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Research Needs and Priorities

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IMPSA

IRRIGATION MANAGEMENT POLICY SUPPORT ACTIVITY
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RESEARCH NEEDS AND PRIORITIES

1. INTRODUCTION

This paper is written as an input for IMPSA Policy Paper #5.0: Achieving High Productivity in Irrigated Agriculture: A Program for Research and Development (R&D) for Technology Generation and Diffusion.

A second staff working paper #5.2: "Institutional Arrangements and Strategies for R and D in future" has also been developed to support IMPSA Policy Paper #5.0.

The first three IMPSA policy papers propound that the key to increasing and diversifying production, and raising profits is the application of efficient and effective technology and management through research and development. They stress participatory action research as the vital link for modernization of the irrigated agricultural sector.

The first policy paper envisions that it will be the policy of the government to provide generous financial support to encourage basic and applied research by national research organizations in cooperation with international institutions. Some of this research will be discipline-based for development of appropriate technologies for improved imgation management and better crop packages; and some will be multi-disciplinary applied research for solving management, sociological, economic, operational and other problems Leading to a firm base for long-term development of the agricultural sector.

The present paper, Staff Working Paper (SWP#5.1), focuses specifically on research needs and priorities for achieving high productivity in irrigated agriculture.

1.1. Objectives

The main objectives of this working paper are to identify and prioritize the research needs relevant to the socio-economic and environmental setting of this country as well as to improve crop productivity and farmers' profitability under the present conventional technology now under use and also to explore through research and development adaptation of modern high technology

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The author was assisted in the preparation of this paper by a Consultation Panel composed of Dr. C.R. Panabokke (IIMI), Mr. D.G.P. Seneviratne (AR&TI), Prof. Y.D.A. Senanayake (PGIA), Dr. S.L. Amarasiri (DA), Mr. S. Wirasinghe (DA), Dr. R.P. Wanigaratne (PMU/MASL), Mr. W.H.E. Premaratne (IMD), Mr. P.C. Senaratne (ID), Mr. N.W.U. Navaratne (DAS), and Mr. Nihal Fernando (IMPSA).

.which can be used profitably to raise high value commercial crops suited to the agro-ecological conditions of the country.

The specific objectives are:

- to critically examine the present status of research in the country with particular reference to irrigation and agricultural technologies and management of irrigation systems;

- to identify the current research needs which are of immediate relevance to improve productivity and profitability of irrigated agriculture and to introduce participatory management in irrigated agriculture;

- to identify long-term research needs for introducing high technology and high value commercial crops; and

- to prepare a research agenda for tackling pressing irrigation management problems of the country.

1.2. Methodology

This paper has been prepared based on the following processes and sources of information:

i) A small Consultative Panel was constituted, consisting of representatives from the ID, IMD, DOA, DAS, MEA, AR&TI, the University, Private Industry and representatives from the IMPSA Secretariat and IIMI/SLFO. This panel held several discussions on the key issues, and is a major source of the data and ideas in this report.

ii) Background data gathered by IMPSA and IIMI staff from various sources including IIMI Review on this topic;

iii) An informal Consultative Workshop with a wider group of researchers at which a draft of this paper was presented, and views of the participants were elicited on research needs and their prioritization. The workshop participants comments and suggestions are reflected in the final document of this paper.

2. IRRIGATION DEVELOPMENT AND CROP DIVERSIFICATION IN SRI LANKA

Irrigation development in Sri Lanka, until recently, has been concentrated on the construction of major new irrigation schemes, both within and outside of the Mahaweli Development Program.. With the slowing down of the Mahaweli Program, the Government has been placing increasing emphasis on improving the productivity of existing irrigation systems through system rehabilitation, improved water management and greater farmer responsibility in system operation and maintenance through self and joint-management of irrigation systems.

The recent new policy of the Government would direct most irrigation development investments away from construction of new schemes toward more cost-effective rehabilitation and improvement programs. The area under irrigation would, therefore, not be significantly expanded, but cropping intensities would increase.

The average cropping intensity of the country's irrigation systems is estimated at 130 percent with only a few exceeding 160 percent. The major constraint restricting the intensity of irrigation appears to be limited water availability during the dry season as well as inefficient and poor water management., The existing low water use efficiencies significantly account for the low cropping intensities. The low efficiencies are due to various factors including system flaws, lack of proper control structures, improper water management and the absence of adequate institutional arrangements for system O&M. In recognition of these deficiencies, the Ministry of Lands, Irrigation and Mahaweli Development, through its Irrigation Management Division (IMD), the Mahaweli Authority and the Irrigation Department, has been increasingly involved in trying to improve water management and overall irrigation system management.

Increased rice production, mainly as a result of increased irrigated areas and higher yields obtained by farmers through the adoption of NHYV technology, combined with higher input use, had brought Sri Lanka close to self-sufficiency in rice by the mid-1980s. Concerns about limited supply of water for rice production, inefficient use of water in areas with soils not suited to rice production, and the low income of farmers have led the Government to embark upon a policy of diversification into other food crops production in imgation systems. The efficient management of irrigation systems for crop diversification is thus a high priority in the agricultural development strategy of the Government.

