (Obligation to Manage; the Executing Body for Construction)

Figure 7. System of Irrigation/Drainage Facility Management

CURRENT STATE OF MANAGEMENT

Miyamoto (2001) reported current state of managing agricultural water facilities in 1994. He selected 143 irrigation project site, total benefit area of which amounted 590 ha, and investigated implementing organizations and cost for managing activities, etc. The results are shown in Tables 2 and 3. According to the result, 85 percent of their management was done by LID, 9.8 percent were by water user's association (WUA) and 2.8 percent were by local governments.

Table 2. Acting Bodies and Management Activities for Irrigation System

(Unit: Percent)

Maintaining Bodies and Rates		Activities					
		Operation	Maintenance				Coordination
			Cleaning	Cutting Weed	Rehabilitation	Reconstruction	Water Allocation
Prefecture	0.0	0.0	0.0	0.7	0.8	11.3	0.9
Cities, towns, etc.	2.8	3.3	8.0	5.8	12.4	17.9	3.5
LIDs	84.6	76.2	53.4	50.7	69.0	54.7	76.5
WUA	9.8	9.0	10.2	12.3	6.2	3.8	13.0
Self-autonomies	2.8	3.3	20.5	17.4	3.1	0.9	5.2
Individuals	0.0	6.6	7.4	12.3	0.0	0.9	0.0
Others	0.0	1.6	0.6	0.7	8.5	10.4	0.9

Source: Miyamoto, 2001.

Table 3. Cost Bearers and Management Activities for Irrigation System

(Unit: Percent)

Maintaining Bodies and Rates		Activities					
		Operation	Maintenance				Coordination
			Cleaning	Cutting Weed	Rehabilitation	Reconstruction	Water Allocation
Prefecture	0.0	0.8	0.0	0.8	1.5	10.7	0.9
Cities, towns, etc.	2.8	10.7	11.8	8.2	16.4	24.6	13.0
LIDs	84.6	78.5	66.9	62.3	74.6	59.0	74.1
WUA	9.8	4.1	6.6	6.6	5.2	2.5	4.6
Self-autonomies	2.8	4.1	11.8	13.1	2.2	3.3	2.8
Individuals	0.0	1.7	2.9	9.0	0.0	0.0	1.9
Others	0.0	0.0	0.0	0.0	0.0	0.0	2.8

Source: Miyamoto, 2001.

Managing Body

In some cases, operation was done by specific operators due to continuity of local rules. Concerning maintenance, there were two types: the first one was routine maintenance, and the second one was rehabilitation and reconstruction.

In case of routine maintenance, such as cleaning and cutting weed, self-autonomy bodies or individuals fulfilled those roles. Rehabilitation and reconstruction, however, were responsibility of government of prefectures or cities because they needed not only high technology but also high cost. In case of coordination of water use allocation, LID played important roles.

Cost Bearer

Cost needed for operation and maintenance (O&M) was paid mainly by LIDs (59-79 percent), however, it was said to be increasing governments payment recently. The government usually pays the cost of relatively high-cost rehabilitation works. In case of cleaning and cutting weed, self-autonomy bodies or individuals paid cost.

Activities

Manpower-needing activities such as cleaning and cutting weed were mainly done by voluntary work of farmers. Usually, one person per household should do the job. Also, self-autonomy bodies or residents' group did the job. Interval of cleaning and cutting weed was mainly once a year, and cleaning and cutting weed were usually done simultaneously.

Annual Cost

Usually, the cost of maintenance was levied to farmers. The amount varied from project to project, reflecting the size of facilities, maintenance activities or subsidies organizations received. The average cost of these 143 projects was ¥2,200 (1996).

STRENGTHENING OPERATION AND MAINTENANCE OF IRRIGATION AND DRAINAGE FACILITIES

Improvement of Management System

Due to advanced land improvement projects as well as technical progress, the number of large-scale I&D facilities are increasing rapidly. Such facilities including dams require sophisticated management technology including water management/control equipment for rationalized management and labor saving. The necessity to properly and safely manage such large-scale and advanced I&D facilities require an improved management system in each LID, engineers including dam management chief engineers, chief electricians and technical personnel for daily checking/maintenance.

Strengthening of Safety Management Measures

Under the influence of growing mixed residence during the process of high economic growth as well as recently increasing national income and expanding leisure time, rural areas have been favorably appreciated as natural scenic beauty. At the same time, traditional culture in rural area has been highly expected as places of rest and peace for people. Under such circumstances, such accidents as falls at dam sites, on headworks, or along I&D canals and those due to flooding have increased, posing a problem of the necessity to strengthen safety management measures while ingeniously utilizing I&D facilities as water-friendly spaces.

ISSUES TO BE SOLVED

During the process of high economic growth in and after the 1960s, a decrease in the number of farmers and increasing part-time farm households met the coincidental occurrence of progressive depopulation and rapid population aging in the rural areas due to the outflow of young people into cities. As a result, the quality of LIDs had substantially changed such as due to the occupancy mostly by elderly members as well as the polarization of composite members into a large number of part-time farm households and a small number of full-time farm households.

This had not only brought differences in opinions about the management of land improvement facilities and disputes over interests, but also deteriorated the voluntary joint management function that performed so far water utilization, canal maintenance, etc. resulting a LID to increase its burden.

Furthermore, expanded urban areas introduced into rural areas the growing mixed residence where farm and non-farm households coexist. Therefore, municipal wastewater and refuse were allowed to flow into irrigation canals to contaminate water quality.

On the other hand, despite a less increase in farm income under the influence of the internationalization of agriculture such as liberalization of farm products, the expenses required for the implementation of land improvement projects (construction works and facility management) and operation of organization have increased.

Under such circumstances, small-scale LID still account for an overwhelmingly large part as mentioned above, posing a major problem of the necessity to reinforce LID's organization system and financial basis by means of merger, etc.

Hence, the government promotes its general reinforcement policy for LID through the implementation measures of subsidizing such as: (1) each LID for the expenses to develop its revitalization initiative; (2) prefectures for the expenses to prepare their basis LID consolidation plans (master plans); and (3) the expenses of those LID involved in the mergers intended for a scale above a certain level.

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6. REPUBLIC OF KOREA

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INTRODUCTION

The total land area of the Republic of Korea is 99,461 km^2, 64.6 percent of which is forest, 19.0 percent is farmland, and the rest 16.4 percent is urban area and others as of 2000 (Table 1). Along the eastern coast of the Korean peninsula there is a large range of mountain with two branches to the southwest direction. Mountain area is steep and mostly covered with forest. Most of the farmland is located in western and southern part of the country. Population is 46,136,100 and population density is very high, 462 persons/km^2. Number of farm households is 1,383,500 and rural population is 4,031,000, which is 8.7 percent of total population in 2000.

Table 1. Utilization of Land

(Unit: 000 ha)

Classification	1970	1980	1990	2000
Agricultural land	2,316 (23.1)	2,196 (22.2)	2,109 (21.3)	1,889 (19.0)
Forest	6,611 (65.8)	6,568 (66.3)	6,476 (65.2)	6,422 (64.6)
Others	1,118 (11.1)	1,136 (11.5)	1,343 (13.5)	1,635 (16.4)
Total	10,045 (100.0)	9,900 (100.0)	9,928 (100.0)	9,946 (100.0)

Source: Ministry of Agriculture and Forestry, 2001.
Note: Figures in parentheses are percent.

Korea is located in the monsoon region of Asia. The annual mean climatic factors are as follows: a) annual precipitation, 1,283 mm; pan evaporation 1,159 mm; sunshine hours, 2,449 hours; annual mean temperature, 12.2ºC; and wind velocity, 2.2 m/s. Frost-free season varies from 160 to 240 days depending on the location. Summer months are rainy and hot while winter months are dry and cold. May to November is growing season while the rest are dormant season except in greenhouses.

Agriculture

Agriculture has been the basic foundation for the food and fiber supply in Korea in the past. However, the role of the agriculture in national economy has been decreasing rapidly. The agriculture, forestry and fishery comprised 48 percent of the national product in 1961, and it has declined to 8.5 percent in 1990. Agriculture sector comprised 3.9 percent of the GNP in 2000. This means that the national industrial structure is changing from primary industry to secondary and tertiary.

Total agricultural land area is 1,888,765 ha (as of 2000). About 60 percent of the total agricultural land area is paddy field and the rest is upland field (Table 2). Total paddy area is 1,149,041 ha, of which 76.6 percent is irrigated and the rest is rainfed area (Table 3).

Average extent of farmland per household is 1.37 ha, of which 0.83 ha is rice paddy and 0.54 ha is upland field as of 2000. The climatic condition and the international grain trade system allow only one cropping per year except for some vegetable and food crops. The productivity of the main crops is relatively high mainly due to the high input of fertilizers and pesticides, advanced farming techniques and farm mechanization.

Table 2. Agricultural Land Area

(Unit: 000 ha)

Classification	1970	1980	1990	2000
Paddy field	1,283 (55.4)	1,307 (59.5)	1,345 (63.8)	1,149 (60.8)
Upland field	1,033 (44.6)	889 (40.5)	764 (36.2)	740 (39.2)
Total	2,316 (100.0)	2,196 (100.0)	2,109 (100.0)	1,889 (100.0)

Source: Ministry of Agriculture and Forestry, 2001.
Note: Figures in parentheses are percent.

Table 3. Area of Paddy Fields Classified by Managing Organizations and Irrigation Conditions

(Unit: ha)

Irrigated Paddy				Rainfed	Total
KARICO*	Irrigation Associations	Farmers	Sub-total		
520,355 (45.3)	190,084 (16.5)	170,005 (14.8)	880,444 (76.6)	268,597 (23.4)	1,149,041 (100.0)

Source: Ministry of Agriculture and Forestry, 2001.
Note: * Korea Agricultural and Rural Infrastructure Corporation.
Figures in parentheses are percent.

Rice paddy is mostly cultivated for one crop per year. Upland field and some paddy fields are used for two or more cropping per year. Table 4 shows the cropping pattern by area and production amount of the main crops in Korea as of 2000. Total cropping area inclusive of multiple cropping is 1,949,000 ha indicating 103 percent land use rate, of which 1,072,000 ha is rice paddy, 386,000 ha for vegetables, and 173,000 ha for fruits.

Table 4. Cropping Pattern by Area and Production of Main Crops, 2000

Classification	Rice	Barley	Pulses	Potatoes	Vegetables	Fruits	Others	Total
Area (000 ha)	1,072	68	107	46	386	173	97	1,949
Production (000 mt)	5,291	163	134	248	11,282	2,429	132	19,679

Overall self-sufficiency rate of the agricultural production was 29.7 percent in 2000. The self-sufficiency rates of the rice and barley are 103 percent and 47 percent, respectively. However, those of wheat, corn and soybean are 0.1, 0.9 and 6.4 percent, respectively. Corn and soybean are mostly used for animal feed. Excluding animal feed, the self-sufficiency rate reaches 55.6 percent. Starchy roots, fruits and vegetables production is nearly self-sufficient.

Rural Development

Rural development projects have mostly been executed by the government. They include farmland consolidation, upland reclamation, tideland reclamation, irrigation and drainage improvement, rural living environment improvement and others. Among them, large-scale comprehensive agricultural development projects and integrated tideland reclamation projects have been the most effective with large investments.

So far, 15 large-scale comprehensive agricultural and tideland development projects with a total land development area of 161,667 ha have been completed, and six projects are under progress with a total land development area of 104,830 ha and a capital investment of ₩3,937 billion (US$3.15 billion).

Although new farmland is developed by reclamation projects, the farmland area is continuously decreasing since 1980 at a rate about 20,000 ha annually because of the conversion of farmland to industrial sites, urban development, and others.

IRRIGATION SYSTEM DEVELOPMENT

In Korea, irrigation systems have been essentially developed for rice paddies. The first fill dam was constructed in 330 A.D. to irrigate 10,000 ha of paddy field in Korea. With the advancement of agricultural technology from 1392, large irrigation programs were systemized to help increasing crop production.

During the Japanese occupation (1910-45) Korean peninsula acted as a granary of the Japanese food supply. During this period modern irrigation structures, including a concrete arch dam, were installed. Since the independence from Japan, efforts were made to construct irrigation facilities to achieve self-sufficiency in staple food. Since 1970s, major large-scale agricultural development projects, which included irrigation systems, have been completed.

