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IRRIGATION MANAGEMENT NETWORK

NEWSLETTER

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Agricultural Administration Unit, Overseas Development Institute, London

The Overseas Development Institute (ODI) is an independent, non-profit making research institute. Within it, the Agricultural Administration Unit (AAU) was established in 1975. Its mandate is to widen the state of knowledge and flow of information concerning the administration of agriculture in developing countries. It does this through a programme of policy-orientated research and dissemination. Research findings and the results of practical experience are exchanged through four Networks on Agricultural Administration (Research and Extension), Irrigation Management, Pastoral Development, and Social Forestry. Membership is currently free of charge to professional people active in the appropriate area, but members are asked to provide their own publications in exchange, if possible. This creates the library which is central to information exchange.

The International Irrigation Management Institute, Colombo

The International Irrigation Management Institute (IIMI) is an autonomous, non-profit making international organisation chartered in Sri Lanka in 1984 to conduct research, provide opportunities for professional development, and communicate information about irrigation management. Through collaboration, IIMI seeks ways to strengthen independent national capacity to improve the management and performance of irrigation systems in developing countries. Its multidisciplinary research programme is conducted on systems operated both by farmers and by government agencies in many co-operating countries. As an aspect of its dissemination programme, it has joined ODI in the publication of the Irrigation Management Network papers, to enable these to appear more frequently to an enlarged membership.

The ODI/IIMI Irrigation Management Network is sponsored by:

ODA

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NEWSLETTER

Mary Tiffen

1 NETWORK PAPERS AND DISCUSSION

This first issue of the African edition of the Irrigation Management Network papers is concerned with one of the major problems of African irrigation. This is the high cost of operation and maintenance, particularly when a government ministry or parastatal is responsible for managing the schemes.

Few governments are able to continue to subsidise the recurrent costs of irrigation when there are many other calls on the public budget. This tends to lead to a decline in maintenance standards, and in due course to shortage of water, or to water logging and other forms of deterioration. These conditions then prevent farmers from obtaining good yields and adequate incomes. Parts of the scheme may be abandoned, and the expectations on which the original capital investment was made are not realised. It is therefore now generally agreed that farmers should pay the costs of operation and maintenance, even if they make no contribution to the original capital costs of construction. However, if they are to be able to afford these contributions, the efficiency of the operation and maintenance service must be high, and its costs must be kept as low as possible.

Paper 90/1b by Mary Tiffen, ***Variatibility in Water Supply, Income and Fees: Illustrations of Vicious Circles from Sudan and Zimbabwe*** looks at the relationships of farm incomes, ability to support operation and maintenance costs, and the design of the management structure in two cases. The first is the huge Gezira scheme in the Sudan (800,000 ha). The Gezira has a special importance in the history of irrigation in Africa since it became the model for the management structure of many other irrigation schemes, large and small, in the colonial period. It was a model that was often inappropriate, particularly for smaller schemes which are more typical in other countries of sub-Saharan Africa. The second study is of one such smaller scheme, Nyanyadzi, covering 400 ha in Zimbabwe. The paper shows how farm incomes differ from year to year, and according to location, in both schemes, depending on the amount of water received. In some years and in some locations farmers cannot afford to make any payment for irrigation services; yields are so low that they have trouble in obtaining even their basic needs for subsistence. Sometimes the lack of water is due to poor maintenance. However, it may also be due to other factors such as the year-to-year variability in the source of supply, lack of storage facilities, and lack of a ground water resource that can be used to supplement the surface irrigation supply. A great responsibility lies upon irrigation engineers to design and maintain schemes in such a fashion that the water supply is as reliable as possible, and is delivered as equitably as possible. At the same time, management costs need to be kept as low as possible, to be within the capacity of farmers to pay. Low costs are particularly important when it is not possible to prevent year-to-year fluctuations in water supply, since in this case, farmers' income, averaged over a period of years, will be much lower than in the case where they receive a reliable water supply.

Paper 90/1c, by J Jaujay, ***The Operation and Maintenance of a Pilot Rehabilitated Zone in the Office du Niger, Mali*** looks at another large irrigation scheme, modelled on the Gezira, which has had a troubled history since its establishment in the 1930s. The rehabilitation of a small part of the scheme was carefully designed to take into account the way it could be managed with the available resources of manpower, and in accordance with a revised financial system in which farmers' service payments are banked locally, are under the control of the project management, and are used to pay for operation and maintenance. Thus, the local management has some financial autonomy. Farmers are given clear responsibilities for carrying out themselves some of the operation and maintenance functions, which not only keeps costs down, but also allows them to identify particular maintenance problems. It is intended that in due course the farmers, who are already being given information about the budget, and who are organised in field channel groups and village associations, will be represented on the management team controlling the budget. The paper is also interesting because the maintenance requirements were carefully costed and specified; all too often some percentage of capital costs is taken as the maintenance requirement, without any careful investigation of its adequacy. The paper concludes that farmers' payments should be able to cover costs. It is worth noting, however, that there is at the moment no problem of water shortage in the area.

In Zimbabwe, the Government is very conscious of the high cost of operating itself small irrigation schemes such as the one described in Paper 90/1b. The scheme described there is one of several that were established before independence without regard to financial and social considerations.

Paper 90/1d by J M Makadho, ***The Design of Farmer Managed Irrigation Systems: Experiences from Zimbabwe***, shows the very different approach now taken. Under the National Farm Irrigation Fund farmers are expected to pay for the infield costs under a loan scheme (the infrastructure to the scheme edge being provided by government) and to manage, operate and maintain the scheme entirely by themselves. This results in a completely different design approach. First, the design team have to ensure that the farmers genuinely want an irrigation scheme, and are aware of the costs, in finance and in labour, as well as the benefits. Apart from discussions on site, they have found it useful to take the farmers to visit an existing irrigation scheme. It is important to notice how the farmers are left to make their own enquiries of their fellow farmers, and how they are given time to have internal discussions amongst themselves on their return home. The designers are then able to have an informed discussion with the farmers on their cropping preferences and management preferences. Makadho describes one of the designs that has found favour, a sprinkler system in which farmers are individually responsible for part of the equipment. They prefer this to shared responsibility. During the first year they are given considerable help by extension personnel, but they are already responsible for management, and for making enough money to fulfil their financial obligations at the end of the first year. The schemes described are relatively small, catering for an average of 20 to 25 farmers each. Again, there is financial autonomy at the project level; in this case, the farmers' group organisation is the responsible management authority. The method of approach for physical design and institution building seems very practical for small schemes. Larger schemes for several hundred or thousand hectares would require more elaborate investigation by an interdisciplinary team, but the principal of thorough discussion of farmers' needs and preferences is important for schemes of all sizes.