Upto the early 1980s, investment in Sri Lanka was directed primarily at creating irrigation infrastructure in order to produce more rice. Since then, the emphasis has shifted to institutional and policy reforms. The Irrigation Management Policy Support Activity (IMPSA), a major policy reform project in irrigated agriculture, has outlined in its vision paper a broad policy framework for the year 2000 and beyond. It is envisioned that the irrigated agricultural sector will become dynamic, diversified, efficient, equitable, productive, sustainable and participatory in order to achieve high productivity, profitability and environmental stability. To realize the benefits of these innovations, more efforts into research and development, policy reform, and institutional strengthening, are needed.

3. RESEARCH IN IRRIGATED AGRICULTURE

The IMPSA's vision paper foresees that transformation of Sri Lankan agriculture into a modern, diversified, productive sector of the economy will require strong supporting institutions for research and development. It will also require a continuation and intensification of the spirit of experimentation that has characterized irrigation management for a decade; a strong extension and Support services for the farmers' organizations to adapt and utilize the research results will also be needed. By the year 2000, the government will have strengthened existing national educational, training and research institutions by streamlining the institutional mechanism, funding adequately important research, providing incentives for researchers through rewards for outputs, and building excellent training programs linked to both research and practical realities for professionals and farmers. The irrigation management institutions such as the ID, MEA, IMD, etc., in association with "farmers' organizations" will have developed a considemble capacity for identifying researchable relevant areas, funding for necessary research, and interpreting and adapting the result for improving performance.

Achieving the above vision requires major investments in research and development aimed at improving the research capacities of national organizations including private firms, developing technology and management packages for immediate gains in the profitability of imgated agriculture, and testing and adapting appropriate technology packages to be implemented in the future.

Research; including irrigation research is characterized by a building process, with new understanding growing from past experience. Therefore, it has to be carried out in close collaboration with planners, designers, implementors and operators of irrigation systems. Irrigation research is neither cheap nor quick. Many of the key problems have multi-disciplinary backgrounds, It is now an accepted fact that this type of research can and will produce solutions to the pressing problems of imgated agriculture. If we are to tackle practical problems, we have to ensure that the research programmes are field-oriented, well targeted, and aiming to answer real questions. The overall goal of irrigated agricultural research must be that the results of research, should significantly influence actual practices in the field leading to greater productivity, profitability and sustainability without causing environmental degradation. The research results must be useful to all connected with irrigated agriculture: the farmers, operators of irrigation systems, designers, consultants, policy makers donors, and consumers.

3.1. Characteristics of Irrigation Research

i) Irrigation is a socio-technical process, i.e., a management process that combines both technological and social processes (often referred to as 'hardware' and 'software'). Technologies are embedded in institutional framework through which they are manipulated to achieve objectives. Irrigation engineering by itself is a necessary, but not a sufficient component of irrigation management; irrigation is not a purely technical field; it is a socio-economic phenomenon as much as - or more than - it is a technical process.

Therefore, there is a pressing need to carry out not only technical research but **also** research relating to economic, social and institutional aspects.

ii) In many countries, where irrigation is practiced, the emphasis in the past on research and development of irrigation systems technology has yielded a wealth of information that is available to designers. However, it is the application of knowledge and technology rather than ils'availability that has been, and still is, slow. Much of the new technology has resulted from a focus on high input/high output production systems. It is often costly and may not be suitable for use under conditions of small farm-size, low-value crops and inadequate management conditions that prevail in many schemes. Therefore, it is necessary to carry out adaptive research under farmers' lield conditions to make technology to suit the local requirement and make it more appropriate to the socio-economic conditions prevailing in the farm **sector.**

iii) Increased competition for the limited water resources and the consequent need to improve productivity have necessitated that research must concentrate in creating more efficient irrigation systems and management practices designed to improve production efficiency and prevent environmental degradation. Such research activities will, include among other things downstream control systems, scheduling technology, water conservation technologies and main system management process including development of information database for monitoring of irrigation system performance.

iv) To achieve the long-term development objectives of the country, the agricultural sector must modernize and diversify so that the profitability of agriculture *can* be increased. Technological innovations, such as more efficient and demand-driven water control technologies and new cropping packages, will be tested in order to realize these objectives in the long-term. But in order to **use** these new technologies effectively, the institutions must be in place; in addition adaptive research to refine and modify these high technologies to suit the local environment has to be carried out and be ready for adoption.

v) Maximizing the efficient use of water in irrigated agriculture to achieve the highest crop productivity is dependent on all the other agricultural practices (variety choice, fertilizer, crop protection, tillage, management, etc.) being optimized. The technological packages to help do this which are crucial to cropping systems need refining; one of the main reasons is the limited testing of information available with experimental stations under farmers' conditions, and not all experimental stations conduct research on issues and questions raised by farmers attempting to attain higher yields.

vi) Irrigation research often tends to follow disciplinary lines rather than focussing on complex multi-disciplinary problems. One of the critical problems in irrigation research is that of distinguishing between 'problems' and 'research needs'. At any given time, there are many more problems affecting irrigated agriculture than there are issues which warrant research; the task becomes one of differentiation and selection.