Water Resources

Total amount of water resources in Korea is 127.6 billion m^3. The annual precipitation of 1,283 mm is 1.3 times greater than that of world average 973 mm. However, annual per capita precipitation volume is only 2,700 m^3 that is only one-tenth of the world average 26,800 m^3.

Fifty-five billion m^3 evaporate or transpire as losses from the total water resources and the rest 73.1 billion m^3 flows through rivers. Therefore, maximum amount of renewable water resources is 73.1 billion m^3. Out of the total renewable water resources, 49.3 billion m^3 flow as flood flow during the flood season and the rest 23.8 billion m^3 as normal flow. Forty billion m^3 directly flows to the sea.

Total water use in 1998 was 33.1 billion m^3, which includes 16.1 billion m^3 of river flows, 13.3 billion m^3 reservoir water and 3.7 billion m^3 groundwater (Ministry of Construction and Transportation, 2001). The amount of water use represents 26 percent of the total water resources.

The temporal and spatial variation of the precipitation restricts effective water use in Korea. Spatial variation shows annual precipitation of less than 1,000 mm in the inland Kyungpook province to 1,500 mm along the south coast. Temporally, more than two-thirds of the precipitation falls during four months, June to September. Annual mean precipitation varied from 754 mm to 1,683 mm for the last 80 years. Therefore, Korea experiences frequent flood or drought damages.

Water resources development in Korea is mostly from rivers and streams. Natural lakes are rare and groundwater development is not well progressed yet. Therefore, the main physical facilities of water supply are dams, headworks and pump stations along rivers and streams, and estuary fresh water reservoirs.

Total annual water use in Korea was 33.1 billion m^3 in 1998, which was composed of 7.3 billion m^3 of municipal use, 2.9 billion m^3 of industrial use, 15.8 billion m^3 of agricultural use, and 7.1 billion m^3 of stream low flow augmentation.

Agricultural water use is 15.8 billion m^3, which accounts for about 48 percent of the total water use. Therefore, efficient water use in agriculture is very important for the national water conservation. The majority (97 percent) of the agricultural water is for the paddy rice, and only very small amount is used for upland crops.

Irrigation Methods

Transplanting is the general cultural practice in Korea, but about 10 percent of paddy fields are direct seeded. Rice plants are transplanted around late May and harvested in early October. Irrigation season lasts about 100-110 days. Nursery stage is about 30 days long.

Basin irrigation method is used for paddy fields. First two-thirds of the growing period is continuously irrigated while the last one-third is intermittently irrigated. The ponded depth is either shallow or deep depending on the growth stage. The paddy fields are drained and exposed to the sun for seven to 10 days after tillering stage to improve paddy growth. Recently, the idea emerged that the intermittent paddy irrigation as well as shallow ponded depth is beneficial for the crop yield and water conservation.

Methods such as furrow, border, sprinkler, and trickle are used for vegetables and fruit trees. The furrow method is widely employed for vegetable crops such as Chinese cabbages, radishes, etc. Sprinkler systems are used for some vegetable fields and orchards. Only very few trickle systems are used in vineyards, orchards, vegetable fields and greenhouses. Irrigation efficiency and institutional arrangements of the Asian countries are reported in APO (2001).

Irrigation Facilities

Table 5 shows irrigated land area with regards to water sources and managing organizations as of 2000. Total number of irrigation water source facilities is 64,543 with beneficial area of 880,444 ha. The main facility is reservoirs with beneficial area of 516,783 ha, followed by pump stations, 123,634 ha; headworks, 102,499 ha; and tube wells, 35,382 ha. The irrigated rice fields experience frequent drought damages because of the insufficient drought-frequency designs.

Table 5. Irrigated Land Area Classified by Sources of Water and Managing Organizations, 2000

Facilities	KARICO		Non-KARICO		Total	
	Number	Area (ha)	Number	Area (ha)	Number	Area (ha)
Reservoir	3,299	379,677	14,614	137,106	17,913	516,783
Pumping station	3,044	93,936	2,893	29,698	5,937	123,634
Pumping and drainage station	95	29,685	24	360	119	30,045
Drainage station	433	535	57	655	490	1,190
Headwork	3,897	14,052	14,453	88,446	18,350	102,498
Infiltration gallery	446	2,371	3,234	16,688	3,680	19,059
Tube well	1,081	98	16,973	35,284	18,054	35,382
Others				51,853		51,853
Total	12,295	520,354	52,248	360,090	64,543	880,444

Source: Ministry of Agriculture and Forestry, 2001.

There are 17,913 irrigation reservoirs, among which 54 percent were constructed before 1945. Hence these are very old and pose problems in operation and maintenance. Total irrigation canal length is 109,833 km. Earth canals account for 63 percent of the total irrigation canal system (Table 6).

Table 6. Lengths of Irrigation Canals, 2000

(Unit: km)

Managing Organization	Main		Sub-main		Lateral		Total	
	Earth	Structures	Earth	Structures	Earth	Structures	Earth	Structures
KARICO	6,315	8,516	10,092	9,063	20,248	8,562	36,655	26,141
Non-KARICO	7,202	3,314	11,285	5,074	14,570	5,593	33,057	13,980
Total	13,517	11,830	21,377	14,137	34,818	14,155	69,712	40,121

Source: Ministry of Agriculture and Forestry, 2001.

They are prone to large seepage losses and are difficult to maintain. In some test project sites, earth canal lining, concrete canal, and even pipeline system in paddy fields showed improved water use efficiency. Also, automation of irrigation water management system with TC/TM is in the test stage in Korea.

IRRIGATION MANAGEMENT SYSTEM

Various institutional arrangements and operating modes of the irrigation systems are presented in Jensen and Lord, Jr. (1990). Five types of the more common organizations and institutional arrangements are as follows:

* Government agency water allocation and distribution;
* Public-managed water distribution system serving water user groups;
* Farmer-managed irrigation system;
* Quasi-public systems operated by project personnel; and
* Independent farmer-owned water supply system.

There are two major operation and management (O&M) systems in Korea, one by the Korea Agricultural and Rural Infrastructure Corporation, a government corporation, and the other by non-KARICO, which includes irrigation associations (IAs) and individual farmers under the supervision of city or county authorities. The present O&M system of agricultural water system as of 2002 in Korea is shown in Figure 1. Institutional arrangements are government agency type in the KARICO area and farmers group type in IA area.

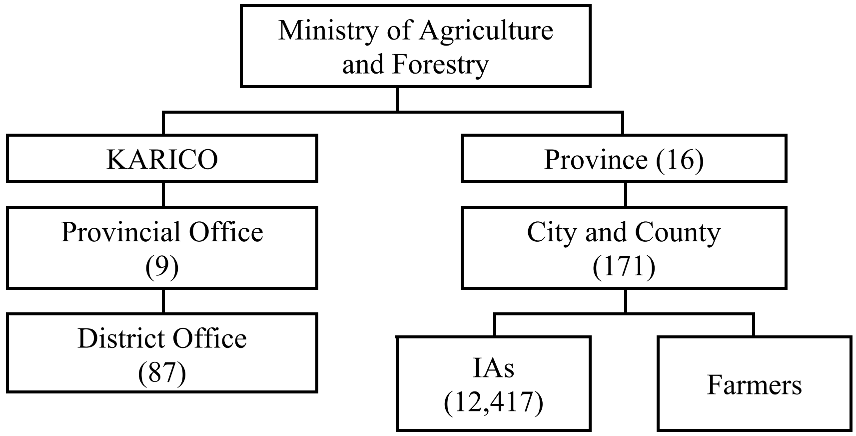

Figure 1. Organization Chart of Irrigation Management System in Korea

KARICO is composed of one headquarters, one research institute, nine provincial offices, 87 district offices, and four comprehensive project offices. District offices are responsible for the water management from the source to the tertiary canals. Within the city and county managing area, there are 12,417 IAs.

KARICO manages large-size land areas exceeding 50 ha, while IAs manage small-size lands of 5-50 ha. Individual farmers manage irrigation facilities in the land area less than 5 ha. KARICO, a government corporation, was founded in January 2000 through merger of three organizations; Rural Development Corporation, 103 farmland improvement associations and Federation of Farmland Improvement Associations.

The notable features of water management in Korea are the integrated management of agricultural water system from water sources to tertiary canals in a package, and the exemption of irrigation fees in the areas managed by KARICO.

Korea Agricultural and Rural Infrastructure Corporation

1. ***Historical Background***

The beginning of KARICO, which was commissioned to carry out rural development projects by the government, goes back to the Chosun Union of Irrigation Associations established in 1940, which was renamed as Union of Korea Irrigation Association in 1949 and then Union of Land Improvement Association (ULIA) in 1962. In 1970, Agricultural Development Corporation (ADC) was established through merger of ULIA and Groundwater Development Corporation, and became a core organization executing the integrated large-scale agricultural development projects. In 1990, ADC was expanded, reorganized, and renamed as Rural Development Corporation (RDC) by adding on the functions of transaction and rental of the farmlands. In January 2000, KARICO was born by combining RDC, 103 farmland improvement associations and Federation of Farmland Improvement Associations.

2. ***Roles and Functions***

KARICO aims to contribute to the economic and social development of rural areas by means of increasing farmer's income. Other goals are comprehensive management of agricultural infrastructure facilities and construction of environment-friendly production system, among others. In addition, it formulates agricultural policy for the future.

Furthermore, KARICO intends not only to develop rural area into affluent community harmonized with nature, but also to take the leading role as the key agency in charge of executing agricultural policies such as rice production, efficient management of national resources, and disaster prevention.

KARICO manages 59 percent of the total irrigated paddy areas in Korea (Table 5). The number of reservoirs in KARICO area is 3,299, representing only 27 percent; however, the benefit area is 73 percent. This indicates that the reservoirs are the major water source for the paddy fields managed by KARICO.

3. ***Details of O&M Works Executed by KARICO***

The O&M works for irrigation and drainage systems by KARICO are categorized into two parts, i.e., water management and facility maintenance. Table 7 shows the detailed functions of KARICO. The agricultural water system in KARICO area is operated and maintained through the financial support from the Central Government, and no water fees are collected from farmers.

Table 7. Operation and Management Functions of KARICO

Category	Detail works
Water quantity management	Database setup and planning for water supply Canal flow gauging and prevention of natural disasters Water-saving for drought mitigation Preventive measures for flood protection Appropriate supply of water at proper time Proper allocation of water to canals Proper drainage of excess water Weed control and dredging in canals
Water quality management	Monitoring agricultural water contamination Treatment of polluted irrigation water Planning for water pollution control
District/user management	Enrollment and exclusion of benefit area Bookkeeping of user list
Record management	Transfer and takeover of facilities Registration and abolition of facilities
Inspection and maintenance	O&M planning of irrigation system Inspection of facilities Maintenance and rehabilitation of facilities Planning emergency measures Construction of safety and disaster prevention facilities, and communication systems Decision on utilization of facilities for purposes other than normal Diagnostic inspection of facilities

Source: After Lee, 2001.

Irrigation Associations

1. ***Historical Background***

IAs are typical rural fraternity to manage irrigation facilities at the village level. IAs were born as mutual cooperative farmer groups with long history and background. They played important roles in overcoming agricultural disasters such as droughts and floods, and helping each other in various agronomic activities. They also preserved local traditions and community spirit. Each IA has members not less than five and of land area not smaller than 5 ha.

2. ***Roles and Functions***

The IAs operate and maintain small-scale water sources such as small reservoirs, diversion weirs, and wells to supply water for the scattered small-scale lands. The operation of IAs and collection of O&M fees are subjected to province regulations. Among the 360,089 ha of non-KARICO-managed paddy area, 190,084 ha are managed by 12,417 IAs with 415,517 members as of 2000 (Table 8).

Individual farmers or small farmers groups manage the balance 170,005 ha. Within the IA area, reservoirs and pumping stations supplied irrigation water to 58 percent of the authorized area, while diversion weirs and others covered the rest.

ISSUES AND CONSTRAINTS

OECD suggested on water management policy as follows (OECD, 1998):

- Collect water fee;
- Increase water supply to other sectors by saving agricultural water use;
- Improve water quality; and
- Enhance favorable environmental impacts of agricultural water use.

