

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

WATER USE AND MANAGEMENT

(Agenda Item 7)

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome 1976

## RESEARCH NEEDS ON WATER USE AND MANAGEMENT

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## 1. Introduction

The present paper was prepared by FAO in reply to a memorandum from the TAC Secretariat in which information was requested on research priorities in respect of water resources use and management. It was specified that such information should have a relation to the use of water in farming systems where water represents a severe constraint, and reference was made at this point to the semi-arid areas of developing countries.

The paper deals with the problems in a very condensed form, leaving references to details to the quoted papers. The idea was to review the existing studies rather than to undertake a new study. It was felt that in such a context the paper can deal with research on water management without extensively referring to different climatic zones. After TAC have set priorities, more definite proposals for action can be worked out, which then might be related to the requirements of different regions.

## 2. Water Management

Field water management is the focal point of water control for and water use in agriculture:

- (a) Field water management aims at the supply and control of water at the farm level to provide optimum growing conditions for the plant within the requirements of farming systems.
- (b) Field water management, at the same time, is a part of the water system as a whole, be it (i) the irrigation/drainage system for almost complete control of water as an agricultural production input, or (ii) the rainfall/runoff system in non-irrigated agriculture which is to be modified for optimum use of available rainfall as well as for the protection of soil and water resources through measures of conservation, erosion and flood control.
- (c) Field water management, furthermore, is done directly by the farmer himself, who acts and reacts within his rural socio-economic environment; hence, field water management requires adaptation to and adoption by the farmers as part of the rural socio-economic system.

Field water management, in the above sense, means the functional control of technical facilities according to an operational concept for achieving the desired results. This requires:

- Technical design and construction of irrigation and drainage systems, and measures for water conservation, erosion and flood control, i.e. essentially the investments required for water development for agriculture.

- Water application and operation of systems for the supply of water in the required quantity, quality and timing, and removal of excess water, i.e. essentially the use of water in agriculture.

Both of these items have to be commensurate with (a), (b) and (c) above; they are interrelated as far as planning, surveys and use of basic data are concerned; however, their requirements with regard to research needs and research priorities are quite different and will have to be dealt with individually, with view to the following:

- (a) Each of the above components has distinctive site-specific and non site-specific aspects, in particular with regard to the transfer of technology and know-how which might be developed elsewhere, but will require adaptation to the local conditions and adoption by the local farmers and calls for additional knowledge which can be generated only at the site.
- (b) Each of the above components has to be seen in relation to the timing of investments. Investments for water development projects for agriculture normally have a long gestation period and are planned for a lifetime of 25 to 50 years. This time-horizon justifies a long-term research aspect for field water management which tries to develop new, advanced technologies and methods to be used in future project development. On the other hand, investments have been made and are being made at present according to previous or present-day knowledge of technologies which due to changing requirements is not fully used. Short-term research is needed to improve knowledge about adaptation of technologies and methods to changing local conditions of their use. Therefore, a distinction has to be made between research needs for long-term and short-term project development.

The above classifications have been used to prepare a matrix (Annex 1) for the identification of research fields.

### 3. Research priorities

#### 3.1 Previous reports

Research priorities have recently been analysed in two reports:

- (a) Water use and management: report by Dean F. Peterson, prepared for the International Development Research Centre, Ottawa, Canada, 1972.
- (b) Report of a research review mission to the Near East and North Africa, prepared for the Technical Advisory Committee of the Consultative Group on International Agricultural Research, Rome, 1973.

The Peterson report concludes that a large part of the problem is the implementation of technology that is already known, rather than a lack of available technology. It emphasizes the need for water management at the field and project levels to be considered as important elements at the regional and national policy and planning levels. The report comes out in favour of the establishment of an International Centre for Monsoon Asia. This Centre would concentrate on systems research, information processing and education as related to the total system of water delivery and management. Technological research would primarily be undertaken by existing local research institutes.

The TAC Near East mission report proposes the establishment of a major, multi-disciplinary research centre for Mediterranean agriculture. In addition to carrying out training programmes and cooperating with local institutes, the Centre itself would also undertake on-site research. Concerning research objectives in water management the report refers to the continued need for developing and improving design and operational criteria for irrigation methods and practices.