We generally tend to' catalogue a multitude of problems, usually classified by discipline and stop; since problems are defined in discipline-specific terms, it is very difficult to prioritize across the self-imposed boundaries and we end up taking a few listed items from each discipline. One important task in irrigation research is to identify key issues for research; typically little attention is given to the way in which problems are organized and prepared for research - this often causes us to try to answer wrong questions.

By way of illustration, let us consider the following example. First identify a broad issue such as poor performance of large imgation system; then. examine the relative importance of such issues as: adequacy and variability. in water supply, management by the public agency, management by farmers, external economic disincentives, marketing arrangement and so forth to isolate the category containing most potent causes, of poor performance. Multi-disciplinary attention would then be concentrated on that category.

Unfortunately, we presently lack both significant numbers of individuals with .holistic approach to problems in this fashion, and relatively simple research methodologies which can be used to assess system performance and isolate the most constraining sub-systems. This is an area that deserves immediate attention by research institutions.

vii) In irrigation schemes, 'there'are many reasons for advocating an experimental approach to management reform rather than prescribing specific reform packages. Irrigation research always follows 'an:action-research mode;, under this, a pilot action program involving experiments in alternative management methods which a research team helps to design and monitor with a view to subsequent replication of the approach on a larger scale after,field tests have shown it to be viable.

The action research brings theoretical knowledge as well as a breadth of ,experience to the problem-solving process. The clients bring practical. knowledge and experience of the situations in which they are trying to solve problems. Neither client nor researcher has better knowledge; in a sense, they are both experts.

Action research process is a cyclical process with five phases:

- diagnosing' (identifying or defining a problem);
- action-planning (considering alternative courses of action for solving, a problems);
- evaluating, (studying the, consequences of an action);
- specifying learning (identifying general findings leading to recommendations));

- action taking (selecting a course of action) and testing.

viii) To determine research priorities, and plan and program research activities, both local and national needs and institutional capabilities must be considered. Setting research priorities at the national level is a complex process because of the myriad of inputs which must be considered in decision making. It involves strategic: planning, that is the formulation of research strategies compatible with national objectives. Strategic planning develops program objectives from which projects, experiments and work plan are generated. Priority ordering is an important procedure in the allocation of funds to various research projects. Most research programs are by nature long-term. Hence, to ensure that funds will be available until the project is completed, a budget commitment is necessary before commencing a project.

4. PRESENT STATUS OF RESEARCH IN IRRIGATED AGRICULTURE

At present in Sri Lanka, the capacity to undertake research varies among the respective agencies. The DOA by virtue of its longer research tradition has a significant complement of research staff undertaking on-farm oriented water management research. The other line agencies do not possess a similar staff strength. The more important constraints, however, is the lack of proper institutional arrangement for conducting inter-agency collaborative research that is essential for identifying a broader research agenda, generating innovations, and interpreting and adopting research findings to improve the performance of irrigation systems.

4.1. Irrigated Agriculture

Prior to the 1960s, irrigated agriculture in Sri Lanka had been synonymous with asweddumized irrigated rice culture; the initial stages of shift in irrigated agriculture from its traditional mooring of asweddumized culture took place around the mid-sixties mainly because of the limiting factor of water rather than land to further expand the irrigated extent in the dry zone. Therefore, it has become a necessity to investigate and field test crop options other than high water demanding irrigated rice. By the late 1960s, the essential base of research information and extension experience was available for launching a program of diversified cropping on irrigated land. Significant progress has since been registered in the field of diversifying cropping both in major and minor irrigation schemes over the last two decades.

One of the factors that controls the type of crop and cropping pattern is the availability and reliability of water supply for irrigated agriculture. According to Chris Panabokke (1990), major irrigation schemes in Sri Lanka with stable water supplies year round are well suited for production of high value, export-oriented crops; in major schemes with less favorable water supply, dry season diversified cropping should be encouraged to meet the domestic rather than export market; in the drier south-east and north-west of the country, the potential for diversified cropping even during the maha season could be successfully exploited as recently demonstrated in the Kirindi Oya Project and some area of the Mahaweli system.

Minor irrigation schemes,with moderately stable water supply will raise essentially wet season maha rice with a marked shift toward diversified cropping for the yala season in the future. Minor imgation schemes with less reliable water sqpply needs a new thrust and innovations to integrate rainfed upland, cropping with the irrigated component to achieve some measure of the stability in farmers income even at a lower base. .Lift irrigation schemes coupled with drip or trickle irrigation practices could be foreseen as the irrigation method to raise more profitable crops. There will also be increasing use of low-head lift pumps from shallow seepage wells located .within the major irrigation schemes.