Table 8. Status of Irrigation Association with respect to Facilities, 2000

Facility	Number of Facilities	Benefit Area (ha)	Number of IAs	Number of IA Members	Assessed Area (ha)	Amount Assessed (₩ 000)
Reservoir	6,537	88,606	5,465	195,530	66,888	2,369,017
Pumping and station	1,440	22,218	1,159	42,418	16,860	1,124,977
Pumping and drainage station	24	821	25	1,244	648	97,052
Headwork	3,319	40,176	2,587	93,922	31,639	1,273,381
Infiltration gallery	598	6,317	412	12,421	4,464	274,829
Tube well	3,204	19,212	2,397	53,057	13,989	1,049,433
Feed canal	17	810	17	1,103	704	29,973
Sea dike	338	11,672	324	14,940	1,665	86,365
Others	34	252	31	882	182	18,356
Total	15,511	190,084	12,417	415,517	137,039	6,323,383

Source: Ministry of Agriculture and Forestry, 2001.
Note: US$1 = ₩1,250.

From the commencement of KARICO in 2000, farmers were exempted from water and operation and maintenance fees. Until 1999, farmers in this area paid part of the cost of irrigation system operation and maintenance. This change is opposite to the international trend, which follows ‘user pay principle.’ In addition, the institutional system of KARICO is “government-oriented”, which is also contrary to the public participation principle suggested by OECD.

Major issues and constraints as well as the general issues and constraints are given below:

Duality of Management System

The dual system of the irrigation water management system is the largest problem in Korea: management by KARICO and that by IAs. Farmers in the KARICO receive a better service without any fee, while those in the IA-managed area farmers pay part of the operation and maintenance cost of the irrigation facilities. Generally, in this area the service level of the irrigation system is inferior to that in the KARICO area. Therefore, many farmers in the IA area appeal to transfer their management system to KARICO (Mo, 2001). This dual system should be changed for equity as well as for efficient water management.

Cost Allocation of Irrigation Facilities Management

Irrigation projects have various positive effects such as increasing crop production, conserving rural environment, preventing disasters and improving rural amenity. The recipients of these benefits are not only farmers but also Central and local governments representing general public. Therefore, in principle, farmers and Central and local governments should share the construction, operation and maintenance cost of the irrigation facilities (Kim, 2001).

General Issues and Constraints

O&M techniques have been steadily improved in the recent past, however, there are still much more to be improved. More specific issues related to policy and management have been discussed in the previous section and the more general issues and constraints in the water management system in Korea are listed below:

* The main general issue of the irrigation system management is that many facilities are old, and should be replaced or repaired in the near future;
* Budget for new development, rehabilitation, repair and management of the irrigation system is limited;
* Watercourses at the head of distribution canal receive more than sanctioned, and those at the tail, less;
* Farmers often do not receive adequate notification of canal closings;
* No water measuring devices are installed in the farm level causing excess water supply;
* Optimal O&M of the farm irrigation system is required for better performance of the system; and
* Water supply system is supply-oriented; this should be changed to the demand-oriented system for a better water use efficiency.

FUTURE PERSPECTIVES

Water distribution among sectors will be a critical issue in the future, and the portion of agricultural use will decrease. Due to very old irrigation facilities and lack of adequate management, water loss is large. In addition, basic data, which are a prerequisite for well-planned water management, are limited. Water quality deterioration, budget constraints, and lack of farmers' cooperation are problems for more efficient water management.

The 10-year agricultural water resources development project from 1995 to 2004 by the Ministry of Agriculture and Forestry is underway. The total capital investment for this project is ₩14.4 trillion (US$11.5 billion). At the end of this project the irrigation ratio of the paddy fields is aimed at 88 percent from the present 77 percent.

The basic method of the irrigation water development is construction of new facilities such as reservoirs, pump stations, headworks, etc. Rehabilitation and repairing of the existing old facilities, such as dredging old reservoirs and canal lining, are also important.

Strategies to Improve Irrigation Management System

To improve irrigation system management practices in general, the followings should be accomplished:

* Systematic data collection by installing sufficient flow measuring devices;
* Proper canal maintenance to keep out sediment and plant growth so as to keep canal conveyance;
* Introduction of water metering for water charge as well as water conservation;
* Adoption of demand-oriented irrigation rather than supply-oriented to reduce water loss; and
* Change of water fee policy. Farmers have to pay for the services they receive and water charge with metering system will reduce water usage.

The most important policy changes and management strategies to improve irrigation management system are as follows:

Augment Farmers' Participation

Korea is classified as water deficit country by the United Nations. The country will face water right conflicts in the near future because of increasing competition among water use sectors. Among water use sectors, agriculture sector receives low priority in water distribution policy in Korea. In addition, agricultural water use has lower productivity than other uses. Therefore, farmer participation in the irrigation facility maintenance will be very important in securing the water right.

Maintain Consistency of Government Policy

Recent government policy, which exempted water and maintenance fees from farmers, is regarded as a backward movement. This change increases government burden and cannot obtain a national consensus.

So far, the government has played an important role in agricultural water supply and maintenance of irrigation facilities; however, it has neglected effective use and management of agricultural water resources.

Considering various problems on irrigation water and facility management, the government has to develop policies and maintain them consistently by setting farmer's role in water management, impose certain responsibilities on farmers and improving water service level.

Promote the Roles of Local Governments

Local governments have to consider agricultural water in terms water quality, environment, preserving traditional culture and sustenance of rural community as well as water supply aspect. Therefore, they have to share the cost of the irrigation facility maintenance.

Revise the Role of KARICO

KARICO has to improve water supply system such as year-round water supply. Then, it has to ask farmers to participate and charge farmers water and maintenance fees. In addition, KARICO has to endeavor to reduce maintenance cost through effective management of irrigation facilities.

CONCLUSION

There are two major O&M systems in Korea, one by the KARICO, a government corporation, and the other by non-KARICO, which includes IAs and individual farmers under the supervision of city or county authorities. Main issues and constraints in the irrigation facility management are as follows:

i. The dual system of the irrigation water management system is the largest problem in Korea; management by KARICO and that by IAs. This dual system should be changed for equity as well as for more efficient water management.
ii. From the commencement of KARICO in 2000, farmers were exempted from water and operation and maintenance fees. This is against the international trend, which follows 'user pay principle'. In addition, the institutional system of KARICO is government-oriented, which is also contrary to the public participation principle suggested by OECD.
iii. Irrigation projects have various effects such as increasing crop production, conserving rural environment, preventing disasters and improving rural amenity. The recipients of these effects are not only farmers but also Central and local governments representing general public. Therefore, both farmers and Central and local governments should share the construction, operation and maintenance cost of the irrigation facilities.

Major strategies to improve irrigation management system are as follows:

i. ***Augment Farmer's Participation***: Korea will face water right conflicts in the near future because of increasing competition among water user sectors. Farmer participation in the irrigation facility management will be very important in securing the water right;
ii. ***Maintain Consistency of Government Policy***: Recent government policy, which exempted water and maintenance fees from farmers, is regarded as a backward movement. It increases government burden and cannot get a national consensus. The government has to develop policies and maintain them consistently by setting farmer's role in water management, impose certain responsibilities on farmers and improving water service level;
iii. ***Promote the Roles of Local Governments***: Local governments have to consider agricultural water in terms of water quality, environment, preserving traditional culture and sustenance of rural community as well as water supply aspect. Therefore, they have to share the cost of the irrigation facility maintenance; and
iv. ***To Revise the Role of KARICO***: KARICO has to improve water supply system such as year-round water supply. Then, it should ask farmers to participate and charge farmers water and maintenance fees. In addition, KARICO has to endeavor to reduce maintenance cost through more efficient management of irrigation facilities.

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7. MALAYSIA

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INTRODUCTION

This paper aims to discuss, from the viewpoint of the author as the manager of an irrigation scheme (1995-2000), the various issues and constraints involved in the management of irrigation systems, measures for improving performance in irrigation management and the future direction of irrigation management in Malaysia.

Paddy/rice is the staple food of the country. Compared to other food crops, the total area for paddy cultivation (240,938 ha, 1990) is the largest. The concentration of paddy cultivation is in the eight granary areas, identified by the government for the crop, which covers an area totaling 212,497 ha.

One of the granary areas which the author has had the pleasure of serving is the Seberang Perak Irrigation Scheme (SPIS), covering an area of 8,708 ha, in the State of Perak, Malaysia. Because of its relatively small size compared to other granary areas, the Department of Irrigation and Drainage (DID) Malaysia has chosen this scheme as a pilot project to implement the quality system management as per ISO 9002 for the operation of irrigation system. Since its certification by the Management and Manpower Planning Unit (MAMPU) of the Malaysian Public Services Department in 1998, few other granary areas have also followed this approach and standardized the operating procedures of the irrigation system.

MANAGEMENT OF IRRIGATION SYSTEMS

The SPIS is irrigated by diverting water from the Perak river through an intake structure at Teluk Sena. The main canal then delivers irrigation supply through a bifurcation structure to two compartments, namely; the Right Branch Canal (RBC) and the Left Branch Canal (LBC), which serves 4,343 ha and 4,365 ha, respectively. The RBC is made up of Blocks E, F and G and is managed at the tertiary canal level and on-farm by a corporate body, FELCRA (Federal Land Consolidation and Rehabilitation Authority) as a paddy estate.

The LBC is made up of Blocks A, B, C and D and is managed by the DID up to the tertiary canal level. The on-farm water management is carried out by the farmers with the technical advice/assistance from the DID or the Department of Agriculture (DoA).

Issues and Constraints

Traditionally, the irrigation systems in the country have been agency-managed and there was no farmer-initiated and farmer-managed system. Of late, there has been a shift in the approach towards a more participatory one whereby participation of the farmers is encouraged. However, the nature of their participation has been confined to determining the irrigation and planting schedules through various communities at the farm locality and district levels. Even then, there have been problems of farmers' failure to keep up to the agreed schedules due to various reasons, such as farm machinery, labor shortage, capital and pest attack.

Funding for operation and maintenance (O&M) of irrigation systems has all along been borne by the government through the DID, DoA and other agencies. Although the DID's proposal on norms for various maintenance work is in line with the government's policy on maintenance culture, the allocation that is provided has not been able to cater for the ideal maintenance of the irrigation infrastructure like canals, drains, farm roads, structures and crossings. Very often maintenance work of farm roads and structures are done only when they become unserviceable and need costly repairs. Clearing of vegetative growth in the canals and drains need to be done on frequent and regular intervals, at least three or four cycles per year. With the rising costs of maintenance, farmers have been encouraged to jointly bear the costs through group-based activities. However, bureaucratic procedures have not gone down well with the farmer groups, thus hampering the smooth running of the maintenance work.

Unlike other schemes in the granary areas, the SPIS is blessed with abundance of water from the Perak river. Conveyance and distribution of irrigation water from an intake structure through a network of earth canals have seen many successful harvests. Until recently, several property development projects involving massive earthworks and land clearing in the upper catchment of the river has caused heavy siltation in the canal bed due to the suspended sediments brought down by the river. The situation is compounded by illegal farming of cash crops and rearing of cattle in the canal reserves, which aggravate further the reduction in the carrying capacity of the earth channel. Although the DID and other authorities are equipped with the necessary legislative and executive powers to prosecute the non-conformists, they are reluctant to do so because of possible political intervention, reprisal from the local community or plain sympathy with the generally poor non-conformists.

As irrigation supply is not a problem in the SPIS, sense of efficient and productive use of water is lacking among the farmers. The misconception that "flowing water in the paddy fields is better than standing water" has caused many paddy plots left without proper field bunds (*batas*) and drainage outlet pipes left unplugged. Efforts to educate the farmers on good on-farm water management practices is being carried out continuously to instill good farming habits and to create awareness among the farmers on the productive use of water.

The National Agriculture Policy (NAP; 1992-2010) outlines a production target of 65 percent self-sufficiency by the year 2010. Based on the rate of rice consumption of 79 kg per capita per year for a projected population of 28.27 million by 2010, the nation will need at least 2.43 million mt of paddy to meet the 65-percent self-sufficiency target. To meet this target, the production of paddy in the granary areas has to be increased to 6.03 mt/ha with 190 percent cropping intensity. The SPIS, with 200 percent cropping intensity, has been targeted to produce 10 mt/ha to assist in the overall achievement of the target. During a time when paddy is seen as a sector which is noncompetitive, uneconomic and inefficient; the biggest challenge in the development of the paddy sector, therefore, will be to increase productivity through effective and efficient use of resources. This issue must be viewed with an open perspective, and a more progressive and holistic approach needs to be implemented. The promotion and establishment of water users' groups (WUGs) is one of the ways identified to bring about efficient and effective use of the various inputs and resources in paddy cultivation. Existing policies and legislation are unclear and found to impede the formation of WUGs although its formation is very much desired. They will have to be modified to lend credence and provide legal protection and support to facilitate the formation of WUG.