It has been found, through research carried out by the International Irrigation Management Institute (IIMI) in Asia, that the payment of irrigation service fees affects and improves the performance of those responsible for the management of irrigation mainly when the irrigation agency has to rely on fees which it collects directly for a substantial part of its income. It has financial autonomy in relation to general government revenues, although it is dependent on its farmer clients. There is little relationship between fees and efficiency when the irrigation agency is dependent on general government revenues for its income. As this research is very relevant to many countries in Africa who are already establishing, or who are considering establishing, independent self-managing agencies for irrigation, we are reprinting a summary of its conclusions, by Leslie Small as Paper 90/1e. (This was first published as ODI/IIMI Irrigation Management Network Paper 87/1c.) For English readers it will serve as an introduction to the full report which is now available from IIMI; L E Small et al, 1989, ***Financing Irrigation Services: a Literature Review and Selected Case Studies from Asia.*** (Please write to IIMI for a copy and not to ODI.)

Increased farmer-management is seen as the way forward in Africa, particularly in the smaller schemes which are often best suited to the nature of local resources of water, land and manpower. It is not always a very popular idea with farmers who have been taught to depend on instructions from above, and who know that water costs are subsidised, as I found in Zimbabwe. However, as is also illustrated in Zimbabwe, it is feasible and even popular with farmers who from the beginning are encouraged to be self-reliant, and who have had a voice in the design of irrigation.

Those who want to give more thought to irrigation charges may like to look at a recent article by Mick Moore, in ***World Development***, 1989, Vol 17, No 11, ***The Fruits and Fallacies of Neoliberalism: the Case of Irrigation Policy.*** In it he discusses both the Leslie Small Paper 90/1e and Robert Repetto's ***Skimming the Water: Rent-Seeking and the Performance of Public Irrigation System***, published in 1986 as Research Report 2, World Resources Institute, 1735 New York Avenue, NW Washington DC 20006, USA. In general, Mick Moore finds convincing Repetto's use of rent-seeking analysis to explain the poor performance of large gravity irrigation schemes serving numerous small farmers. This analysis supposes there are various private interest groups which seek to shape public policy to their own advantage, ranging from the staff of irrigation agencies who are able to get more private benefit from new construction than from maintenance, to engineering firms who need new contracts, to aid agencies that wish to disburse funds as easily as possible, to farmers at the top of a system who take more water than they are supposed to. Repetto (and Moore) blame this on the "lack of any financial mechanism linking resource use decisions to resource costs", both for investment and for operation and maintenance. From this they go on to discuss the role of irrigation service fees. They agree it is often difficult to charge farmers the full costs of water, because past rent-seeking activities have resulted in a stock of projects which are uneconomic. (One might quote as an example the Nyanyadzi case cited in Paper 90/2b; the Sudanese case is different, since the Gezira was originally economic, but has deteriorated under bad management.) Moore goes on to agree with Small, that it is impossible to adopt volumetric water-pricing in the type of system he is describing; mainly because of "the incomplete capacity of the system managers to control and direct the water they have". (This is amply illustrated in Paper 90/2b; it was a main intention of the rehabilitation programme in the Office du Mali, Niger, described in 90/2c, to improve water control.) Moore further thinks it unrealistic to assume that water can be 'whole-saled' to groups of farmers who will then undertake fair distribution and payment collection within their own area. This is certainly something we should all think seriously about. He argues from the example of Taiwan that it is instead possible to make the managers of a system responsible to the needs of the farmers, and he identifies two factors there. The first is that the staff are locally based, and subject to local social pressure from the farmers they serve. The second is that the speed with which they collect the water fees is one element in the formal grading system for staff. Those responsible for water delivery are also responsible for fee collection, as in the system set up by Asaduzzaman in Bangladesh and described in Paper 89/2e. If service is not satisfactory farmers are inclined to delay payments.

The linking of fee collection with staff rewards and with quality of service does seem effective; it has basically worked in the Philippines, as discussed in Newsletter 89/1a. There may be more scope for wholesaling water to farmer groups in the small systems which are quite common in Africa than in the large Asian systems with which Moore is familiar. Another point of difference between Asia and Africa is the greater importance of pumped systems in Africa. With pumped systems it is relatively easy to charge according to water delivered, since the cost of the fuel utilised acts as a proxy for water measurement.

Another good discussion of the relationship of irrigation water charges, maintenance, and ability to pay, which is easily available, is the ***Report of the Expert Consultation on Irrigation Water Charges***, held in FAO in 1986. Write to FAO, Land & Water Division, for this.

Farmer management and farmer consultation has been a theme of many recent studies and discussions of African irrigation. In Paper 90/1f, ***Design for Sustainable Farmer Managed Irrigation Schemes in Sub-Saharan Africa***, J J Speelman has compiled the results of these studies, particularly as they relate to design. In editing it, I have added some comments of my own, since I was involved in many of the conferences to which he refers. I hope this will lead others to make contributions indicating what they think are some of the most important things we have learnt for the improvement of African irrigation. Speelman notes the importance of seeing irrigation as part of the existing social and agricultural system. He refers to some of the points brought out in the papers discussed above, such as the constraints on good management in large, government financed schemes, the risks associated with dependence on external inputs, the need to consult with farmers on design requirements (where Makadho describes one method), the need to proceed carefully, building on initial pilot schemes where possible, (as in the case described by Jaujay). One of the gaps he notes is on land tenure; we note some recent studies in the publications section of this Newsletter.

One of the points not clearly brought out in Speelman's summary is the very great variety of water resources in Africa. There are few great rivers such as the Nile. More important to many farmers than irrigation is some kind of water management, ranging from water harvesting techniques in arid areas to use of swamp land, low-lying water retaining land, flood recession agriculture, etc. In some countries there is considerable traditional expertise in these techniques. In some areas, drainage rather than irrigation could bring new land into cultivation. However, in all these cases it is important to look at the existing uses of the land, and to see how farmers want to develop it, and how far this can be done without damaging the environment in areas downstream from the development. In some cases the obstacles to full-scale irrigation are not likely to be overcome in the near future, and it may be a more appropriate policy for governments to see how far it is possible to develop rainfed agriculture. In other cases, full control of water in a formal irrigation scheme is appropriate, but because of the management problems encountered in the past we need to consider carefully how to reform the institutional structure whenever a physical rehabilitation is undertaken.