While rice cultivation in the island will continue to dominate the irrigated agriculture, it is perceived that in the future significant changes and trends in respect of other non-rice crops, cropping calendars and patterns might take place in the dry zone irrigated agriculture landscape. These changes are likely to result by the need for having to stretch the limited water resources as far as possible by recourse to improving water saving practices in irrigated agriculture and also by the need to raise farmer incomes. Innovative use of irrigation'supply, and adoption of more profitable crops and cropping patterns will accompany such changes.

Crop diversification in the dry.zone,environment will develop and expand to the extent that effective and sustainable supporting. institutions for irrigation "management for crop diversification are established. A shift from rice to non-rice crop calls for radical changes in planning, water allocation, operation and maintenance, most of which are not adequately addressed and needs research.

The Department of Agriculture has a strong research capacity and strength in on-farm irrigation. The Department also provides very effective in-service training for extension workers in water management. There exists close collaboration between research, training and extension. Research effort however is fragmented and dispersed between two or three outreach regional research centres. Some degree of coordination takes place through the Land and Water Use Research Center at Peradeniya, and also through the Standing Research Committee which meets twice a year.

The research units have been conducting water management research at the on-farm level primarily in the experiment research stations,relating to crop water requirements, irrigation methods, scheduling for various crops, efficacy of drip and sprinkler irrigation, socio-economic studies and farmers' profitability etc. The research results are not effectively integrated in the design, construction and planning operational schedules by the implementing agencies--such as Irrigation Department, and Mahaweli Economic Agency (MEA). Effective linkage between the concerned line agencies and diffusion .and feedback of technology to the implementing agencies were missing links.,

The Agrarian Research and Training Institute. (AR&TI) was, (established under the Ministry of Agricultural Development to carry .out institutional and socio economic research and training. It was the first institute in the country to establish a water management division with interdisciplinary staff and to carry out water management research. Its involvement and

contribution in the Gal Oya project, later in Tank Irrigation Modernization Project (TIMP), more recently in Village Imgation Rehabilitation Project (VIRP), and now in the evaluation of INMAS projects are worth noting. One of the apparent weaknesses noticed in all research work conducted by AR&TI is non-involvement of the implementing agencies directly in the conduct of research with the result that when the recommendations are provided, there was no institutionalized mechanism for
implementing the recommendations. In its future directions, institutionalized arrangements have to be established to work with the project management staff.

The Post-graduate Institute of Agriculture at Peradeniya which is under the Ministry of Higher Education was established in 1975, in order to meet part of the requirements of post-graduate trained personnel, that are needed primarily in the agricultural sector and other sectors of the country as well. During the
first 15 years its research students have completed 16 theses in the area of water-management related to irrigation, and 5 research studies in hydrology. Currently 9 research studies are being carried out on the same fields of study. Many studies have been completed in the north-west dry zone and in the Mahaweli systems B, C and H. While a pool of knowledge has been built up, many of the findings have yet to be followed up by user agencies.

4.2. Irrigation Technology

Sri Lanka possessed a prosperous hydraulic civilization in the ancient times. During the British Government, the emphasis was on technology required for capture, regulation and storage of water for irrigation; the concepts adopted during this period were basically typical of the ancient irrigation technology; during the post-independence period, irrigation construction technology received greater priority over the human settlement aspect and technologies required for managing irrigation water and land. Only in the recent past especially after 1970, there was a growing concern for efficient utilization and management of water. This prompted a new policy direction to seek ways and means of increasing water productivity in addition to increasing land productivity. This policy dimension resulted in the ernphasis of irrigation technology expanding from capture and storage of water to the distribution and management of water. Irrigation canal designs underwent some conceptual changes for better manageability (eg., the one cusec field canal concept) with more agricultural orientation. Since then, the focus of irrigation technology has been on increasing the structural potential of irrigation systems by providing adequate control, regulation and measurement devices and facilities to enable emphasis on more management, Such technological interventions have been implemented through various water management improvement projects, irrigation rehabilitation and modernization projects by the government and through Mahaweli irrigation system designs and construction. Also, there has been pilot testing of a few downstream control systems technology but without much success. Contrary to the irrigation technology, on-farm technology did not progress satisfactorily inspite of the fact that the Agriculture Department as well as the Land-Use division of the Irrigation Department have conducted much research on various on-farm methods of irrigating other field crops and achieved some successful results.

.The Department of Irrigation has quasi-research divisions of Hydrology, Hydraulics, Soil mechanics and Geology, Designs and Land Use which are service oriented departments. They primarily collect data, analyze and interpret it to provide design parameters to designers, without concerted effort to use the data in applied research. .The O&M division also gathers operational data,:, No systematic analysis of these data are attempted now in order to improve performance or management efforts.