Modernization has been identified as one of the ways to improve management of irrigation systems. With advances in communication technology and sophisticated telecontrol and telemetry devices, operation staff of irrigation systems can be easily trained to acquire new skills and expertise to handle the systems more efficiently. However, the reception of new technology and modern management of irrigation systems within the farming community is still uncertain due to the varying levels of educational background, socio-political organization, traditional beliefs and practices of farm inheritance and also due to the decline of productive labor force.

Attempts by the FELCRA to achieve 250 percent cropping intensity (i.e., five crops in two years) in the RBC area have been made with little success. Although there is potential in obtaining reasonably good yield (4 mt/ha or more) in the paddy estates, the shorter fallow period in between harvests and the subsequent cropping schedule may hinder any maintenance work required for the irrigation infrastructure and this could affect adversely on the supply of irrigation water. With further research by the relevant authorities to obtain shorter duration paddy variety, the attempt to increase cropping intensity to 250 percent may prove worthwhile.

IMPROVING PERFORMANCE IN IRRIGATION MANAGEMENT THROUGH WATER USERS' GROUPS

Given the issues and constraints discussed above, it could be suggested without doubt that the output of an irrigation system can be optimized by efficiently managing all resources at all levels of the system. The service provider or the supplier (DID) and the farmers have to play their respective roles to ensure that irrigation management delivers what is expected of it. To facilitate the input of the resources, a mechanism has to be established to coordinate the various processes or activities involved in paddy cultivation (ranging from supply, land preparation and on-farm practices to harvesting and milling).

The development and management of irrigation systems, in general, has been implemented by the government (through the DID) and is considered as the national responsibility. As a matter of fact, the farmers had played this role originally and they are more suitable to implement them because they derive the direct benefits. In line with the national development nowadays, it is appropriate that the irrigation management is taken over by the farmers through the WUGs or organizations/associations.

Generally, paddy farmers are involved in many forms of groupings and organizations. These institutions and organizations can be categorized as:

i. village-based, locally-initiated organizations, e.g., mosque committees, village funeral associations, parent-teachers' associations (PTA);
ii. village-oriented formal organizations, e.g., village development and security committees, community development agencies; and
iii. project/farm-based organizations, e.g., group farming (under DoA), mini-estate and paddy estate (under FELCRA).

A farmer can be a member of any one of the above organizations or a combination of organizations she/he prefers.

Under the Farmers' Organization Act (Act 109) and the Farmers' Organization Authority Act (Act 110) established in 1973, farmers' organization structures have been set up at: a) the area (Area Farmers Organization [AFO]); b) the State (State Farmers' Organization Authority); and c) the national levels (Farmers' Organization Authority [FOA]). The AFO is comprised of farmers in the area it is formed. A farmer who does not register with the AFO is not entitled to fertilizer subsidy from the government. No fee is collected upon registration or annually, and most farmers are registered with the AFO.

The farmers' group under the AFO is managed by a committee called "Farmers' Group Committee" and is chaired by a farmer. The Secretary and the Treasurer are both staff of the AFO. Four or five farmer members are elected to sit in the committee to hold various functions such as crop protection, water management, farm machinery, marketing and socio-cultural affairs. Depending on the level of progress (maturity) of the farmers' group concerned, the posts of Secretary and Treasurer may be held by elected farmers.

Group farm status of the SPIS is shown in Table 1.

Farmers' organizations within the granary areas are not without problems and constraints. They can be generally categorized as socio-cultural and organizational.

Socio-cultural Constraints and Problems

i. Incongruity in the formation of village-based and farm-based organizations resulting in different village neighbors and farm neighbors (i.e., different boundaries for village-based organization and irrigation-based organization)
ii. Aging of experienced farmers and aged farmers losing interest in joining the farmers' group
iii. Declining interest among younger generation of farm members towards paddy cultivation.

Organizational Constraints and Problems

i. Limited degree of participation by farmers in the system design and project formulation stages
ii. Low level of confidence by the farmers to operate and maintain the systems
iii. Existence of two categories of group farming under two government agencies; group farming under the DoA and mini-estate under the AFO
iv. Lack of legal coverage for farmers' groups under the supervision of DoA
v. Absence of standardized quantitative criteria for performance evaluation for upgrading of group farming to mini-estate either by DoA or AFO
vi. Lack of detailed breakdown of different categories of farmers (owner operators, tenants and owner-tenants) involved in group farming.

Table 1. Seberang Perk Irrigation Scheme: Group Farm Status

Group No.	Group Name	Date of Formation	No. of Farmers	Area (ha)	Average Yield (mt/ha)			
					S-1 2000	S-2 2000	S-1 2001	S-2 2001
A 91601	Block A 1	23.3.1998	15	64.7	4.23	4.32	4.20	4.75
A 91602	Block A 6	19.5.1997	23	64.7	3.24	3.40	5.30	6.00
A 91603	Block A 5	20.1.1993	24	89.0	4.47	4.55	4.10	4.45
A 91604	Block A 4	20.3.1998	35	105.2	3.68	4.90	5.80	5.20
A 91605	Block A 8	20.1.1993	24	78.9	2.20	2.96	3.25	3.75
A 91606	Block A 2	20.3.1997	5	64.7	3.55	4.16	4.40	4.53
A 91607	Bukit Chawi (vegetable)	11.3.1983	3	1.0	0.00	0.00	0.00	0.00
A 91608	Block A 3	10.1.1993	19	50.6	2.76	2.96	3.60	4.10
A 91701	Parit Hj. Hassan	2.3.1999	48	97.2	5.50	6.10	6.50	6.42
A 91702	Parit Hj. Isa	1.7.1999	81	115.2	5.20	6.00	6.08	6.10
A 91703	Parit Buang Tok Salleh	1.7.1999	54	64.8	5.25	5.83	6.29	4.80
A 91704	Parit 4 Sungai Buaya	5.7.1998	35	64.8	5.40	6.60	6.20	6.80
A 91705	Parit Hj. Md. Zain 1	9.7.1987	56	118.0	3.80	5.08	4.80	6.20
A 91706	Parit Hj. Md. Zain 3	9.7.1987	27	71.0	4.20	5.12	5.40	5.50
A 91707	Parit Rawi	10.8.1997	102	180.0	5.01	6.30	6.60	6.30
A 91708	Parit Hj. Md. Zain 2	9.7.1987	26	45.0	4.01	5.20	6.02	6.97
A 91709	Parit Tok Paa	7.7.2000	40	48.0	4.80	5.65	6.20	6.40
A 91710	Parit Gajah Mati	7.7.2000	30	63.6	5.90	6.20	6.45	5.70
A 91711	Parit Aman	1.1.2002	35	61.2	5.40	6.30	7.05	5.80
A 91801	C9 Sungai Jejawi	9.7.1996	15	30.3	2.00	3.81	3.30	4.50
A 91802	C8 Sungai Jejawi	9.7.1996	23	46.5	3.54	4.15	4.55	4.50
A 91803	C7 Sungai Jejawi	9.7.1996	26	52.6	3.06	3.26	4.80	4.84
A 91804	C6 Sungai Jejawi	9.7.1996	23	46.5	3.26	3.33	4.25	4.34
A 91805	C5 Sungai Jejawi	9.7.1996	25	50.5	4.16	3.18	4.93	5.10
A 91806	C4 Sungai Jejawi	9.7.1996	24	48.5	3.91	3.03	5.04	4.60
A 91807	RTBK	25.6.1990	80	211.0	4.35	5.41	5.50	5.69
A 91808	C2 Bukit Chawi	5.7.1999	23	46.5	3.91	4.30	4.50	4.80
Total/average			921	1,980.0	3.92	4.49	4.97	5.12

Note: S-1 = season one; and S-2 = season 2.

Measures to Strengthen Farmers' Organizations

The DID of Malaysia and the Japan International Cooperation Agency (JICA) in a jointly organized national seminar on modernization of irrigation water management system in granary areas of peninsular Malaysia in May 1998 have proposed measures to strengthen farmers' organization in water management. The following factors have been taken into consideration:

i. Water, being the central focus in irrigation management, shall be the basis of reinforcing the roles of farmers' organization. WUG approach is proposed in this context. As farm neighborhood and common water sources take priority over village neighborhood, it follows that reorientation or adjustment of the farm layout is necessary under this approach;

ii. WUG should be the avenue for greater farmer participation in the O&M activities at the tertiary level. Participation in these activities shall be promoted on group rather than on individual basis. As for the O&M activities, it is conceptualized that the nature of involvement is gradually transforming in stages from full government aid (in financing, O&M) to farmers participation in O&M works through the group farming or the mini-estate, to joint venture efforts of farmers' organization and investors (individual or corporate) and ultimately full privatization of the systems management by the joint-venture entity; and

iii. As part of the strategic approaches to sustain whatever progress to be achieved through the modernization exercise, there is a need to integrate the WUGs to the overall national organization systems and to consider structural changes to streamline the functions of all agencies involved in farmers' organization on both short- and long-term basis.

In reinforcing the farmers' organization, the following steps are proposed:

(a) Strengthening the foundation of farmers' organization at the project level (i.e., group farming or mini-estate) through the delineation or demarcation of boundaries based on water regime or irrigation system boundaries rather than on administrative, village or residential boundaries; intensive membership drives, training and extension; establishment of Inter-granary Task Force (comprising experts from the DID, DoA, AFO, etc.) to coordinate action plans pertaining to the delineation of physical boundaries, identification of problems and constrains and details of forming WUGs; establishment of pro-tem Inter-granary WUG Leaders Council to expedite the implementation of the proposed modernization program. This council shall be the communication link between the farmers and the implementing as well as the decision-making agencies. As the program would also involve large-scale land leveling as well as land consolidation, which can be very sensitive socially and politically, farmers' support is very vital indeed. The council shall interact with the proposed Inter-granary Task Force in this challenging program;

(b) Strengthening institutional support at the federal, state and project levels to ensure well-coordinated and sustained commitments in reinforcing farmers' organization due to the large-scale land leveling and land consolidation involved;

(c) Promotion of mini-estate where there is demand or request by the farmers' group or where there is serious labor shortage due to aging experienced farmers and declining interest of younger generation towards paddy cultivation; and

(d) Reinforcing or establishing WUG and strengthening the existing roles of the water management sub-committee of the AFO, based on irrigation systems boundary. Once reinforced, these WUGs can be organized to participate in O&M works to be given/contracted out by the DID. Over time, there should be a progressive building up of WUGs' capacity to become more involved in bigger income-generating projects that would generate benefits to their member farmers. As their commercial orientation and their financial management capability is strengthened, these WUGs could then be mobilized to actively engage in related farm-based enterprises on their own or as joint venture partners with outside investors in contract farming business with, for instance, rice milling company. This would pave the way for WUGs to participate in related privatization program of the systems management with the joint venture entity.

Progress of the Proposed Formation of Irrigation-based Water User Group

A National Workshop on Water User Groups, jointly organized by the DID Malaysia and JICA was held in March 1997. It was well represented by various agencies under the Ministry of Agriculture (MOA), Malaysia. A draft guideline for WUG development in all the granary areas has been drawn up by the DID, incorporating resolutions, views and suggestions from all agencies concerned with paddy cultivation and irrigation management. The paper was subsequently presented to the MOA for adoption as a development policy in all granary areas.

The MOA has deliberated over the matter and has yet to endorse it. Meanwhile, minimal funds for WUG-related activities are made available through the project office.

FUTURE DIRECTIONS FOR IRRIGATION MANAGEMENT

The agriculture sector has been recognized by the government as one of the leading engines of growth of the country's economy. A sustainable performance of the irrigation services will help ensure the realization of the NAP. In view of compelling budgetary constraints, a humble beginning has been initiated under the 7th Malaysia Plan (1996-2000) with about RM10 million allocated for modernization of irrigation management in the country. The irrigation modernization program was aimed at development in five main activities, namely; irrigation performance assessment, automation, WUGs, water saving, and management information system.