It appears, then, that views on the basic problems in water management and the scope of efforts needed to solve them as expressed in both the Peterson and the Near East reports, are essentially similar. This implies that, in a general sense, the recommendations for Monsoon Asia are equally applicable to the Near East, and the reverse. They are likely to apply to other parts of the world as well.

A difference in emphasis and scope may be noticed about the type of research needed. While the Peterson report considers research as being primarily related to "the total system of water delivery and management", the Near East report refers more specifically to the continued need of a more conventional type of research on irrigation methods and techniques, crop water requirements, drainage criteria, drainage materials, reclamation methods, water quality, amongst others.

The Peterson report, moreover, stresses the need to implement technology whilst it is not clear in the Near East report whether continued research should precede the design and implementation of development projects or whether it should be undertaken as an activity that runs parallel to such projects.

Both reports suggest a regional research centre as an important means of promoting solutions. Whilst, however, the Near East report envisages considerable on-site research at the Centre, the Peterson report considers that technological research should be carried out by existing local research institutes.

At TAC's 8th session, the committee generally agreed with the report's analysis of the problems and the setting of priorities. TAC observed that considerable gains in water use efficiency can be made through application of known technologies and without additional research. However, it considers that inadequate soil moisture regimes are often the major factor which holds crop yields at low levels. TAC therefore has urged all international centres to accord water management an important place on their research agendas.

On the tasks of the proposed centre, TAC considered training, collection and dissemination of information on research rather than research itself as the main possible tasks. There was, however, "a consensus of doubt that existing research gaps were of sufficient importance to warrant the creation of a new centre". TAC stressed the site-specific nature of most of the adaptive research and the advisory services required were also stressed. A network of cooperating national centres, and the development of the water management activities of the International Agricultural Research Centres, were considered as possible alternatives.

### 3.2 Present views

Present views on research priorities have been grouped in the matrix presented as Annex 1. This matrix serves to show major categories of problems requiring research and some typical examples of topics. It has been based largely on information presented in the above-mentioned reports as well as on papers prepared for an international symposium on research needs for on-farm water management (USAID/CUSUSWASH Park City, Utah, 1973), FAO field experience and related reports. No attempt has been made to be exhaustive. The categories and topics have been classified as site-specific or non site-specific whilst a distinction has been made as to short or long-term needs.

Although the class definitions used are rather imprecise and there is the unavoidable subjectivity of judgement, some conclusions appear nevertheless justified.

- (a) First, the available technology is considered largely adequate for the short-term improvement of on-farm water management and, thus, to raise crop production on most irrigated lands having low crop yields due to poor water conditions. Short-term technical research needs are largely on some special problem soils and, particularly, on the adaptation of technology to suit local farming, socio-economic and institutional conditions.
- (b) New concepts and technologies - even if modified to fit local conditions - are often not easily adopted by the farmers. Constraints to adoption are found, amongst others, in cultural patterns, education, institutions, water laws, land consolidation, water pricing, credit provision, regional

and national planning of development projects, and public participation. The influence of these has not yet been subjected to intensive and systematic research at the required scale. A major coordinated effort, which takes into account the rather unique position of water management in agricultural development, would seem justified. This position is primarily characterized by the large, non recurrent, capital investments needed for water systems and by the fact that water management activities are largely beyond the control of the individual farmer, organized by groups of farmers being a pre-condition.

- (c) On a long-term basis the research needs cover both the socio-economic and the technical fields. Socio-economic research will continue to focus on the problems of adaptation to and adoption by farmers. In the technical field research should be conducted on the further improvement of present methods and techniques as well as on the development of new technologies, concepts and methodologies for optimization of water use, technical designs and the effective operation and maintenance of water control systems.

#### 4. On-going research

A considerable amount of research on water management is being conducted by a large number of institutions in both developed and developing countries. Topics researched are primarily technical and the common objective is to improve and refine existing concepts, methods and techniques of water management, as well as to develop new technology.

Research on adaptation of technology and constraints to adoption by farmers has been undertaken during recent years by only a small number of institutions and some private firms. The work done is rather local in nature, and there is little coordination or harmonization of methodologies. Examples of such local research are that conducted by the Moona Experiment Station in Pakistan, supported by USAID/Colorado State University, and research programmed by USAID and Dutch bilateral agencies in Egypt. There are also a few regional and interregional organizations dealing in part with socio-economic aspects of water management. They are, amongst others, the Asian Regional Irrigation Communication Network (Singapore), the International Irrigation Information Centre (Israel) and the FAO-Near East Land and Water Use Commission.