2 IIMI PROGRAMMES IN AFRICA

Because of the great variety of conditions within Africa, the International Irrigation Management Institute (IIMI) has opened three separate offices as the first step in its African programme. These are:

(a) Morocco

At the end of October 1988, IIMI signed a memorandum of understanding with the Kingdom of Morocco for the establishment of a country unit in Rabat. This unit started in March 1989, hosted by SEHA (Service des Expérimentations d'Hydraulique Agricole, Irrigation and Drainage Experimentation Service), a branch of the Ministry of Agriculture and Agrarian Reform.

IIMI decided to start operations in Morocco because this country provides valuable examples of the Western Mediterranean approach to irrigation. The climatic conditions of this area are generally semi-arid to arid with no abundant water resource, such as the Nile river in Egypt and Sudan. Water saving is thus a major concern and several thousand years of continuous experience has led to original, sophisticated and effective irrigation organisations and methods. They are characterised by:

- close integration of irrigation with agriculture and agro-industry (no specialised irrigation bureaucracy);
- decentralised management of irrigation systems;
- flexible mixed-cropping systems;
- a wide variety of irrigation techniques, from ancient *khettaras* (underground drainage and conveyance canals) to modern central pivots;
- water delivery more or less related to demand.

However, this expertise is almost unknown in other developing countries, especially in those outside the Arab world and francophone Africa. The opposite is also true and Morocco could benefit from Asian and Latin-American experiences, especially in FMIS (Farmer Managed Irrigation Systems) and farmer participation in the management of large systems.

IIMI decided to adapt its programmes in Morocco to focus its operations on projects with significant 'exportation' of Moroccan expertise and/or 'importation' of foreign ones. In September 1989, a Moroccan Consultative Committee, composed of Moroccan experts and officials, agreed with this approach and gave practical recommendations for the development of a programme in the country. As there are numbers of well-trained Moroccan researchers in disciplines linked with irrigation management, IIMI decided to work on projects in close collaboration with local research and management institutions. The specific role of IIMI will mainly be to develop relations between Morocco and the external world. The first stage, identification of problem and definition of a research methodology of a project on FMIS in a piedmont valley of the Atlas mountains, was completed in 1989. Further stages, under development, should lead to realistic recommendations for efficient absorption of small traditional indigenous irrigation schemes in bigger and more modern systems.

A Moroccan ORMVA (Office Régional de Mise en Valeur Agricole or Regional Agency for Agricultural Development) is involved in the preparation of a multi-country project about the implementation of the techniques, methods and principles of management to irrigation agencies. Other countries involved are Burkina Faso and Nigeria.

In May 1990, jointly with the Moroccan Ministry of Agriculture and Agrarian Reform, IIMI is organising an international workshop on African experience in FMIS. This workshop will be centred on the arid and semi-arid zones of the continent and will be held only on invitation, but the proceedings will be disseminated.

The IIMI Morocco Representative is:

Mr Jean Verdier
IIMI abs du SEHA
461 Avenue Hassan II
Al Akkari, RABAT
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Tel: 212(7)-922 03 & 912 04
Telex: DERMARA 32705 (using IIMI as heading of telex)

(b) West Africa

The programme for West Africa is related to the general pattern of irrigation in the region and the overall mandate of IIMI with its emphasis on irrigation management issues.
The programme combines national interventions to meet the local or national requirements within a comprehensive regional approach.

The programme is based on:

(i) a 5 country programme, Burkina Faso, Mali, Niger, Nigeria and Senegal;

(ii) a regional intervention to promote and coordinate a West African Action-Research network, and;

(iii) a training programme in the application of management techniques, methods and principals of the management of irrigated areas.

(i) The 5 Country Programme

In Burkina Faso, to increase irrigation around small dams, the government is looking for ways to improve the physical state and the management of these small systems, by promoting farmer organisations. IIMI's programme will start this year, with support from the African Development Bank.

In Mali, IIMI is concerned with information collection and communication, adjustments of water supply, monitoring of systems and maintenance of the system. Included in this management model are water supply methodologies and their application, and social and organisational support structures.

In Senegal, the government is concerned with the efficient use of water resources made available by the new dams on the River Senegal. Related to this is a policy of restructuring the national rural development corporations and reducing their role in irrigated agricultural production. IIMI seeks to help the government of Senegal turn over irrigation responsibilities to farmers' groups. Canadian cooperation has been requested by the Senegalese government to fund this programme so as to increase system performance, farmers' participation, cost recovery and systems maintenance.

In Niger, the government requested IIMI to help it by reducing pumping costs, through more efficient irrigation water management practices, as well as diversification of agricultural production. The African Development Bank is supporting this programme as from 1990.

In Nigeria, the reduction in petroleum revenues has led the authorities to reduce subsidies to the irrigation agencies responsible for large formal irrigation schemes in northern Nigeria. The government is aiming to reduce the role of these agencies, and to increase the role of farmers' associations in agricultural production and scheme management. With support from the Ford Foundation, IIMI will assist in this programme, in close collaboration with the Institute for Agricultural Research of Ahmadu Bello University.

(ii) Network for Research and Development on Irrigation:

IIMI and its national partners are using a network concept in elaborating the West African programme. This envisages a structure in which:

- there are certain general research themes common to all projects;
- the choice of priority themes for the country concerned takes into account its irrigation management characteristics and its regional development strategies;

- linkages are developed between countries, so that they can take advantage of the phase in the programme where research results are applied. In this way each research and development programme will have an immediate national impact and a regional impact through the IIMI network.

This West African irrigation network is intended to promote and facilitate cooperation between researchers, and those responsible for irrigation programmes in national and regional institutions. It will have three main functions:

- to collect, develop and disseminate information on irrigation management in West Africa and to encourage researchers to publish their findings through a quarterly bulletin edited by IIMI and published in English and French, in close collaboration with institutions such as CIEH, WARDA (West African Rice Development Association), RSPAO and USAID.

- to organise, or help to organise, training courses for researchers and other professionals concerned with rural development;

- to stimulate research through facilitating exchange of experience, especially through seminars, workshops, meetings, study tours, etc, within West Africa and also in other countries of Africa and Asia.