The government, with the technical assistance of JICA, has conducted a study for a more systematic implementation of the irrigation modernization program. The study involves the preparation of a master plan for irrigation modernization in five granary areas (Pulau Pinang, Kerian-Sungai Manik, Seberang Perak, Besut, Kemasin-Semerak) and subsequently feasibility studies for three selected areas from the original five. The study recognizes the need for cooperative efforts that link irrigation services, agricultural development services and farmers' participation to bring about the desired results in rice production.

As suggested in the study, the irrigation modernization has action plans drawn up for each granary area and comprises a 3-staged program of works, namely; (a) Immediate Action Plan by year 2000; (b) Medium-term Action Plan by year 2005; and (c) Long-term Action Plan by year 2010.

Judging from the studies conducted, and the target set in the NAP, it is obvious that irrigation management in Malaysia is heading in a positive direction.

CONCLUSION

It is important to look at irrigation as a service. Technology, however modern it is, can only facilitate this service function. It is the people involved that could make the service into a responsive one. The service provider (DID) accepts accountability and sees the farmers as partners in the pursuit of the common goal in rice production/paddy cultivation. Meanwhile, the customers (farmers) appreciate the resources made available and optimize output through active participation in irrigation management.

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8. PAKISTAN

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INTRODUCTION

Pakistan with a geographical area of 796,101 km^2 contains large rivers like Indus, which along with its five tributaries, namely; Chenab, Jhelum, Ravi, Kabul and Sutlej, forms one of the mightiest river systems of the world. The river system comprises two storage reservoirs, 19 large rivers headworks, 43 canal system measuring 58,000 km, some 1.6 million km of water courses and field irrigation channels. Pakistan has big rivers like Indus, Chenab, Ravi, Jhelum and Sutlej, where discharges in summer season vary from 100 thousand cusec to 1,200 thousand cusec (3-34 thousand cumec) and, at times, cause tremendous loss to human lives, crops and property. Due to limited capacity of storage at Tarbela and Mangla dams on river Indus and Jhelum and with virtually no control on Chenab, Ravi and Sutlej, devastating problems are faced between July and October in the event of excessive rainfall in the catchments.

Pakistan comprises of four major administrative units; Punjab, Sindh, Northwest Frontier Province (NWFP) and Balochistan. In addition, there are federally administered tribal areas. The country's population as estimated in 2001 is 140 million and the population growth rate is estimated at 2.1 percent. The overall population density is 174.63 per km^2. However, there exist large regional variation in population density.

Pakistan is a country with a very diverse social and geographic landscape. It comprises high mountains in the north, to desolate plateaus, fertile plains, sandy deserts, coastal beaches and mangrove forests in the south. It has the largest share of the highest mountain peaks in the world and has more glaciers than any other land outside the North and South Poles. Pakistan's glacial area covers some 13,680 km^2, which represents an average of 13 percent of mountain regions of the upper Indus basin.

The Irrigation Network

The irrigation system of Pakistan is the largest integrated irrigation network in the world, serving 34.5 million acres (13.96 million ha) of contiguous cultivated land. The water of the Indus river and its tributaries feeds the system. The salient features of the system are three major storage reservoirs, namely; Tarbela and Chashma on river Indus, and Mangla on river Jhelum with a present live storage of about 15.4 billion m^3 (12.5 million acre-foot [MAF]); 19 barrages, 12 inter-river link canals and 43 independent irrigation canal commands. The total length of main canals is 58,500 km. Watercourses comprise another 1,621,000 km.

Diversion of river waters into off-taking canals is made through barrages, which are gated diversion weirs, and a system of link canals. The main canals in turn deliver water to branch canals, distributaries and minors. The watercourses get their share of water through outlets in the irrigation channels. Distribution of water from a watercourse is effected through a time schedule or "*warabandi*" under which each farm gets water for a specified period once a week. The time-share of "*wari*" is proportionate to the farm area owned by a farmer under the command of the watercourse.

Annually, the system draws an average of 106 MAF (131 billion m^3) of surface water for irrigation. Supplemented by an annual groundwater pumping of some 50 MAF, the average depth of water available at the farm gate is 3.07 feet per acre. Approximately three million individual farms with an average size of about 12 acre (5 ha) benefit from this system.

Water Availability and Utilization

Pakistan has a diverse agro-ecological setting and is divided into three hydrological regions; the Indus basin which is the major sources of Pakistan's water, the Kharan desert in West Balochistan with inland drainage, and the arid Makran coast along the Arabian Sea in the Southern part of Balochistan. The deserts in the south (Thar and Cholistan) have no water resources. Most of the Indus basin has been formed as a result of alluvial deposits brought by rivers from the mountainous ranges in the north. The flows in the Indus river are from glacial snowmelt, as well as rainfall outside the Indus plains. Under the Indus Water Treaty 1960, the flow of the three eastern rivers, the Sutlej, Beas and Ravi have been allocated to India and water from the three western rivers, the Indus, Jhelum and Chenab is available for Pakistan.

The flow of the Indus river and its tributaries constitutes the main source of surface water for the country. Based on 74 years of historic data from 1992-93, the average annual inflow of the western rivers at the rim station amounts to 140 MAF (173 billion m^3). The flow varies from year to year; the maximum was 186.79 MAF (230 billion m^3) in 1959-60 and the minimum was 86 MAF (106 billion m^3) in 1999-2000. This presents a variation of more than 65 percent in the annual average flows.

The groundwater storage capacity in Pakistan is estimated to be around 55 MAF (67.8 billion m^3). The hydro-geological conditions are mostly favorable for pumping by tube wells. It is estimated that 15,504 large capacity public tube wells and 469,546 private tube wells of low capacity are currently installed in the country. Thus the groundwater pumpage in the Indus basin has increased from 33.4 MAF (41 billion m^3) in 1959 to about 50 MAF (62 billion m^3) in 1999-2000. Groundwater quality is variable with about 79 percent of the area in Punjab and 28 percent in Sindh as fresh groundwater suitable for irrigation. However, indiscriminate pumping without proper monitoring and lack of knowledge about the chemistry and hydrodynamics of the aquifer has already contributed to the pollution of aquifers in certain pockets.

At the time of independence of Pakistan in 1947, about 64 MAF of water was being utilized annually in the irrigation canals in the country. With the construction of more barrages, link canals, and storage dams, water use has increased to an average of 106 MAF (131 billion m^3). Per capita water availability has gone down from 5,104 m^3 in 1950 to the present level of about 1200 m^3. Out of the 35,040 MAF flowing to the sea, a total of about 20 MAF (25 billion m^3) can be used for future development through construction of multipurpose storages, remodeling of canals and irrigation extension schemes. There is little potential for increase in water availability for Pakistan from surface or groundwater sources. However, 9th Five-Year Plan envisages that about 4.32 MAF can be made available through conserving measures and installation of tube wells in fresh groundwater areas.

Currently, 97 percent of the freshwater in Pakistan is used in the agriculture sector and only 3 percent is available for domestic and industrial use. The competitive demands from different sectors have not yet emerged as a key issue in Pakistan but are likely to become a major issue in the future. A review of growth trends shows that as the income of a country increases, the use of water by different sectors changes dramatically and the water needs of the industrial and domestic sectors grow rapidly. In certain high-income countries water requirements are less than half of the available water. In this context, in the immediate future, Pakistan needs to review strategies for reallocation of water from irrigation to domestic and industrial use to harvest economic benefits. The rate of return of a cubic meter of water used for agriculture is less than 10 percent of that of municipal and industrial use. Conservation measures in agriculture can therefore help in increasing the productivity of water.

Irrigation and Water Management Issues

Water resources development and management has acquired new dimensions in Pakistan. A host of factors constrain the performance of irrigation, which are multifaceted and multidimensional. The major constraints facing the irrigation management broadly include physical constraints, financial inadequacies, institutional issues and environmental problems. The physical constraints have been caused by the agricultural development beyond the system design capacities, scarcity of irrigation water, lack of storages, and gradual deterioration of the network due to the overstressing and aging. The main financial issues include inadequate maintenance funding, rise in maintenance expenditure of public tube wells and flood works as well as escalating expenditure on establishment, stagnation of *abiana* rates, and the widening gap between the expenditure and cost recovery. The institutional issues have emerged because the changes in the institutional setup are lagged behind the changes that have taken place in resources base and socioeconomic context over the years. On the environment front, the main problems are water-logging and salinity, salt imbalance, and increasing pollution of water bodies.

A small fraction of the population pays tax; agricultural income tax has never been imposed on full-scale basis despite its potential to generate resources for the country. The revenue from *abiana* (water tax) is also not collected seriously and there is massive leakage in the system. There is a legal framework in place for Water Users' Associations (WUAs) in Punjab (1981) and Sindh (1982). Water Users' Association Ordinances provide for such associations at the watercourse level and the Punjab Irrigation and Drainage Authority Act (1997) and the Sindh Irrigation and Drainage Authority (1997) provides for establishing Farmers Organizations (FOs) at distributory and minor levels. Despite this, the WUAs do not feel empowered to undertake the responsibility of operating and maintaining their watercourses or have any autonomy in the management of their water resources. Similarly, a uniform policy exists for the water supply and sanitation sector but it is not fully implemented. The National Environmental Quality Standards exist but these are not enforced seriously.

Indus Basin Irrigation System was installed almost a hundred years ago and now its efficiency has reduced to such an extent that more than 50 percent of the irrigation water is lost in transit and also during application to the crops. The quantum of wastage of precious irrigation water is not only the limiting factor for expansion of the irrigated area and realizing the maximum benefits per unit of already irrigated land but also has aggravated the severity of the twin menace of water-logging and salinity. Crop yields on average Pakistani farms are considerably lower than the average yields attained by many other countries of the world under similar agro-climatic conditions. The mounting population pressure has furthered the importance of conservation and better management of this scarce resource. Thus, the low productivity of irrigated agriculture and ever-increasing population pressure present a major threat to the country's food security in the future. Therefore, this necessitated a dire need to save every drop of water wasted in the irrigation system and at the farm level through active participation of the end-users.

The importance of water for Pakistan cannot be underestimated, particularly for irrigated agriculture in the country. In Pakistan, irrigated agriculture covers 16.2 million ha (74 percent) out of the total cultivated are of 22 million ha. Irrigated agriculture uses 97 percent of available water and provides over 90 percent of agricultural produce, it accounts for 25 percent of GDP, earns 70 percent of the export revenue and employs 50 percent of the work force directly and another 20 percent indirectly. Although the share of agriculture in GDP has destined over the years, it is still the largest single contributor to GDP. However, despite its importance, the level and growth of agricultural production falls short its real potential. The sustainability of irrigated agriculture is threatened due to continuous deterioration of the irrigation infrastructure.

The need for improvement and upgrading of irrigation system has become imperative. Indeed, over the last three decades, some damages have occurred with huge economic losses due to floods causing stoppage of irrigation water large areas. Recent surveys have revealed that numerous important hydraulic structures are in precarious state and the need for rehabilitation is urgent. Besides rehabilitation, the system also needs overall improvements to allow efficient operation and equitable water delivery in order to cater for the enhanced water demand and to meet the challenges of 21st century.

In order to address the sustainability issues, a number of policy interventions have been proposed. While the main thrust of the policy framework remains on institutional reforms, other policy interventions like global water law, disinvestments of fresh groundwater tube wells, groundwater regulatory framework, optimizing irrigation water allocations and alternative rate mechanisms, are also proposed for optimizing the overall irrigation management. A sector strategy and National Water Policy are also being formulated to have a historic approach for water sector development and management.

At the moment, the irrigation and drainage system of Pakistan suffers from a number of fundamental problems, notably:

* unsatisfactory planning and programming of public expenditure on drainage;
* implementation delays;
* unsatisfactory planning, funding and execution of operation and maintenance (O&M);
* deteriorating capabilities of key institutions;
* lack of public participation;
* inadequate investment in drainage;
* poor monitoring of drainage projects and infrastructure; and
* inadequate investment in drainage research, and lack of application of research results to policy and planning.

FARMERS PARTICIPATION IN CANAL IRRIGATION AND WATER USERS ASSOCIATIONS

Nature has blessed this country with the world's largest and the most integrated irrigation system. This network was installed almost a hundred years ago and now its efficiency has reduced to such an extent that more than 50 percent of the irrigation water is lost in transit and during application to the crops. The quantum of wastage of precious irrigation water is not only the limiting factor for expansion of the irrigated area and realizing the maximum benefits per unit of already irrigated land but also has aggravated the severity of the twin menace of water-logging and salinity.