There are at present several IARC's (International Agricultural Research Centres) that have included water topics in their programmes, in line with TAC's recommendation to "accord water management an important place in their research agenda".

The work carried out by these includes the following:

- the adaptation of known technologies to achieve the best possible control of soil moisture in the conditions at the research stations, and especially sophisticated experiments dealing with crop tolerance to different water regimes;



- the identification of existing water management practices in field conditions which limit the impact of high yielding varieties and the development of simple water use techniques and devices as part of a package of crop improvement factors;
- research on the technical and socio-economic aspects of water use in different farming systems, in particular on soil and water conservation in rainfed systems and on optimal water use and control in irrigation systems;
- related information exchange and training activities.

It appears that the water topics dealt with at the IARC's have primarily been selected as complementary items to on-going agricultural research activities. The programmes of the IARC's do not provide presently an adequate coverage of the research items for field water management as identified in the foregoing, nor can they at present provide the desired backstopping of site-specific water research in the developing countries of their region. Moreover none of the institutes has a water department which could provide such services at present.

#### 5. Options for action

In summary, it appears that the main thrust of research in the field of water management in agriculture is to be directed towards more effective application of advanced, known technologies at the farm and project level. For this, priority will have to be given to research concerned with adaptation of technologies to local conditions, and investigation of constraints to the adoption of technological advancements and their removal. This also calls for a concentration of efforts to local, site-specific research at the field and project level.

Some important projects are presently being carried out in the above fields. These projects can very well serve as examples of what is needed and what can be achieved at the field level, but they cannot provide the necessary impact for the required breakthrough in the water management field because their number is far too small to adequately cover the more important irrigation areas in the world, the results of their work are not systematically collected and disseminated for other users, and no substantive and coordinated support for expansion is provided through national or international institutions.

From this it can be concluded that action is needed at two different levels:

(a) The field and project level, to carry out research on:

- adaptation of known technologies to local conditions;
- improvement of local technologies and operation methods;
- identification and removal of constraints to the adoption of advanced technologies and operation methods.



This can be done by existing or new local institutions, such as research institutes and university faculties, and also by extension services, project administrations and government organizations concerned with water and/or agricultural development. To perform effectively, these institutions will require direction and support from international centres. The second level, therefore, is:

(b) The national/international level, to initiate, guide and support the activities under (a) above, by:

- providing financial support;
- coordination of field activities and programmes;
- collection and dissemination of information (reference centre);
- organizing training of research staff and technical meetings.

This can be done by the creation of national water management centres for the national level in larger countries, and at the international level by one or more international centres for water management, preferably one in each major region. These centres should function as focal points in the region for the mentioned tasks rather than undertake on-site research themselves. Therefore, their staffing and physical facilities could be kept comparatively small.

1. Water Management at Farm Level

	Technical design and construction		Water application and operation of systems	
	Site-specific	Non site-specific	Site-specific	Non site-specific
Research needs for short-term project development	(a) appropriate field techniques, e.g: - land preparation - maintenance of field installations - water measuring devices (b) specific problems, e.g: - gypsiferous soils - sandy soils - clay soils	None	on-farm methods, e.g: - irrigation cum fertilizer use - irrigation/drainage cum mechanization - irrigation schedules in relation to the farming system - irrigation/drainage in rice fields *	None
Research needs for long-term project development	(a) improved techniques, e.g: - use of local material - low cost equipment - application of mechanization (b) problem soils	- mechanization in irrigation - water lifting devices	- integration of on-farm requirements in system operation - farmers' participation in scheme operation	- irrigation schedules and farming systems

\* surveys of planning data not considered as research.