For further information, please contact the IIMI West Africa Regional Representative:

Mr Jean-Claude Legoupil
B 5373
OUGADOUGOU
Burkina Faso
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(c) Sudan

IIMI has also opened an office in the Sudan. The Resident Representative is M S Shafique, and his office address is IIMI, PO Box 318, Wad Medani, Sudan, telex 50013 HR SD. We hope to carry information on the programme of this office in the next issue.

3 WORKSHOPS ON AFRICAN IRRIGATION

IIMI and DER (Department of Rural Development of Moroccan Ministry of Agriculture and Agrarian Reform) are holding an international workshop from 15 - 19 May on **Strategies for Developing and Improving Farmer Managed Irrigation Systems**, focusing on the experience of the countries in the arid and sub-humid zones of northern and western Africa. In spite of the physical, climatic, economic and cultural differences between these two regions, they all share certain constraints in expanding irrigation and in operating the existing systems, including limited water resources which are spatially very dispersed. This has led the national governments concerned to promote small irrigation systems. Because of their small size, these systems can only become economically viable if some of the management responsibility is taken over by the irrigators themselves, even if assisted by governmental or parastatal agencies. Both areas have a rich and varied experience in farmer managed systems, and this should provide important lessons now that policy is moving away from management by the public sector. The proceedings will be published and disseminated by IIMI.

This follows an important workshop held in Wageningen, February 5 - 8 1990, organised by the Agricultural University Wageningen, on **Design of Sustainable Farmer Managed Irrigation Schemes in Sub-Saharan Africa**. It was attended by over 70 people from 8 African and 4 European countries, including people with field level experience as well as planners and policy makers. It was a hard-working workshop at which the participants were assumed to have read the large number of interesting case studies, so that they could work in groups on aspects of the general theme of methods to improve the design of small schemes that can be managed by the farmers themselves in a sustainable way. The four sub-themes were: design relevant to local farming systems, making technical and organisational designs within the capacity of local management, design that takes into account relationships with external suppliers of services, and design that takes into account the way economic and social circumstance will change over time. In addition to the case studies there were some papers reflecting on more general issues, as one by Ibrahim Dia on methods of integrating social and technical considerations in irrigation design (in French), and one on the role of different types of training (in English). Two of the papers are republished here, 90/1d and 90/1f. There seemed to be general agreement that it is essential to consult farmers on the objectives of irrigation, for example on the crops to be grown, and on whether it will be a full-time or supplementary occupation, and on the details of the design which will affect the way the scheme is managed, and that this requires a process of interaction, not simply a brief enquiry. How far it always required a professional sociologist, and how precisely women's interests should be dealt with was more disputed. The workshop did not resolve the tension that exists between an outsider's view of what is a fair and equitable way of allocating land between families, or between men and women, and what may appear the normal custom and the 'right' way of doing things according to local people (an issue discussed in ODI-IIMI Paper 89/2b by Levine and Coward, ***Equity Considerations in the Modernization of Irrigation Systems***).

There was some conflict between the suggestion that investigations always require a professional interdisciplinary team and the way that farmer-managed systems have actually evolved in the past, where farmers have been both initiators and designers. However, it is undoubtedly the case that as the best and easiest sites to develop are used up, and as water becomes more scarce, design becomes more difficult. The 33 case studies and 6 analytical introductions have been published in two volumes. They are available at a cost of US$40 or DFL70, plus postage, on application to Ms J Heynekamp, Department of Irrigation and Soil and Water Conservation, Wageningen Agricultural University, Nieuwe Kanaal 11, 6709 PA, Wageningen, the Netherlands. The papers appear in English or French, with a summary in the other language. A team of 10 people from Africa and from the University remained behind to work up the conclusions; these will be published as a separate book which should be available about October 1990. The probable title is ***Adapting the Physical Irrigation Design and its Implementation to Social Conditions in Rural Africa: an Analytical Approach and Field Experiences***. Write to Ms Heynekamp if you would like information on publication.

As the absence of an irrigation policy has been identified as one of the difficulties in African irrigation, the Club du Sahel has commissioned indepth studies of irrigation in Burkino Faso, Niger, Mali and Senegal. A summary report is now being developed, and will be the basis of a regional meeting later in the year for representatives of aid agencies and Sahelian government bodies responsible for policy definition and implementation. For details, contact Jaap Rooimans, Club du Sahel, 2 Rue Andre Pascal, 75775 Paris, Cedex 16, France.

During 1989 the Réseau Recherche-Developpement had monthly meetings looking at case-studies of rehabilitations of schemes in Africa. These included the Rétail project in the Office du Niger (the subject of paper 90/1c), Matam in Senegal, SOMALAC and small schemes in the high plateau, both in Madagascar. This concluded with a round table discussion in September 1989. The poor performance of irrigation projects was attributed to poor design due to lack of consideration of the human factor, over-optimistic estimates of production in feasibility studies, and poor maintenance, very much linked to financial management. A publication is expected in 1990. For details, contact Mme Daniele Ribier, Secretariat Technique, GRET, 213 Rue la Fayette, 75010 Paris, France.

Two seminars on the Nile, sponsored by the Royal Geographic Society, 1 Kensington Gore, London SW7 2AR, UK, and by the School of Oriental and African Studies (SOAS), University of London, London WC1H 0XG, UK, are being held on 2 and 3 May, looking respectively at the nature of the water resource, in the light of evolving concepts of climatic change, and at the political and legal issues in its management. Enquiries to Professor J A Allan, at SOAS.

The seminar will undoubtedly refer to an important book on the southern Nile; Paul Howell, Michael Lock and Stephen Cobb (ed), ***The Jonglei Canal: Impact and Opportunity***, Cambridge University Press, 1988, £39.50. This is a summary of the state of knowledge on the human, physical and biological environment of the great wetlands of the White Nile when construction of the Jonglei Canal was halted by the resumption of civil war. It looks only briefly at the projected needs for water in northern Sudan and Egypt which are its raison d'etre. Most of the 500 pages are concerned to describe the situation and with weighing up potential benefits and costs in the locality itself. The benefits could be greater than the costs, but assessment is not easy, because of very great natural fluctuations in the amount of water flowing into the wetlands. One can only hope that the book will not serve as an obituary for the peoples whose existence and culture has once more been devastated by war.

A seminar on irrigation policy and other issues is being planned by the Zambian government, probably in September 1990. It is mainly for Zambians, but with some participation from other countries and from international organisations. For the latter categories, assistance is being sought from the Netherlands government; for details contact Ir T Van der Zee, International Cooperation, Government Service for Land and Water Use, PO Box 20021, 3502 LA Utrecht, the Netherlands.