4.3. Irrigation Management

Until recently irrigation has been viewed as a purely technical field. This narrow perspective is a major cause of the inability to adapt to changing needs and demands. It is now heartening to note that there has been a revolution in thinking and attitudes of Sri Lankan irrigation professionals during the past decade; they have now realized the need to work with well-organized farmers' organizations, in a system of 'joint management' of irrigation systems. This,,revolution in thinking occurred due to a unique set of experiments, applied research, imaginative individual leadership, effective consultancies, and assistance from outside that. supported indigenous efforts.

These experiments and innovations have led to a new organizational design, now generally accepted and having implemented in many major schemes under the INMAS programme. The INMAS programme, which is' implemented by the Irrigation Management Division on 35 major schemes managed by the Irrigation Department was the first officially approved programme to improve management of irrigation schemes with very low investments through the joint efforts of farmers and Government. It now provides a source of lessons and a model for future expansion of the joint management concept. The Government has now accepted the participatory management policy with its 'major objective of establishing strong farmers' organizations which would take increasing responsibility for management of systems,' through joint' management with the Irrigation Department on larger schemes, and full farmer management of smaller schemes. Together with institutional and policy reforms that are,now under: way, technological innovations, in ,'the form of more efficient and demand-driven water control technologies, new cropping packages and efficient support services will be necessary to achieve a diversified, dynamic and growth oriented irrigated agricultural sector.

In addition, there are other institutions 'that are often involved in research on irrigation related aspects, Among them are: the Rural Development Research and Training Institute (studies on change-agents); Mahaweli Authority of Sri Lanka (by its Act, it is expected to do research); Department of Agrarian Services (DAS) (mainly on socio-economic aspects); the research departments of the People's Bank and Central Bank (socio-economic aspects);, and several private firms and non-governmental organizations. Most of the research carried out to-date by these, institutions pertains to socio-economic aspects of irrigated agriculture.

4.4. IIMI's Review on Priority Research

In 1988, the International Irrigation Management Institute in collaboration with the Irrigation Management Division (IMD) and the Irrigation Department (ID) reviewed literature in four areas of relevance to Sri Lanka's irrigated agriculture: system operations and performance; organization and management of irrigation systems; rehabilitation and modernization of irrigation systems; and resource generation and mobilization. Most of the literature reviewed concentrates on large irrigation schemes and focusses on literature published since 1978. The review raised many important research questions, some of which are relevant even today. These and other background materials form an important source for conceptualizing research needs for this country.

5. PRIORITY ISSUES AND AREAS FOR RESEARCH

Presently research is being conducted by various agencies in relative isolation with no well defined irrigation research programme with identified priorities. There is an urgent need to develop a coherent medium and long term research programme with clearly identified priorities and to coordinate the various research and implementing agencies to achieve successful implementation.

5.1. Development and Strengthening of Irrigation Institutions

It is now generally accepted that major improvements in system performance can only be brought about by a transformation in the system management. It has been found appropriate for the present time to have a system of participatory management where the beneficiaries have a major role in the decision-making and coordination processes in the management of the scheme; this can be achieved through the establishment of autonomous farmer organizations. Such a transformation should involve not only the farming community but also the agencies operating and managing the systems. Attempting to transform either one party without attempting to modify or change the other may not lead to the desired result. Therefore, institutional transformation both agency and farmers' organizations is a pre-requisite for improving the system performance. Research in the area of institutional transformation and institutional change need to be given top most priority. The main objective of this research is to build and strengthen the farmers' organizations capacity to take over management of the FCs and DCs and at building the capacity of the ID, MEA and IMD to solve management problems in partnership with the farmers' organizations.

Some of the specific areas of research are:

i) Investigate the level of sustainability of the farmers' organizations formed in the country since Gal Oya experiment and identify the reasons for their sustainability or otherwise;

ii) identify necessary modifications from the Gal Oya model required for success in systems where conditions are different from Gal Oya (e.g., different ethnic groups, already

existing organizations requiring strengthening; different management agency such as Mahaweli Economic Agency (MEA) or where the projects are different (e.g., not a rehabilitation project, shifting a system from rice to mixed cropping; improving efficiency on a water short system, improving maintenance).

iii) field-test alternative methods of organizing farmers' groups that would be effective and perhaps less costly financially and in terms of management intensity in achieving program objectives? For example, can IMD Project Managers, or Unit Managers in Mahaweli Systems, implement such a program effectively on their own? If so, under what conditions?

iv) investigate institutional transformation of irrigation agencies; behavioral pattern and motivation of irrigation agencies; and farmers and agency's interlacing problems.

5.2. Irrigation System Management and Performance

Many large scale canal irrigation schemes are being operated by engineers with formal training in design and construction of structures. The engineers have to learn to operate the systems with a sensitive eye to the collective wishes of the end users, the farmers. A long range goal of the project should be improved system management including development of the broad range of discipline skills needed for comprehensive agency involvement. The short range objective should be system operation for predictable water delivery which will result in more stable and sustainable production systems.