WUAs were not a part of the agricultural system in Pakistan till as recently as the late 1970s. With the onset of the On-Farm Water Management (OFWM) pilot projects, their involvement was experimented at times when it was considered a politically explosive and socially vulnerable area, and proved successful. Under various OFWM programs, efforts were exerted to involve them at tertiary levels of the irrigation system and by now, they are contributing 55 percent of the cost of the civil works on the watercourse. The usefulness of farmers' participation in other countries fostered the testing of some pilots on their participation at secondary levels of the system. A few pilot surveys have been conducted so far and the results have shown that the WUA's participation can play a promising role in the O&M of the already deteriorating irrigation systems, not only in improving productivity but also in sustaining the environment. Their performance will nevertheless, hinge upon effective organizational efforts, imparting necessary training to them, proper recognition and adequate legislative support from the government and commitment from operating agencies.

The government has recently taken strategic initiatives to address the longstanding issues of irrigation management that had been reflecting on the performance of the sector. The new strategies primarily focus on better governance, decentralization, participatory management and sustainability. Under the institutional reforms agenda, Provincial Irrigation Departments (PIDs) are being transformed into Provincial Irrigation and Drainage Authority (PIDA). The management responsibilities would be decentralized at canal command level to Area Water Boards (AWBs), and most of the existing functions at the distributory/minor level would be performed by the FOs. The focus of most of the above activities would initially be on pilot AWB and pilot FOs on the system. Subsequently the reforms package will gradually be extended to other AWBs and FOs on the basis of the monitoring results and learning experience of the pilot programs. Government has enacted the legal framework and, reform agenda is under implementation to varying degree in all provinces.

The strategy consists of the following interlinked parts:

* Restructuring the PIDs to form Public Utilities (PUs) around canal commands;
* Actively promoting formation and development of FOs;
* Strengthening federal agencies, notably the Water and Power Development Authority (WAPDA)'s Water Wing, to better implement their federal responsibilities; and
* Formalizing water markets and individual water property rights.

PIDAs have been established in all the four provinces. One AWB in each province has been notified. Also Punjab and Sindh have notified rules and regulations for FOs. Other provinces are in the process for the same. Thirty FOs have been registered in Punjab. Formation of 23 FOs has been completed following by registration in Sindh province under PIDA Act.

NWFP has designated the existing Northern Irrigation Circle Mardan as AWB swat canals (pilot) and its members have already been notified. The OFWM of Agriculture Department have already constituted a FO in third Lora Canal Scheme in Lakki Marwat district and they are busy in forming FOs in Peshawar and Charsadda areas.

The FOs for K. K. Bund Irrigation Schemes in Balochistan have been registered. FOs registration for rehabilitation of Lasbella canal is in process.

The issues of physical/financial sustainability of irrigation and drainage network is assuming increasingly critical proportions. The specific policy interventions, which are under consideration, include the following:

i. Drainage cess and/or other appropriate measures including cost-sharing by non-agricultural beneficiaries to finance the O&M cost of drainage infrastructure;
ii. Mechanisms for financing the O&M costs of flood works which may *inter alia* include transfer (or cost-sharing) of non-irrigation flood infrastructure to the local bodies/other relevant beneficiaries and/or charging flood cess, etc.;
iii. Redefining water rates and alternate rate mechanisms to enhance the incomes and to rationalize assessment costs. For a start, flat-rate assessment could be introduced in pilot FOs;
iv. Redefining water rates for water use by non-agricultural users;
v. Adequate O&M funding for proper upkeep of the existing irrigation infrastructure from SCARP (Salinity Control and Rehabilitation Project) tube wells to canals operations; and
vi. Need to reassess the impact of the increase in investment *vis-à-vis* O&M requirements and the increases in *abiana* to sustain such investments.

The following points regarding institutional and environmental issues are now under active consideration of the government:

i. Willingness to invest in social mobilization and capacity building of the upcoming new institutions (i.e., AWBs and FOs) is absolutely essential for the success of the ongoing institutional reforms. For the new entities to be sustainable, the upcoming FOs would require technical assistance and support for quite some time, which may account for about 20-30 percent of the investment costs;
ii. There is pressing need to take steps for expediting the capacity building process for the upcoming FOs if the targets for formation of FOs and transitioning of the management responsibilities to them are to be met; and
iii. In order to optimize integrated resource management, comprehensive and holistic interventions for rationalizing existing canal water allowance need to be undertaken. Appropriate policy also needs to be developed in order to address the emerging environmental issues in order to preserve the water quality and land base for sustainability of the irrigated agriculture.

CONCLUSION

Owing to water scarcity, proper management of water resources is essential for the agriculture sector, which is the largest user of water (97 percent). The development of Pakistan's economy strongly depends on its ability to properly operate and manage water resources. The efficient and effective use of all water resources in Pakistan requires formulation and implementation of an appropriate water sector policy. The Ministry of Water and Power is formulating National Water Policy to face challenges of water scarcity. The overall objective is to unitize the available water resources to meet the socioeconomic and environmental needs for sustainable development in the country. With the new policy agenda, the government has taken strategic initiatives to address the longstanding issues of irrigation management that had been reflecting on the performance of the sector. The new strategies primarily focus on better governance, decentralization, participatory management and sustainability.

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9. THAILAND

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INTRODUCTION

Thailand represents a long tradition of irrigated agriculture in Asia. A large number of irrigation systems have been developed and the Royal Thai Government was responsible for all such developments, including the cost of providing irrigation service delivery. The Royal Irrigation Department (RID) is responsible for most of those irrigation systems. Latest statistics show that the RID's budget is Ƀ35,000 million which is equivalent to 4.4 percent of the national budget. From this amount, the RID allocates Ƀ4,195 million for maintenance and modernization. The government attempts to reduce these costs by reorienting the RID. Much of the decision-making authority and responsibility are expected to be transferred to local administration and communities. Irrigation efficiency is expected to be improved as a consequence of such a process of Irrigation Management Transfer (IMT).

The Participatory Irrigation Management (PIM) is the foundation of the proposed program because it establishes and strengthens Water Users' Group (WUG). These groups are the basis for farmer empowerment. The aim is to strengthen farmers in order that they would form a true partnership with the RID. PIM is not about mobilizing farmer's labor, but rather about improving farmers' decision-making authority so that they can manage their own irrigation systems, based on these five dimensions:

– Deciding what the service should be provided;
– Who is providing the service;
– Paying for the service;
– Providing and improving infrastructure; and
– Supporting the service.

The PIM strategy transfers the primary decision-making authority for irrigation system management to formally organized Water Users' Associations (WUAs), federated from the sub-lateral, through the lateral, to the main canal level. With the transfer of decision-making authority, farmers would have the power to determine operation and maintenance (O&M) objectives, approve O&M plans and budgets, set irrigation service fees, select and supervise O&M service providers, and enforce rules through sanctions. Government would shift its role to providing support services. The responsibility for minor rehabilitation would be shared with water users through a new incremental process of repair and improvement.

A strong WUG or WUA with established decision-making authority is in a position to deal and negotiate with the irrigation service provider (in most cases, RID) from a client or customer perspective. It is expected that this perspective would lead to the development of a Service Agreement between the WUG/WUA and the project level RID.

The Service Agreement is a Cost-sharing Agreement. It defines what the farmer would pay and what the RID project would deliver to them. Within cost-sharing, farmer contributions can be either in cash or in labor contributions to O&M or construction. The cost-sharing agreement specifies these proportions in a way that is amenable to both the RID and farmers. The important aspect is that there will be an agreement.

Farmers are now being asked to pay for a service they have previously received for free. They need something in return for them to feel confident that such a process would result in improvement to their own livelihoods, which has been identified through stakeholder surveys as improved irrigation service. The agreement defines the improved service.

Cost-sharing is a new approach to cost recovery, based on a partnership between the government and the farmers. This accelerates the sense of farmer ownership and so emphasizes the indirect route to reduction in government spending on irrigation. Cost-sharing reduces government spending in irrigation in several ways:

i. Through direct farmer contributions to capital costs through "Cost-Sharing Agreements" made prior to the approval of the project;
ii. Through direct farmer contributions to O&M costs through detailed "Service Agreements";
iii. Through the transfer of specific O&M management responsibility to farmers;
iv. Through the proposed "Incremental Repair and Improvement (IRI) Fund" for financing future rehabilitation and improvement projects; and
v. Through the evolution of demand-driven investment in new schemes, rehabilitation and O&M expenditures.

In "Cost-sharing", farmer contribution to irrigation follows the development of their decision-making authority through PIM, as is illustrated in Figure 1.

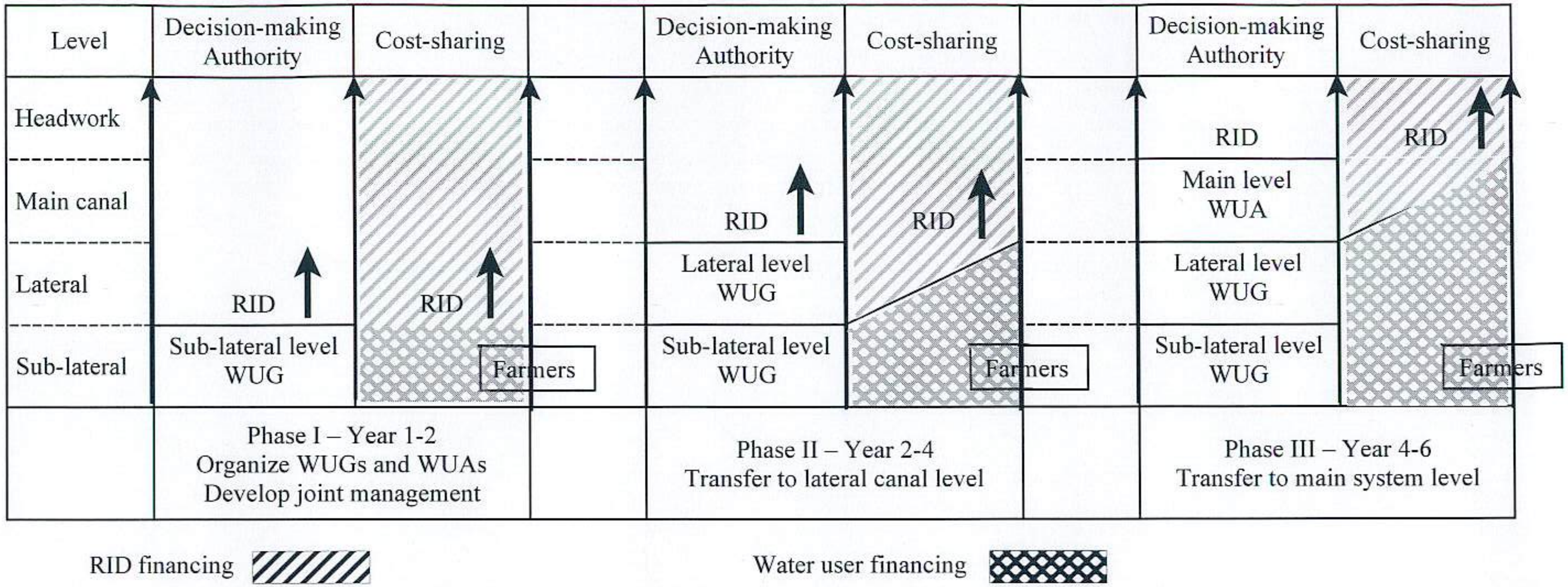

Figure 1. Link Between Transfer of Decision-making Authority and Cost-sharing

Notes: RID will maintain control of, and responsibility for the headwork.; and WUAs will gradually increase their level of responsibility and decision-making authority up to main level. As their authority increases, so does their proportional share of the costs for irrigation.

* Time required for water users' organization will vary depending on current state of organization and size and complexity of irrigation system.

10. VIETNAM

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INTRODUCTION

The development of irrigation in Vietnam can be divided into two phases. At the end of the Second World War, irrigation in Vietnam was concentrated on the Mekong Delta. In other areas of the country, there were only 13 schemes commanding a total of around 300,000 ha. These schemes were concentrated largely in the North and Center of the country.

Fifty years later the situation has changed drastically. At present, there are some 750 reservoirs and dams ranging from medium to large. Two thousand pump stations serve some 1,000 large schemes. In addition, there are approximately 10 thousand small schemes. At present, Vietnam's irrigation command area totals to some 3 million ha, out of which 7 million ha is arable land and irrigation has been considered of crucial economic importance, not only it is crucial for national and regional food security, it also plays a major role in export achievements.