2. Water Management as Water Control Technology  
at Project Level

	Technical design and construction		Operation and management of water systems	
	Site-specific	Non site-specific	Site-specific	Non site-specific
Research needs for short-term project development	Research on development of appropriate techniques	None	None <sup>1/</sup>	None
Research needs for long-term project development	Research on development of appropriate techniques, e.g.: <ul style="list-style-type: none"> <li>- use of local material for construction</li> <li>- combined use of surface and groundwater, etc.</li> </ul>	Research on water development and management technologies, and construction techniques, e.g.: <ul style="list-style-type: none"> <li>- labour-intensive construction</li> <li>- energy requirements</li> <li>- automated water control</li> </ul>	Research on: <ul style="list-style-type: none"> <li>- water allocation criteria for competing uses</li> <li>- water administration</li> <li>- effect of water management on environment, salinization, flood zoning, erosion control, etc.</li> </ul> <sup>2/</sup>	Research on: <ul style="list-style-type: none"> <li>- data collection systems</li> <li>- systems analysis applications</li> </ul>

<sup>1/</sup> Surveys and resources assessment not considered as research.

<sup>2/</sup> Surveys on environmental impacts of water use in irrigated and non-irrigated agriculture not considered as research.

3. Water Management within the  
Rural Socio-Economic System

	Technical design, equipment and construction		Operation and management of water systems	
	Site-specific	Non site-specific	Site-specific	Non site-specific
Research needs for short-term project development	(a) adaptation of techniques: - improvement of traditional techniques - modification of advanced tech- niques to local conditions (b) constraints to adoption of improved/advanced techniques	None	(a) modification of traditional operation systems to meet changing demands (b) constraints to such modifi- cations (c) farmers' motivation (d) irrigation extension	None
Research needs for long-term project development	- constraints to introduction of new techniques	- benefits of new techniques	- water admini- stration - water pricing - compensation for water rights	- interrelation between water rights and land use rights - government supervision of water use - integration of agricultural water use systems in national water plans and policies

WATER MANAGEMENT - STATUS OF AID SPONSORED RESEARCH

APRIL 1976

AID sponsors several centrally funded research projects in the field of Water Management. Individual country missions usually do not develop specific research projects in Water Management, however, often a component of an on-farm water management loan may involve some research. For example, in Egypt, at the present time, a project is being developed whereby farmer water management problems will be analyzed and improved management packages will be pilot tested.

Some of the work at the International Centers involves water management. ICRISAT is especially involved because of the farming systems approach. But, in general, these research efforts are not concentrated solely on water management as the principal objective. Two centrally funded research projects were initiated in 1969 with the main objective of increasing food production through Water Management research. These projects are presently active and are being considered for renewal. A third project is being developed. Following is a description of the several central projects relating to Water Management:

1. Irrigation Water Management research conducted in Pakistan. This project has involved a detailed study of the on-farm Water Management problems, development of a package of practices to improve management, pilot testing the packages in the farmer environment, and development of a national program to spread the technology.

The problem identification phase is essentially complete. It was found that contrary to popular belief the efficiency and effectiveness of water use was very low indeed. Pilot programs are underway utilizing improved technologies (land leveling, improved delivery systems, better planting methods, proper irrigation rates). Techniques for spreading the technology are being tested, training requirements analyzed, and cost/benefit analyses prepared in order that the techniques can be utilized in other locations where on-farm irrigation water management needs improvement.

2. On-farm Water Management - South America: This project is seven years old and has involved conducting water management research in seven Central and South American Countries. In general, these studies have been at the request of the host country and usually involve highly scientific plot work, on experiment stations in cooperation with the host country research organization.

A great deal of data has been gathered on the water-fertilizer response surfaces for corn. Some research has been conducted on methods of irrigation, especially sprinkler and more recently the trickle method. Mole drainage as a technique for removal of excess precipitation has been studied in detail.

A significant contribution of this project has been an analysis and compilation of the existing water laws in South America.

3. A new project will study the physical, biological, economic, and organizational dimensions of existing irrigation systems in order to a) develop tools and procedures to thoroughly analyze irrigation systems to b) identify key areas needing improvement and to c) recommend planning or policy procedures which might lead to better water management.

The project will involve a study of at least three systems in three separate locations.

4. Some other centrally funded research projects have components dealing with water management even though their main thrust is some other aspect:

a) One of the Soil Management projects involves manipulating soil and plants (mulches) to conserve soil water and extend the growing season.

b) Soil, water and plant relationships are studied in practically all crop related research since measurements taken on any of these aspects increases the body of knowledge.