4 TRAINING PROGRAMMES

Professor Osman Fadl, Dean of the Faculty of Agriculture at the University of Gezira, PO Box 20, Wad Medani, Sudan, has written about the interdisciplinary Water Management MSc which his University offers. One of its aims is to introduce graduates, especially those already working for Sudan's Agricultural Corporations, to the complex situation in which the farmer has to make his decisions about his farming practices. He says it comes as quite a shock to them to have discussions at the beginning of the course on the need and wisdom of having to be led by the farmers' agenda, being used to quite a different rhetoric. The candidates do their research in the Corporation for which they work, but the research problem is chosen in meetings with the farmers and with the management, in conjunction with the student and his supervisor. The problem chosen should be something which concerns both management and farmer. There is also a Water Management Specialisation in the Faculty of Agriculture's undergraduate courses. This includes the problems of the Nile basin development which are the subject of the London seminar mentioned above.

5 OTHER RECENT PUBLICATIONS

Please write to the addresses given for these publications.

General

Of all the recent reports on African irrigation, reviewed in Paper 90/1f, perhaps the most comprehensive is the *African Irrigation Overview* which has just been republished. It is now titled ***Irrigation Development in Africa: Lessons of Experience***, by J R Moris and D J Thom, 1990, published by Westview Press, Boulder, Colorado, USA, price US $55 or £35. UK readers should be able to order through their bookseller; if not contact Drake Marketing Services, telephone (0869)-38701. There are chapters on the hydrological environment, agronomy (with special reference to rice), technical difficulties ranging from water weeds to livestock, socio-economic issues, land tenure, project economics, irrigation management, and implications for donors. There is one chapter of case studies: Bakel in Senegal, Action Blé Dire in Mali, Bakolori in Nigeria, the Gezira in Sudan, and Bura West in Kenya. The chapter on management has a horrendous list of problems facing both bureaucratic and farmer management, closing with a list of ten reforms that might improve the situation. In view of the theme of this Newsletter and set of papers, it is worth noting that the first two are:

"1 We strongly support any interventions which would make scheme staff **more accountable** to the farmers they are supposedly serving;

2 There is an obvious case for diagnostic analysis and training dealing with **maintenance management**."

Land Tenure

Françoise Conac instigated the formation of teams of legal and geographic researchers who would investigate and categorise formal law and custom in relation to water and irrigated land in Africa. Teams were established at universities in Senegal, Mali, Nigeria, Chad and Madagascar. Some of the participants were able to assemble at a seminar at Dakar in December 1987. The papers presented, which often formed part of MSc or doctoral theses, have now been published (in English in the case of the Nigerians, in French for the others) in a special issue of ***Droits Africains***, June 1989, available from the Centre d'études Juridiques Comparatives, Sorbonne, 14 Rue Cujas, 75231, Paris Cedex 05, France. It is particularly useful to have the legal view, since this is often absent from irrigation discussions. Many of the papers both give the details of the formal written state law, and the conflict that often exists, either with historic tradition (for example Moslem law in northern Nigeria), or evolving custom.

Amongst several recent reports of the Land Tenure Center, 1300 University Avenue, University of Wisconsin, Madison, Wisconsin 53706, USA, is ***The Dynamics of Land Tenure on the Bakel Small Irrigated Perimeters***, 1989, by Peter Bloch, available in English and French. This contains the summary of the Discussion Papers published in the series, such as the companion detailed study of one village by David Miller, ***Irrigation and the Dynamics of Access to Land in the Village of Moudery***, 1989. The tenure situation in the Senegal valley is particularly complex, with a traditional aristocratic caste having dominated land control in the past, the details varying between the Toucouleur and Soninke peoples. The Rural Councils under the new national land law can now allocate land to those who can develop it within 18 months. Although nobles dominate the Councils, the Councils necessarily undermine their control of land, and allow the play of new factors such as links with political parties, etc. Most of the village irrigation schemes are allocated land under this new law, and within the scheme, small, equally-sized holdings are allocated by lottery. Whether women are included in the original allocation varies; what also varies is whether, when they are the nominal registered plot holder, it is in fact controlled by the family head. (It is difficult to alter traditional social systems through irrigation; the role of women in society evolves under its own dynamics.)

One of the main thrusts of the reports is that tenure changes over time. Currently it is subject to two contrary influences. On the one hand, good rains since 1984 have increased the importance of rainfed lands and some plots and/or perimeters have been abandoned. On the other, people have become conscious of the new situation created by the Manantali dam which will make water available for double cropping; people fear that under the new law, if they do not themselves use irrigable land, outsiders may be given it. The report concludes with a useful checklist of tenure issues related to design.

Small Schemes: Case Studies and General Principles

The Gambia resembles Senegal in many social aspects. IFPRI Research Report 75, 1989, by Joachim von Braun, Detlev Puetz and Patrick Webb, ***Irrigation Technology and Commercialisation of Rice in the Gambia: Effects on Income and Nutrition*** is another of its valuable studies that look at the effect of the introduction of a new cash crop on incomes and nutrition. In this case their sample was of 900 farmers belonging to 168 compounds in 10 villages, 8 in the project area of the Jahally-Pacharr irrigation project (initiated in 1983) and 2 outside it. The size of the sample permits a comprehensive statistical analysis. The ethnic groups are very similar to those further up the Senegal valley. Typically the compounds are quite large, and there is a compound farm, under the control of the compound head, on which all must work, and which provides the bulk of the household's food. In addition, there are private farms belonging to individual members, men or women.

The project is in an area where there has been a long history of unsuccessful irrigation projects, dating back to 1948. There is also a tradition of swamp rice cultivation, mainly by women, combined with upland cultivation of millet, sorghum and groundnuts, mainly by men. There was a deliberate effort to see that project irrigated land went to those with traditional rights in the area, including women, but in the sample, it was found that most of the fully irrigated land, capable of double season production, was in fact controlled by male compound heads. Women had more of the irrigated fields which produce wet season rice only, and of the swamp production. However, whereas the swamp fields had been, and remained, private, the double-season rice fields were being used as compound land. Consequently, relatively little was sold, but the project assisted incomes and nutrition by providing a more stable food supply, particularly in 1984, when rains were poor. Some of the women had private cotton and groundnut fields. Rice yields were 6.6 tonnes/ha in the wet season 1984, but dropped to 5.2 tonnes/ha in 1985, when the rains were better and labour was diverted to the upland fields. Women's labour input remained the same with the introduction of the new technology; that of the men fell. However, in these villages men provide 62% of family labour on major field crops and women 32%.