Despite the enormous economic and social reliance on irrigation in Vietnam, the sector remains fraught with difficulties leading especially to lower performance efficiency of the irrigation systems. And, the existing irrigation systems meet only of 60 percent of designed irrigation capacity.

However, the recent success of the irrigation schemes in Vietnam in which on-farm water management is given more attention to, has shown that the key problem is relative weakness of the institutional mechanism for cooperation between irrigation companies and water users and among the water users to manage their tertiary canals. In other words, adequate mechanisms for transfer of state management and state ownership of irrigation infrastructure to people and grassroots organizations (socialization of services) are the key point to improve the performance efficiency of irrigation systems.

INSTITUTIONAL, POLICY AND LEGAL FRAMEWORK OF IRRIGATION IN VIETNAM

Institutional Arrangements

There are six institutional levels, including central government, within the Vietnamese irrigation sector. Key points relevant to the current situation are as follows:

* Department of Agriculture and Rural Development (DARD) manages an inter-provincial irrigation company if it serves schemes that span two or more provinces;
* An inter-provincial irrigation company is managed at a provincial level, if one of the provinces has a substantial share of the area in question;
* A provincial irrigation company is managed by the local DARD;
* An inter-district irrigation company is managed by the local DARD;
* A district irrigation company is managed by DARD or by the relevant district people's committee; and
* People's committees at all levels execute the functions of state management such as leadership, guidance, checking, supervision and expedition, as well as ensuring that all is done in observance of the relevant national regulations and laws.

In other words, the institutional arrangements in irrigation in Vietnam comprise a division of roles between those who provide water – the government through its various instrumentality, and those who receive water – the farmers in the hamlets.

Government Institutions

The government, through its various agencies at the different administrative levels, is responsible for the Operation and Maintenance (O&M) of the irrigation systems. The irrigation management companies (IMCs) manage the irrigation systems under the supervision of the government through Ministry of Agriculture and Rural Development (MARD) or of the PPC through DARD. They are responsible for the O&M of the headwork, irrigation and drainage canals, offtakes, secondary and tertiary canals. Under IMCs are irrigation stations and operation groups. The irrigation station is responsible for the management of headwork and main canal systems within the district. The operation group is responsible for management of main canals and biggest secondary canals within the managed area of the commune.

District stations take responsibility to deliver irrigation water to communes, to manage canals, to small offtakes and in the area within district. The district stations are also responsible for techniques with respect to district's pumping station and reservoirs. The accountability of the district stations is to manage water delivery contract between the IMCs and the farmer associations. On behalf of IMC, the head of the station has the authority to sign water use contracts with farmers and collect water fees. One part of water fees collected is remitted to the bank account of the station and the balance goes to the IMC.

The irrigation sub-station does the water delivery and draining for farmers. At the same time, the sub-station coordinates with the communes to gather information on cropping plan of the following year to supply irrigation data to irrigation company and outline water use contract. Staffs of sub-station directly collect water fees from communes or cooperatives pay to the district station.

The commune people's committee or agriculture cooperative manages the irrigation and drainage at commune level. Generally in each commune, there is a cooperative responsible for irrigation and drainage and some other activities regarding agriculture such as fertilizers, seed, pesticides, etc. The cooperative directly signs contracts with district station prior to each cropping season every year and collects water fees from farmers to pay to the district station after harvesting.

Water supply to fields of the farmers and minor repair are undertaken by the commune irrigation team. Water delivery schedule is discussed between commune's irrigation team and irrigators on a weekly basis. Apart from water fee collection in accordance with regulations of the state, the cooperatives collect on-farm water fees to pay the irrigation team. At 100 percent collection of water fees, the irrigation company remits 1-2 percent of the total collection as incentives to cooperative.

Commune Level Institutions

The core institution responsible for O&M of irrigation infrastructure at commune level is the irrigation team. The irrigation teams were organized by the cooperative for piecework contract as per Circular No. 2305-TT/LB dated 23 November 1983 to supply farmers with irrigation water. According to this Circular, the irrigation teams were required to operate, protect and maintain all water management infrastructure within the commune.

Under this directive, only the irrigation teams have the right to use and operate the irrigation system in the commune area. The farmer households are expected to take care of the water management within their holdings, to sign a piecework contract with the irrigation team for water supply and drainage and to pay the water fee. The hamlet heads are the instruments of water fee collection for the cooperatives or the communes.

Policy and Legal Framework of Irrigation

Policy on agricultural management regarding transfer of land use right to farmers has been introduced since the issuance of the Land Law in 1993. The farmer households become the key economic units of production in the rural area. With the Certificates of Land Use Right, the farmers have fives rights:

i. Changing land use right;
ii. Transfer of land;
iii. Lease;
iv. Heritage; and
v. Use as collateral.

As a consequence, farmers have become free to choose the crops they want to plant and sell their product in an open market economy with inputs such as fertilizers, pesticides, and seed supplied in the market.

While land can be transferred to individual households, water is different. Unlike other services in agriculture, such as production inputs, which the farmers may not accept if they can find better in the market themselves, irrigation services such as excavation of the canals and construction of pumping stations, cannot be undertaken by individuals. This needs cooperation among the community of the water users within a defined area served by common irrigation facilities. Water service is like a monopoly, even if farmers do not like it, they still have to accept, because there are no other options.

In comparison with the decentralization process of land management, the management of rural water supply and irrigation and its distribution systems are still centralized at the level of the IMCs and the communes or the communes' agricultural cooperatives, where these still exist. Hence, the decentralization of the management of the O&M of irrigation facilities at lower levels lags behind. Recognizing that a clear definition of responsibilities and right of water users are important factors for improvement of production efficiency, the government promotes the policy and legal reforms in the management of irrigation.

The legal basis of policy on socialization of irrigation services includes the main legal documents listed as follows:

- Decision 112/HDBT dated 25 August 1984 on collection of irrigation fees;
- Cooperative Law issued 20 March 1996 about provision of legal basis for the formation of water users' association (WUA);
- Law on Water Resources enacted 1 June 1998;
- Circular No. 6/1998/TT-BNN-TCCB, the guidelines for organization and activities of IMCs;
- MARD Decision 126 issued in 1998 to establish the Participatory Irrigation Management (PIM) Vietnam; and
- Circular No 94/1999/TT-BCT dated 31 July 1999, the guidelines for rehabilitation of irrigation systems involving farmers.

ANALYSIS AND EVALUATION OF SELECTED PILOT PROJECTS

Regional Characteristics

1. ***Northern Mountains***

Due to the complicated topographical conditions and the large geographical scatter of small-scale hydraulic works, and economic backwardness, the management of these schemes becomes difficult. But on the other hand, facing these difficulties, people in this region has been very interested in learning new managerial models concerning irrigation and ready to leave the old style of agricultural cooperatives. One well-known model has been developed and piloted in Tuyen Quang province. Although this model does not fully follow the Cooperative Law, it has proven its effectiveness and received widespread support from farmers. This model confirms the policy of the government toward transferring the management right to farmers.

2. ***Red River Delta***

Most of the provinces in this region have already invested many resources in medium- and large-scale hydraulic works that are complex and have operated on the heavy subsidy from the government for many years. Therefore there is a reluctance to change the existing system.

Case Studies

Case studies have been selected to represent the specific characteristics of the two geographical areas mentioned above and the whole nature of the opportunities and challenges concerning the socialization of services in irrigation. At present, three types of models exist in Vietnam. They are Join-stock Water Company, water users' cooperatives (WUCs), and Committee of Inter-canals. Details of the last two models, which seem to be the most suitable to Vietnam, are as follows:

Model 1. Water Users' Cooperatives

WUCs have proven to be a suitable model for cooperation among 3-4 communes, both in *Nghe An* and *Tuyen Quang*. The cooperatives link very closely with the government policy, reducing the financial burden on the government in terms of reducing the manpower of IMCs.

In Tuyen Quang, the model has been extended to inter-district level and the provincial irrigation company has been totally dissolved. The water users' companies in Tuyen Quang also differ from those in other places by providing a wider range of agricultural services.

Member of the management board are involved directly in managing activities of cooperatives, thus receiving salaries from cooperatives and management honorarium collected from individual cooperatives.

Model 2. Committee of the Inter-canals

The case of La Khe Project represents a traditional model with the reluctance to move towards transfer to farmers. Experience has shown that this model not to be effective, because the committee members are not accountable to the water users. The committee acts on the behalf of the local administrative body, and not on behalf of the water users or their cooperatives, thus they do not receive salaries from the cooperatives, but from the La Khe Irrigation Management Company.

BARRIERS ON THE IMPLEMENTATION OF IMPROVED IRRIGATION MANAGEMENT AND POTENTIAL SOLUTIONS

Identification of Barriers

For improving the irrigation management, the socializing of irrigation services is essential.

1. ***Legal Framework***

The existing legal framework in Vietnam does not provide a space for various NGOs to exercise their services in line with the policy of socializing services in irrigation. Despite the fact that Vietnam has a good policy towards socialization of many services including irrigation, some regulations do not reflect the policy, especially those regulations providing instructions and guidance. It is fair to say that the existing regulations not yet provide a "legal corridor" for various institutions and organizations to implement the policy of socializing services in rural water supply and irrigation.

Hence it could be concluded that the slow penetration of the WUAs in irrigation management is due to the lack of regulations, by-laws and mechanism for transfer the state-owned irrigation infrastructure to WUAs. For example, the present mechanism, in fact the only one for irrigation transfer, is MARD Decision No. 126-1998/QD/BNN-TCCB dated 8 September 1998 on PIM. This "Decision" authorizes the transfer of irrigation schemes, which lie entirely within one commune, to farmers or association of farmers. For schemes that comprise more than one commune, no mechanism exist for transfer of irrigation management. In reality, some successful cases such as in Nghe An indicate that a similar approach could be applied.

2. ***Awareness and Role of Government Officials***

Irrigation has been still considered from the social and political aspect rather that the technical and economic aspects, thus preventing the effective use of the infrastructure.

There are some cases where officials have hindered the innovative process of providing irrigation services in rural areas due to their own vested interests. Concerned line ministries have not fully implemented many existing regulations such as Decision 141-CP, Decision on Irrigation Fees 112 HDBT, etc. As a result of that these regulations have had limited impact. For example, the policy concerning irrigation fee has been in use for 20 years but not yet revised. The Cooperative Law has not yet been implemented properly according to the legal provisions.

3. ***Role of Local Authorities***

Local authorities have the important role to supervise the implementation policies and regulations at the district and commune levels. Some communes do not want to break the administrative borders to provide the irrigation services more effectively in line with the existing policies and regulations. There have been cases where the local authorities intervene directly in the activities related to irrigation services, especially the financial matters. On the other hand, the local authorities do not exercise their "state management" role, such as the creation of favorable conditions for the development of irrigation services that benefit not only farmers but also the society as the whole.

It should be noted that, some local authorities have used these opportunities to speed up the process of socializing hydraulic services in their localities and achieved remarkable results. On the other hand, some local authorities do not want to follow this innovative policy, or they have the attitude of "wait and see" and react more passively to the reform at the central level.

3. ***Role of Water Resources Sector***

The water resources sector plays a very crucial role in providing irrigation services. In situation of Vietnam, it is fair to say that the sector has not yet been active in recommending the government to formulate and promulgate policies and regulations that are suitable to provide support to irrigation services on time. Many good cases and experiences have not yet been compiled for learning and replication. The attitude "wait and see" is a serious institutional barrier in this sector.

Solutions to Overcome Barriers

1. ***Models***

Based on successful models developed and piloted in different places with different conditions, lessons and experiences could be learned. Such experiences and models need to be further distributed to other locations. In addition, more models need to be piloted representing the nature of the issue, thus providing rich feedback for revising the existing policies and regulations.

2. ***Training***

Training need to be provided and strengthened to concerned officials, agencies, and people in order to implement the government policies more effectively. In the pilots cited, training should be provided to the officials on aspects such as monitoring and supervising the implementation of related regulations.

3. ***Policy and Legal Framework***

As mentioned earlier, the present legal framework in Vietnam is not appropriate and integrated to ensure the sustainability of providing irrigation services. The policy and mechanisms should match with the practice and flexible enough for revision and modification, as required.