Irrigation system management requires a wide range of skills and an understanding that probably can only evolve through a learning process. Attempts to manage systems without requisite data and the understanding and capability of how to use that information can lead to increased uncertainty and unpredictability in water delivery. The impact of improved system performance will be very limited until we more fully understand what is now taking place in the system, why and what its influence is on the total system;

In many large irrigation schemes, deficiencies in main system water distribution were found to be a principal cause of poor performance: design deficiencies were also a contributory factor; productivity of water is generally low and water distribution is mostly inequitable.

The mix of reform measures worth attempting in any given situation will depend on local physical, technical, social and economic factors as well as on what is politically and administratively feasible.

Possible elements in a reform program on roughly ascending order of political and administrative difficulty include:

i) procedural reforms;,

ii) technical and management training;

iii) establishment of representative farmers' groups at FC turnout level and at DC level farmers' organizations;

iv) changes in practices in staff incentives;

v) major changes in organizational structure of scheme management;

vi) changes in methods of payment for irrigation services.

An experimental and action research approach can be used to determine the most appropriate programme in a particular context by means of a gradual sequential testing of measures, starting from the least radical and moving up the scale of difficulty until no further change is feasible.

Water distribution may range from simple river flooding to continuous flow; rotational issue; on-demand deliveries and computer controlled on-demand deliveries. As we move upto the higher levels of sophistication in which water supply can be matched with increasing precision to the field demand, differing levels of control capacity are necessary. Research is needed to adopt these new technologies to the existing socio-economic conditions and make it cost-effective and also to identify new levels of management skills to operate these systems. Information is linked to control, because we cannot exercise control well unless we know what is going on. The information base available to the main system manager must be considered as one of key parameters that govern his operations. *So* we need to study processes of information transfer or communication, and see whether we have realistically designed management systems, as well as ways of bringing that information quickly enough to the point where decisions are supposed to be made; and also whether we can equally efficiently transfer those decisions out to the field to the point where they are supposed to be implemented.

The major problem faced in many irrigation schemes relates to its performance assessment. The question of defining performance is urgent especially in relation to organizational research. There are many possible criteria of good performance - water productivity, farmers satisfaction, low- cost to public treasury, land productivity, cropping intensification and *so* on. On all these, we lack data; these deficiencies severely curtail our ability to make comparisons between systems, or to make predictions about the likely performance of a particular mode of management in a particular environment.

There is a great need to carryout research on the planning of (seasonal and in-seasonal) allocation of water, scheduling, decision-making and improving main system management for reliable, equitable and adequate water supply.

The following are some of the important areas needing immediate research:

i) methods and conceptual basis for these methods need to be developed for assessing the performance of an irrigation system in a holistic sense;

ii) identifying and field-testing irrigation water distribution methods of farmers preference that provide flexibility in operation when there is a mix of rice and diversified crops under the same turnout;

iii) improving the performance of irrigation systems and increasing their effectiveness through flow measuring, control and regulating structures; by providing an irrigation support service that leads to better interactions between operating personnel and farmers; and improved communication methods.

iv) introducing technical, financial and institutional innovations that could lead to improved O&M of irrigation systems.

v) field-testing cost-effective and efficient flow control and regulating structures which are manageable in a technical as well as institutional sense.

5.3. Rehabilitation and Modernization of Irrigation Systems

One of the possible scenarios for future irrigation development in the country outlined in the vision paper relates to consolidating the present trends in irrigation development through rehabilitation and modernization of the existing infrastructure for improved system performance. Research and development for identifying projects for rehabilitation and modernization, cost-effective technologies for rehabilitating projects and strategies for implementing rehabilitation projects and their processes is necessary.

Presently, we do not have procedures to guide system evaluation that leads to diagnosis of the justification for scheme rehabilitation and modernization; engineering and hardware problems although the obvious diagnosis, are not the only element leading to substandard performance; other disciplines can provide clues to help properly specify performance problems and institutional changes or software solutions.

The following is a sample list of areas for immediate research arid development in the area of rehabilitation and modernization:

i) Develop mechanisms to improve communication among agencies, donors, and other interested parties to spread the rehabilitation lessons learned in different projects;

ii) Donors and lending agencies, seem to have, their own preference for different mixes of h'ardware (physical 'rehabilitation of a system) and software (the organizational and institutional dimensions of a system). Questions are often raised on the appropriateness of the mix. More research is needed to help answer this question;

iii) In-effective organizations, poor farmer-agency communications and inadequate O&M resources are thought to be important factors responsible for effecting rehabilitation. If this is so, emphasis should be given to institutional strengthening and its impact on physical improvements. Research is needed to identify whether institutional strengthening leads to more sustainable improvements in irrigation system performance;

iv) The rehabilitation process, the decision making, and the interactions among the various interested parties is an area which is not much researched and deserves greater attention in order to suggest alternative approaches to rehabilitation;

v) There is a need to identify more appropriate methods for evaluating rehabilitating project options, and evaluating the long-term benefits of such projects afterwards. Also appropriate criteria for such analysis and evaluations is also needed.