The study does not look in depth at the economics of the project at national level, but they appear dubious, given the high foreign exchange input into double season rice. However, double season rice gave a high return to labour, and a steady secure food supply. It cannot be greatly expanded, due to shortage of water in the dry season. As yet the returns to rice irrigated in the wet season only are not as attractive, on average, as the low input-low output traditional swamp cultivation. The effect of the additional rice production was an improvement in income and nutrition, relatively well distributed so that the poorer families gained as well as those who started off with most resources. The study concludes that projects in areas like this, where labour is the short factor and rain-fed land is relatively plentiful, have to be designed to live with variable yields. The shifting of labour between rainfed crops and irrigated rice is an efficient allocation of family and national resources. The food security objective is best met by a wide distribution of small plots; however, this makes rice production marginal in years of good rainfall, and probably increases the fluctuation of yields with rainfall. It suggests that rice should not be seen in isolation, but as part of the farming system which includes other crops. In 1985/6 rice provided half the family income in lowland villages, but only 13% of the income in upland project villages with some rice fields. The study neglects livestock. The study deserves close attention for its many insights into the problems of African irrigation.

The village schemes in the Senegal valley must be amongst the most studied in the world; they have attracted scientific attention far beyond their economic importance. However, some of these detailed studies will contribute to wider debates. One of these is on crop water requirements, and whether farmers waste water. The Department of Irrigation and Civil Engineering, Wageningen Agricultural University, has been carrying out some interesting studies with the West Africa Rice Development Association (WARDA). Their report ***Water Management in Village Irrigation Schemes of the Senegal River Valley: Technical Aspects***, 1989, (available in English and French) contains interesting detailed measurements which found that "on average, the measured field water requirement appears to be 20% higher than what actually had been indicated as norm". The norm was indicted by the

Penman formula. As they say, engineers are interested in water requirements to determine canal dimensions and the optimal irrigation interval. These findings indicate a need for broader safety margins. They also illustrate the various ways in which farmers adapt the structures and the watering system so that it better fits their needs, although often at a high labour cost. Another useful paper in the WARDA series is by Ibrahima Dia and Boubacar Fall, ***L'apport des différents types d'etudes socio-culturelles aux projets d'amenagements hydro-agricoles: l'experience de Kaskas***, 1989. It is a rather longer version of the paper already noted in the discussion of the design seminar at Wageningen. Dia and Fall make the useful distinction between multidisciplinary and interdisciplinary research. In doing a feasibility study, the latter is necessary, and sociologists must concentrate their investigations on what is necessary for the scheme, in a way that integrates with the research of the engineers and agronomists. This means concentrating on the socio-political aspects that affect yields, the maintenance of infrastructure and the management of water. They relate this to the investigations at Kaskas, Senegal. Their conclusions are very similar to the ones which I came to in Sudan and Zimbabwe, which are given in Paper 90/1b, and which derive from schemes which had been in operation for many years. For both the above, write either to WARDA, PB 96 Saint-Louis, Senegal, or to the Department of Irrigation and Civil Engineering, Wageningen Agricultural University, 6709 AJ Wageningen, the Netherlands.

In a rather more humid area, K W Knickel, ***Farming Systems Development - Smallholder Swamp Rice Schemes in Sierra Leone***, Studien 27, 1988, Verlag Weltarchiv GmbH, Hamburg, West Germany, reviews farmers' progress in rice cultivation in improved swamps, comparing this with their traditional swamp rice production. He concludes that their practices have to be seen in the context of their total farming system and its labour requirements, as swamp rice is combined with upland cultivation. Although the improved system is profitable, it puts farmers at greater risk from the unreliable systems for input delivery. He recommends step by step swamp development, to give farmers time to adapt to the changed requirements.

Because of widespread disillusionment with large scale irrigation in Africa, many people now put their faith in small scale schemes. Many NGOs, some of which originate in Africa, and others which are branches of expatriate organisations, are now involved in assisting groups of farmers to establish small schemes. FAO have produced a very useful ***NGO Casebook on Smallscale Irrigation in Africa***, edited by Richard Carter, reference number AGL/MISC/15/89, which can be thoroughly recommended to leaders of such irrigation projects. It is available in French and English. It consists of two parts, a consideration of the general issues, and then detailed case studies, with diagrams, of particular schemes, how they were established, and how they fared in operation. One chapter provides the technical background, with suggestions for further reading, for as Carter says, one of the weaknesses of some NGO schemes has been on the technical side. Other difficulties may be outside their control, for example in marketing. It is no good assuming that irrigated farming can succeed everywhere. Carter goes on to discuss the many non-technical issues involved, such as land tenure, farmer associations and cooperatives, marketing, etc. The case studies include both successful and unsuccessful projects, including some that are government promoted.

The full study of the Nyanyadzi scheme described in Paper 90/1b is ***Socio-Economic Parameters in Designing Irrigation Schemes for Smallholders: Nyanyadzi Case Study***, which consists of four reports - OD114: The Effect of Drought on Water Distribution & Farm Incomes on the Nyanyadzi Irrigation Scheme, Zimbabwe, OD115: Net Agricultural Incomes & Plot Size, OD116: Managing Water & Managing Group Activities: Implications for Scheme Design & Organisation, OD117: Summary & Conclusion. These are by Mary Tiffen and collaborators, and are available from ODI or from Hydraulics Research, Wallingford, Oxon OX10 8BA, UK. The first demonstrates the effect of drought not only on incomes but on farm equipment; the second gives details on the variation in incomes by location and by year, and includes the role of livestock; the third discusses farmers' knowledge of water management and their negative attitudes to the possibility that they manage the scheme themselves. The parallel reports by Geoff Pearce are ***Small Irrigation Scheme Design***. This consists of two reports; ***OD97 Distribution of Water Supply***, 1988 and ***OD98 Field Level Water Use***, 1990, both from Hydraulics Research, address as above.

Clark University, International Development Program, 950 Main Street, Worcester MA 01610, USA, in cooperation with the Institute for Development Anthropology, have been carrying out water resource studies in Tunisia. Amongst the reports on irrigation schemes are two impact evaluations, in French, one the *PPI de Garaat Ennaam*, 1986, and one on the *PPI of Bled Debbiche*, 1987, both by Barbara Larson. Both are primarily an analysis of farm management practices and incomes. Both can be recommended for including in the analysis livestock income and rainfed crops. One of the notable differences between small scale irrigation north and south of the Sahara is the importance of irrigated forage crops such as alfalfa and other legumes. It is something that deserves consideration south of the Sahara, since both areas have farmers who also keep livestock, and who need to supplement natural grazing and crop residues if they are to improve the value of their livestock output.