4. ***Role of the Government***

Government needs to have a consistent policy regarding the socializing the services in rural water supply. In addition the government can play more active role in facilitating the transfer process.

CASE STUDIES

North Nghe An Irrigation Model

1. ***General Information of the Project***

The North Nghe An Irrigation System (NNAIC) has been set up and operated over 60 years. The system comprises of a dam on the Lam river and a 60-km main canal watering over 30,000 ha of agricultural land and providing drinking water for nearly one million inhabitants of the four districts: Doluong, Yenthanh, Dienchau, and Quynh Luu.

Supported by ADB and MARD, the NNAIC, in coordination with Yenthanh district and under the guidance of Nghe An PPC, have employed on a pilot basis the model of the cooperatives using the N4-B water. This has actually involved the farmers in the management and operations of irrigation works.

N4-B canal gets water from the main canal of the system to irrigate for 230 ha agricultural land in three communes: Longthanh, Bacthanh, and Trungthanh (Yenthanh district-Nghe An province). Previously, there had been quite frequent water disputes. There was surplus water at the upper canal and water shortage at the lower-canal areas.

2. ***Establishing the Water Users' Cooperative***

Conditions and characteristics of each irrigation area were thoroughly studied and considered. In establishing the WUC, the following steps have been carried out:

i. Establishing the Project-Executing Unit (PEU): This included representatives of DARD, District Political Center, and NIC. The representative of NIC is the head of the PEU;

ii. The PEU met with leaders of communes benefiting the N4-B water. During the meeting, the issues related to requirements, objectives, and formulation process of cooperatives were brought up for discussions in order to receive full support from the communes;
iii. The PEU and the commune's leaderships held meetings at each village to involve local people in the discussions on the proposed model in order to obtain their cooperation and to motivate then to join voluntarily;
iv. Villagers held meetings to nominate their own delegates to attend a general conference where the cooperative management units (CMU) and water operation teams (WOT) were elected;
v. Duties of CMU and WOT members were set up;
vi. There were training workshop for CMUs and WOTs. The issues consisted of financial management as well as technical irrigation management;
vii. The charter and regulations related to WUC were developed; and
viii. The WUC registered the business.

3. ***Assessment of WUC***

<*Lessons Learnt*>

i. PEU was properly set up, which comprised of all relevant stakeholders.
ii. The issues on the cooperative formulation were thoroughly considered and democratically discussed.
iii. All local people got involved and joined the cooperative voluntarily.

<*Achievements*>

A number of positive results have been achieved through this model:

i. The management helps prevent water disputes on the canal and provide water more frequently and more sufficiently;
ii. Increased the "fully irrigated area" to 75 ha at lower canal area (which used to be irrigated by the scooped water in the past), and expanding 30 ha of irrigation area which used to be irrigated by water from the drainage canal;
iii. The levels of rice productivity remain quite even in both the upper and lower areas;
iv. Irrigation works on the fields have been managed by their true owners and have been maintained regularly. This helps water saving;
v. The farmers become the true owners of the irrigation works through their direct involvement in the management and operations of such works;
vi. The cost for receiving water in the lower-canal communes has been reduced by 40 man-days per year;
vii. The irrigation fees have been collected adequately and paid to the government regularly; and
viii. The pattern of public-private partnership has been promoted strongly. The irrigation canals have been concreted rapidly.

<*Constraints*>

Due to lack of proper coordination and regulation between WUC and the local authorities of the communes, there have been a number of constraints and these affect their relationships in terms of management.

Recommendations

The organization and formulation process of field irrigation management is a complex issue. Proper solutions for this undertaking would lead to increased efficiency of water use. This type of models are accepted and supported by the farmers. Through such models, farmers have been involved in the management and operation of irrigation works. However, in order to ensure the sustainability and proper operations of such models and then to expand to entire network, a large number of existing problems with respect to the organization process, policy measures and mechanisms, etc., need to be dealt with. Many such problems are related to state management.

The N4-B WUC is actually a service team, responsible for the management and protection of the field irrigation works as well as the distribution of water to farmers. Specific policy mechanism for the future expansion of this model is required. Particular attention should be given to the policies on the collection and use of irrigation fees.

It is necessary to develop regulations providing guidelines for both the central and local authorities on the formulation of this type of service.

Tuyen Quang Irrigation Management Models

General Characteristics of the State Management Model before 1996: Irrigation and Drainage Company (IDC), which belongs directly to the province's Agro-forestry Department, consists of five irrigation stations in five districts and the *Ngoi La* Irrigation Complex, controlling 152 facilities of less than 3,800 ha and carrying out the collection of the irrigation fees, which is 200 kg of food/ha/year.

The company's financial accounting is based on "income and outlay account piecework" of the irrigation stations. The company has taken the responsibility towards government (taxation, discounting, etc.) and employee (insurance, working regime, etc.) On the average, the total annual revenue from collecting irrigation fee was 400-450 mt of rice (equivalent to Vietnamese dong [VND]450-500 millions). This is just enough to cover the wages, management costs and small-scale repairs. Therefore, the facilities have deteriorated and irrigated area has been decreased from day to day.

Moreover, because the workers live far from the facilities and the facilities are not well connected and synchronized, the irrigation system did not satisfy the irrigation needs of the farmers on time.

Local authorities and farmers regard the management, O&M of the facilities as the company's owned duties. Relationship between sectors and authority as co-leading entities, were also limited. The management and protection of the facilities is difficult, especially in the places where there is a need to provide water but difficult to collect irrigation fees.

Cooperative Management Model

Agro-forestry Cooperatives (AFC) manage the facilities built by farmers themselves. Although some AFCs have managed the facilities very well, more than 80 percent AFCs cannot collect the irrigation fee. This has led to a situation of lack of financing for management and maintenance and the deterioration of the quality of the facilities. Only about 40-50 percent out of the designed capacity has been achieved.

1. ***Change After 1996***

In order to deal with the shortcomings of the two models mentioned above, Tuyen Quang People Committee realized the need to transfer irrigation schemes to farmers, based on the principles of self-management principle. They were also convinced of the need for strengthening local management capacity, gradually abolishing the subsidy regime.

Together with passing the related-transfer-irrigation Decisions, such as the Decision of transfer of state-managed irrigation facilities to the AFCs for management and exploitation, Decision of strengthening and innovating the AFCs; the guidance documents for implementing the decisions as well as the training courses related to irrigation management have been issued.

2. ***Management Models, Their Organization and Activities***

Based on capacity, there are four management models in Tuyen Quang today:

i. <u>Inter-district Irrigation Management Board</u>: The members of the Board are officers with professional capacity on irrigation and some are chairpersons of the communes and AFCs benefiting from the irrigation. The Ngoi La is the typical of this model. The Board manages and maintains the main canal while the AFCs manage and maintain interior-field canal. The Board has a right to use 50 percent water fees (the other half has to be handed to AFCs). However, spending must be conformed with the province's finance regulations and to the guidelines of the DARD. At the beginning of each season, the Board signs water supply contracts with the AFCs so that water will be provided to main canals and stations. The AFCs establish groups for irrigation and maintenance of the facilities located in their areas.

ii. <u>Inter-commune Irrigation Management Board</u>: Members of the Board are the same types as in Inter-district Board, who usually are the volunteers and elected by the cooperative members. Before each season, the Board signs water supply contracts with every member of the cooperative or the production group. The group regulates irrigation according to detailed dates and procedures pointed out in the contracts. Activities of the Boards should be pursued in accordance with the guide of the DARD. The guide shows in details the objectives of management, memberships and their tasks, method of fee collection, rate of spending, etc.

iii. Inter-Agro-forestry Cooperative Management Board: Members of the Board are elected from people of the commune.

iv. Agro-forestry Cooperative Board: The people in the AFCs choose Members of the Board.

3. ***Assessments***

i. After implementing the management models, all of the facilities are managed and controlled closely and became more effective, increasing the total area irrigated.

ii. The volume of irrigation fee collection has increased, resulting in increasing the funds for management, maintenance and upgrading the facilities.

iii. Maintenance and consolidating activities have been increased due to the increased funding from irrigation fee collection.

iv. Role of people in supervision activities has been clearly expressed. Awareness of protection and management has increased.

v. The Management Boards function effectively.

<Lessons Learnt>

At all levels, agriculture sector plays an important role in supporting the Boards to success, especially in term of techniques and management regulations.

Government authorities from provincial to commune levels paid great attention to the management and exploitation of irrigation schemes, providing suitable policies, and they regard it these important steps to increase the effectiveness of irrigation services.

Government intervenes on those projects, which need major repairs and that cannot be solved by farmers through investment program and loans.

Close links between leaders of administrative bodies at all levels, cooperatives, mass organizations to assist and monitor the performance of Management Boards.

La Khe Irrigation Scheme

1. ***Characteristics***

La Khe Canal goes through various communes with sub-canals in Ha Tay province. Due to the unregulated diversification of water along the main canal, there have been a number of disputes among the farmers living in the upstream and those in downstream of the canal especially in dry season. The La Khe Irrigation Company proposed to pilot a new form of management by establishing three Management Boards in three canals (N1, N5, end part of main canal). The objective of this attempt is to improve the management of water resources and to provide better services to the farmers in a more equitable manner.

2. ***Formation of the Management Board***

The La Khe Company invited heads of agricultural cooperatives who benefit from the canal water. A proposal to set up the Management Board prepared by the Company has been discussed at various meetings. After these meetings, a list of representatives of concerned cooperatives has been approved. Members of Board comprised the leaders of the AFCs, heads of irrigation teams in each agricultural cooperative, and the leaders of the irrigation teams of the Company.

3. ***Mandate and Responsibilities of the Board***

The function of the Board is to bridge the gap between the Company and the water users. The specific functions are listed below:

i. To advice the Management Board of the cooperative in the concerned area to inform the Company about the schedule of planting, irrigated areas, etc.;

ii. To report about the plan to pump water from the canal and decide on the irrigation schedule;

iii. To check the parts of canal, which may inhibit the flow and to suggest measures to overcome such problems;

iv. To protect all relevant works along the canal, and fine those persons who violate the Ordinance; and

v. To join the Management Board of agricultural cooperative in appraisal the target for irrigated areas and encourage farmers to pay irrigation fee on time according to the irrigation policies and regulations.

4. ***Performance Assessment***

The Management Board has contributed to the improvement of cooperation between Company and cooperatives. It results in ending up the disputes among the farmers related to water use in the canal. All canals have been checked regularly, repaired and maintained better. The cases of violating the Ordinance have been reduced.

However, there remain a number of problems regarding the role and the way the Board has been operated. Two major problems are: i) due to fact that the members of the Board are part-time staff, the commitment of the members is rather limited; and ii) members of the Board do not receive salary from cooperative and only receive monthly honoraria from the Company. This honorarium is too low to ensure the members to devote their time and energy to fulfill responsibilities of the position.

1. LIST OF PARTICIPANTS, RESOURCE SPEAKERS, OBSERVER AND SECRETARIAT

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2. PROGRAM OF ACTIVITIES

(3-8 June 2002)

Date/Time	**Activity**
Mon., 3 June	
Forenoon	Opening Ceremony Presentation and Discussion on Topic I: *Issues and Constraints in Linking Main System Management for Improved Irrigation Management* by Mr. H. M. Jayathilleke
Afternoon	Presentation and Discussion on Topic II: *Measures to Improve Linkage between Main System Management and Farm-level Management* by Mr. M. M. M. Aheeyar Presentation and Discussion on Topic III: *Irrigation Associations and Improved Irrigation Performance* by Dr. Norman T. Uphoff
Tues., 4 June	
Forenoon	Presentation and Discussion on Topic IV: *Sustainable Irrigation Development* by Mr. Ian W. Makin Presentation and Discussion on Topic V: *Role of Public and Private Sectors, NGOs, Water Users' Associations and Other Stakeholders in Irrigation Management in the 21st Century* by Dr. C. M. Wijayaratna
Afternoon	Presentation of Country Papers by Participants Free Time
Wed., 5 June	
Forenoon	Presentation of Country Paper by Participant
Afternoon	Presentation of Country Papers by Participants
Thurs., 6 June	
Forenoon	Workshop
Afternoon	Leave Colombo for Field Visits
Fri., 7 June	
Forenoon	Field Visit and Discussion (Minneriya Major Irrigation Scheme)
Afternoon	Visit Polonnaruwa Ancient City Return to Colombo
Sat., 8 June	
Forenoon	Summing-up Session Closing Session