5.4. Irrigation and Drainage Technologies

With the proposed turnover of distributary canals and below to the farmer organizations, increasing demands will be made by them for substantial improvements in the quality of operation of the main systems which will continue to be the responsibility of irrigation agencies. Also, any future strategies for ensuring economical use of water through bulk allocation of water, will involve the introduction of cost-effective technologies to facilitate volumetric measurement of water. Raising commercial and other profitable crops require new design concepts, drainage technologies, delivery schedules and water sharing methods to meet their exact water requirement. Building on the experiences gained in many existing irrigation systems, irrigation agencies have to improve their capacities to develop and handle tools such as computer-based water scheduling and distribution models as priority needs. Research and development of cost-effective technologies and techniques for volumetric measurement of water will be a priority in future. Further agricultural modernization will also demand a satisfactory flexibility in operation for irrigating a range of field crops. It will therefore be necessary to develop the appropriate technologies to meet this demand. Drainage provision for raising OFC will be an important research agenda. Development of groundwater wherever there is waterlogging and/or scarcity of surface water and conjunctive use of surface and groundwater will play a vital role in those areas where hydrological and geologic conditions permit. On-farm technologies such as sprinkler, drip, etc. are also to be field tested where there is water scarcity and adapted to the local environment.

The design and operational assumptions used for feasibility and appraisal studies as well as for operation and adoption of new technologies must be tested by participatory action research with farmers and irrigation agencies.

Also lowering the cost of irrigation development and increasing the productivity per hectare of irrigated land and per unit of water have become particularly important issues. The implications of these issues are likely to include:

i) a trend to emphasize small-scale irrigation developments where operation and maintenance are generally less costly;

ii) a tendency to favor rehabilitation over expansion of irrigation into new areas;

iii) increased use of groundwater resources where practical;

iv) increased attempts to improve irrigation practices (including the introduction of water-control and water-saving techniques, improved irrigation scheduling techniques and suitable technologies);

v) improved scheme management through institutional reform, involvement of farmers, better irrigation extension services, training, etc.

All these options are to be field tested for their adaptability, acceptability by farmers and cost-effectiveness.

5.5. Agricultural Technology and Crop Diversification

The critical role played by irrigated agriculture in improving food production in Sri Lanka is widely recognized; but even greater benefits would have occurred from this input if scarce irrigation water resources were more efficiently managed. It is estimated that the application of existing knowledge could increase the efficiency of water use by 30-150 percent (CGIAR, TAC 1990).

During the last few decades there has been a rapid growth in both biochemical and mechanical technology in irrigated agriculture in Sri Lanka. New high yielding paddy varieties replaced most of the traditional low yielding varieties. The tractor has replaced animal draught power for land preparation for rice cultivation to a considerable degree. On the otherhand, agro-industrial technology including marketing management in the country had not advanced to the desired level of satisfaction. There is an urgent need to initiate research and development activities in these area of concern, especially when the country is entering into production of high value, export-oriented horticultural and food crops.

A suggested menu for irrigation related agricultural research is:

i) The major constraints to farmers adoption of diversified cropping are more within the realm of institutional, organizational and management aspects of the irrigation systems rather than with the technological domains of irrigation practices. Therefore, there is a need to identify the socio-economic constraints to effective irrigation management for non-rice cropping in rice-based systems.

ii) Agricultural production in irrigated areas has been confined mostly to the mono-culture of paddy. There is a pressing need for a program of field trials for high value crops for

domestic and export markets, especially in areas with suitable soils and reliable water supply.

iii) In most of the smaller, rehabilitated projects, the package of agricultural practices recommended has not been adopted by the farmers mainly owing to the risk of crop failure. There is a need to field test alternative farming system models for locational suitability.

iv) There is a growing recognition of the significance of the combined contribution of modem irrigation and diversified agriculture in improving the profitability **of** farmers. The introduction **of** new technology to **grow** high value crops needs farmers acceptance and field-testing.

Research is needed to:

a) to field-test modem methods of on-demand water supply both on-farm and in delivery system to the farm to adapt and make it more cost-effective.

b) to investigate small scale-water storage systems with stable water situations combined with the modem technology of micro-irrigation to reduce soil moisture variability which influence yields of seasonal and perennial crops.

c) the following (not extensive) selected research is suggested under on-farm technology:

- farmers variety choices (HYV verses non-HYV);
- identifying different potential crops that can be grown within different agro-climatic regions;
- crop yield response to multiple water shortage;
- field-levelling and drainage arrangement required to improve yield;

design and development for effective, simple, cheap on-farm irrigation methods such as sprinkler, drips, etc.

v) Agri-business is gaining momentum in this country. Research must be directed towards improving this segment of agricultural activity. In addition, research and development programmes for post-harvest technologies and agro-based industries for adding value to crops and also providing new employment opportunities are to be initiated.