Health

Another guideline which I hope will be useful is on health. PEEM, the Joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control, is producing a new PEEM Guidelines Series. No 1, by Mary Tiffen, is *Guidelines for the Incorporation of Health Safeguards into Irrigation Projects through Intersectoral Cooperation*. It identifies the most important points where those responsible for irrigation need to cooperate with those responsible for health or other social and infrastructural programmes, at the different stages in preparing and operating an irrigation project. It goes on to discuss the special factors associated with new, large project schemes with a resettlement component, small informal irrigation activities, and rehabilitation. It is intentionally brief, since it is meant to be a handbook for busy planners, but it contains an extensive bibliography for those requiring further information. It is available from ODI or from WHO, Geneva.

Extension

Summary Report - Central Tunisia Rural Extension and Outreach sub-Project. This contains a brief but well-illustrated summary, in English and French, of the simple but innovative technology and the effective irrigation extension programme carried out by the Ministry of Agriculture, Tunisia, with Oregon State University, USA. For a copy write to Office of International Research and

Development, Oregon State University, Corvallis, Oregon 97331, USA. Further details of the programme are available in ODI-IIMI Paper 87/3e, M N Shearer, ***Developing Effective Extension Irrigation Programs with Appropriate Technology***, available in English only from ODI.

6 TOPICS FOR THE NEXT ISSUE

This is a Network that aims for an exchange of information. Please let us know what you think should be the main theme of the next African edition, and let us know why you think it important. If possible, send us papers or references to papers which you think should be considered for the theme you recommend. The original should be in either English or French, and preferably, should not be longer than about 20 pages.

Topics that you might like to consider are the role of livestock in irrigation; training for self-management and/or for commercial activities; privatisation of activities currently carried out by state organisations; making more use of groundwater; the role of NGOs. However, we welcome other suggestions.

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IRRIGATION MANAGEMENT NETWORK

VARIABILITY IN WATER SUPPLY, INCOMES & FEES: ILLUSTRATIONS OF VICIOUS CIRCLES FROM SUDAN & ZIMBABWE

Mary Tiffen

ODI/IIMI Irrigation Management Network Paper 90/1b April 1990

Papers in this set

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VARIABILITY IN WATER SUPPLY, INCOMES & FEES: ILLUSTRATIONS OF VICIOUS CIRCLES FROM SUDAN & ZIMBABWE

Dr Mary Tiffen

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Mary Tiffen is Chairman of the Agricultural Administration Unit, Overseas Development Institute, Regent's College, London NW1 4NS. The research on which this paper is based was carried out in association with Hydraulics Research, Wallingford and, in Zimbabwe, Agritex and Ministry of Agriculture, Zimbabwe. In the Sudan there were parallel studies by the Socio-Economic Research Unit of the Sudan Gezira Board, and by the University of Gezira.

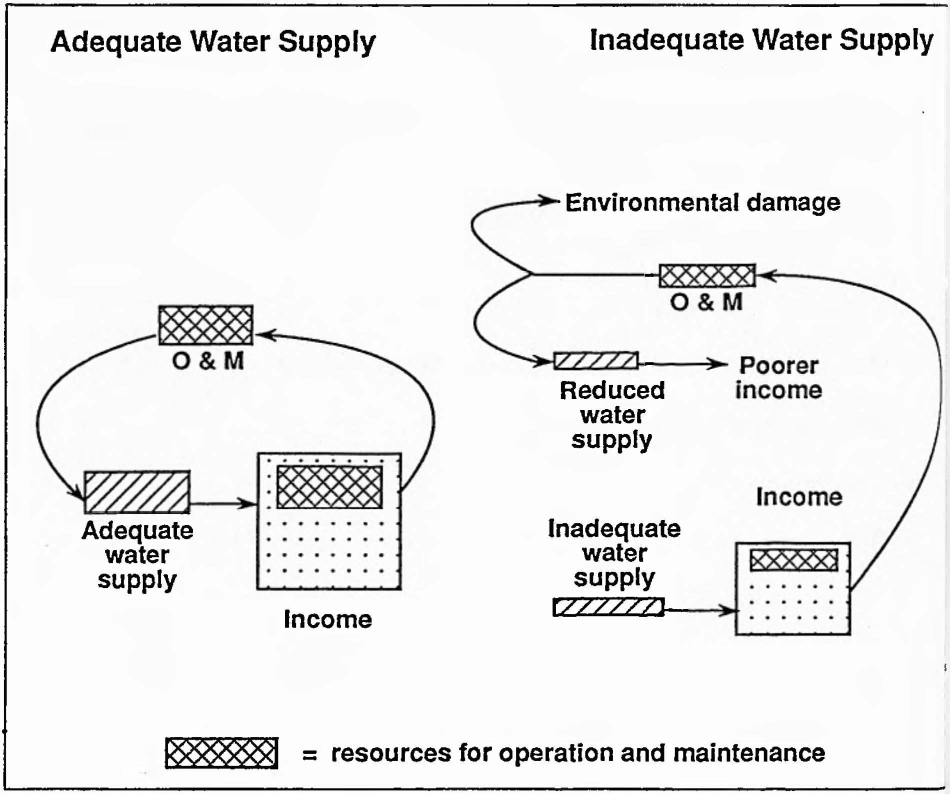

Fig 1 Relationship between water supply, income, and amount available for O & M.

VARIABILITY IN WATER SUPPLY, INCOMES & FEES: ILLUSTRATIONS OF VICIOUS CIRCLES FROM SUDAN & ZIMBABWE

Dr Mary Tiffen

1 THE RELATIONSHIP BETWEEN WATER SUPPLY, INCOMES & MAINTENANCE

This paper looks at the effect of variations in the supply of water on farmers' incomes, drawing upon two case studies in Sudan and Zimbabwe.

When the supply is reduced below crop water requirements, production naturally falls, but incomes fall in an even more drastic fashion. This is because the farmer has usually invested in inputs, (seed, fertiliser, etc) and the first part of any production is required simply to cover these costs. His or her income is derived from the difference between the value of inputs and the value of output. Part of the resultant income is required for the subsistence needs of the family. The surplus meets other needs. One effect of a diminished income is an inability to pay irrigation service fees.