5.6. Resource Management

i) There is limited .information on the actual experience of collecting irrigation fees, managing the funds collected, allocating and spending them. Research into various aspects of resource mobilization and utilization for O&M of major systems is needed. Also research is needed in the area of decision making about allocating the maintenance budget; farmers' participation in these decisions; experience with farmers' organizations accepting the maintenance contract; and relationship between the development of effective farmer organizations and the rate of resource mobilization from farmers.

ii) Imgation fees from medium-scale systems maintained by the ID (i.e., systems having service area between 80 to 200 ha) are not collected; the farmers in these systems are encouraged to maintain them under the supervision of the Irrigation Department. The farmers are left to mobilize their own resources and maintain these medium-scale systems. Little research has been down on the O&M of these systems. There is an urgent need to take up research work on resource mobilization, performance evaluation and operation and maintenance management of these systems.

iii) Research on cost-sharing of rehabilitation and modernization and O&M activities between farmer organizations and line agencies and pricing of water on volumetric basis are needed.

iv) Assistance strategies for self-management systems and irrigation support services.

5.7. Environmental Effects of Irrigation

Irrigation involves a conscious effort to reconstruct the environment for human benefit. We must, therefore, expect beneficial as well as detrimental effects due to construction and operation of irrigation projects. it is only recently that growing concern over environmental degradation has prompted the government and funding agencies to require statements about the possible environmental effects of proposed projects from their planners and designers. No comprehensive methods are available yet to predict all the likely environmental changes that a particular project could introduce to the physical and ecological systems, which support it.

Research is needed to provide project .designers and managers with usable information based on research findings which will help them to identify possible environmental effects, to decide which of these are the most important and to recognize if opportunities exist for environmental management 'to ameliorate adverse effects. To achieve this, it requires a combination of applied research, communication and education.

Three broad levels of research can be identified. The first level includes only those effects arising from both the design and the operation of the irrigation project, the effects which will influence the performance of the project itself within its life-span. These may include such effects as erosion and sedimentation of the source, choking of channels with sediment or

vegetation,. soil. salinization, waterlogging, groundwater pollution, crop pests and diseases, human.health and other changes within the irrigated agricultural environment. the second level .refers to climatic changes, the downstream impact of river regulation on river channels, flood plains, acquifers, estuaries and coasts; changes in surface water quality including the possibility of saline intrusion; and environmental changes due to infrastructure development, fuelwood collection and settlement in the area surrounding the project. The third level relates to conservation issues: ,the preservation of unique habitats, and rare and endangered species and sustainability of coastal fisheries.

In the .short-term, research can contribute for improved environmental management by improving the quality of predictions of environmental change; to achieve this, the following three activities are of immediate relevance: a systematic recording of past experience in a form which is readily available for future reference; the regular collection of data from existing irrigation schemes to provide more detailed information; and the development of practical tools and procedures to achieve better predictions making maximum use of available data.

6. GUIDELINES FOR PRIORITIZING RESEARCH NEEDS

Based on the government policy for short- and long-term development of irrigated agriculture in the country in the year 2000 and beyond, the following broad areas of research needs are identified:

i) Development and Strengthening of Irrigation Institutions;

ii) Irrigation System Management and Performance;

iii) Rehabilitation and Modernization of Irrigation Systems;

iv) Irrigation Technologies;

v) Agricultural Technology and Crop Diversification;

vi) Resource. Generation and Mobilization;

vii) Environmental Effects of Irrigation.

Among these broad areas, research priorities have to be defined with reference to the needs of the main clients (farmers) and research programmes have to be formulated on the basis of these priorities.

We must have certain broad principles for consideration as guide-posts in charting a course through the multitude of irrigation-related problems confronting us towards pritoritizing research needs. The first and foremost principle is that researchable issues should be carefully formulated using a performance-oriented approach. Secondly, we must aim our research results

at a .wider audience, i.e., one including ministries of planning, finance, agriculture and irrigation, irrigation professional and farmers. In other words, issues to be studied must be related wherever possible to examining the larger policy questions and demonstrate their importance in that context. Thirdly, we need to treat the irrigation scheme as our fundamental unit of analysis, employ a system perspective in the study of these fundamental units, and make system performance our primary concern. Fourthly, we need to understand the socio, political and economic changes that the research results would bring about in' established practices and procedures of irrigation system planning, design, operation, maintenance and management. The processes involved in implementing changes and the consequences of its impact on existing socio-economic conditions are to be well understood before research is undertaken.

Finally, the research needs arid priorities must emanate from the end beneficiaries, the farmers and the farmer organizations, the implementing agencies at the field-level, the project management committees and from the feedback obtained from the training program conducted by these personnel. Prioritization of research needs and priorities among other things depend on regional priorities, resources allocation, manpower requirement and government priorities of thrust areas.