It has frequently been found that the best maintained and operated schemes are those with an autonomous financial structure, where the irrigation service fees are paid to the agency that has the duty of operating and maintaining the supply (Small et al, 1987, 1989). However, if the water supply is variable, farmers may not be able to maintain their payments; in consequence there may be insufficient resources for good maintenance. The long term consequences of this will be the degradation of canals and storage reservoirs, a further reduction in water supplies, still smaller incomes, still more failures to pay irrigation service fees, worse maintenance, poorer water supplies, and eventually, a loss of interest by farmers in the scheme, since it is incapable of generating an attractive income. This is shown diagramatically in Fig 1.

If irrigation service fees are paid to the central treasury, which then provides the Department of Irrigation with revenues for operation and maintenance, the relationship is not so direct. Theoretically, the government could provide adequate revenues for operation and maintenance, subsidising irrigation if necessary out of general taxation. In practice, this situation leads to a lack of interest in collecting irrigation service fees (which are always politically unpopular), competition by other services for general revenues, shortage of revenue in the Irrigation Department (which is then inclined to cut resources for maintenance rather than the number of its staff), bad maintenance, falling incomes, falling or static general taxation, and falling production of export crops. In countries heavily dependent on the irrigated sector, this may lead to a general financial crisis, one aspect of which is usually a shortage of foreign exchange, and an even more acute shortage of those elements in the operations and maintenance budget which require foreign exchange.

The purpose of this paper is to illustrate the very drastic effect of water shortages on incomes and ability to sustain the family and to pay service fees, through two case studies. It argues from this that the first duty of any irrigation authority must be to maintain the capacity of the system to supply water, and secondly, to distribute that water as fairly as possible. The provision of other agricultural services are by comparison of much less importance, since without water most other inputs are useless, and with water to make agricultural production profitable, farmers will make their own efforts to obtain the necessary complementary inputs. It draws attention to the necessity of concentrating resources on effective operation and maintenance, if farm incomes are to be raised to a level where they can meet these costs. Without maintenance, there will not be the increases in production that will provide a country both with the general revenues it needs for social and other services, and access to essential foreign exchange.

2 TYPES OF VARIABILITY IN WATER SUPPLY

Before looking at the two case studies, it is useful to distinguish between two different types of variability in water supply, and to look at the causes of variation. The two main types of variation are variation over time, and variation over the geographic area of the scheme.

Variation over time can be divided into two types; normal or predictable, and erratic and unpredictable. It is normal that there is a seasonal variation in water supply. In some climates, the rains and therefore, the rivers on which an irrigation scheme may depend, are more reliable than in other cases, and supplies are regularly available in certain months. In other cases, the timing and quantity of rainfall is more erratic. It is not always possible to reduce the year to year variation in supply through a large dam and reservoir upstream of the scheme. If there is no reservoir the annual variations in rainfall will be reflected in variations from year to year in the timing and quantity of supplies to the scheme. An unpredictable supply, in an arid climate, may be better than no supply, but, as will be shown in the Zimbabwe case, it means that farmers' incomes are subject to large variation from one year to the next, making it difficult to pay high irrigation service fees on a regular basis.

The second type of variation, variation over the geographic area of the scheme, includes the well known 'top-tail' syndrome, with more water available to farmers at the top end and less to farmers at the tail end. If the supply is variable over time, in years of shortage it is frequently the farmers at the tail who suffer most. However, distribution of water supply across a scheme may be very complex. There may be top-tail variations within the different levels of the scheme, i.e, there are top-tail differences along tertiaries as well as along primaries and secondaries. In some cases, topography and levelling problems may occur in specific areas. In some schemes, canals at the top may have become so silted up that they cannot take their design water and so more water than designed passes on to the tail.

The causes of variation in supply, then, are many. Some variation over time may be due to the nature of the water supply, particularly when we are dealing with a run-of-the-river scheme. It may not be possible to do much about this. However, there are causes which lie within the direct responsibility of irrigation departments or agencies. These include:

* failure to carry out essential maintenance, leading to canals and drains which are clogged with weeds and silt, night storage reservoirs which cannot store the designed quantity, gates which cannot be operated as designed, etc;

* design faults - such as inadequate control and measurement structures, so that the water cannot be

equitably divided; canals wrongly sized for the area they are supposed to command, etc;

* construction faults, so that maintenance is difficult;

* management faults, such as an inadequate scheduling plan, or failure to have an alternative crisis management plan when it is known that shortages occur every few years.

The farmers as a group may share the responsibility for these faults, if they are communally responsible for design, construction, management of scheduling, or maintenance. However, in most large schemes, and some quite small ones in Africa, these matters are the responsibility of the agency. In the two cases that we are going to examine, farmers were only responsible for some maintenance at the lowest level.

3 HAMZA MINOR CANAL, THE GEZIRA SCHEME, SUDAN

The Gezira is one of the oldest irrigation schemes in Africa, established in 1925, and it is still one of the largest[1]. It was originally planned to grow cotton as a commercial crop. The farmers, who had grown sorghum and kept cattle previously under rainfed conditions, were allowed to grow sufficient food and fodder crops for their needs, but in the early days these were not marketable, because of the absence of towns and communications. Because cotton was a new crop, not only to the cultivators but also, in that area, for the management, it was organised in a very top-down fashion. Agricultural operations were the responsibility of the Sudan Plantations Syndicate (SPS), whose successor is the present Sudan Gezira Board (SGB). Research and experimentation was carried out centrally; recommendations were passed to Block Inspectors who, at least initially, had little agricultural training, and

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[1] The best recent reviews of irrigation in the Sudan are Wallach, B, 1988 "Irrigation in Sudan since independence", Geographical Review, 78,4 and D'Silva, BC, 1986 "Sudan's Irrigated Subsector: Issues for policy analysis", ERS Staff Report AGES860811, United States Department of Agriculture, Economic Research Service, Washington DC 20005-4788.

whose task it was to see that the farmers, who were tenants, carried out cotton cultivation according to instructions. This top-down management structure has continued despite the accumulated experience of the farmers. The Block Inspectors also calculate the water requirements of their area, and pass their water indents to the Ministry of Irrigation which is responsible for delivery of water down several primaries (known as Majors) to the heads of the secondary canals, known as Minors. The Sudan Gezira Board is responsible for operating the Minors, but they are maintained by the Ministry of Irrigation.

Originally, as construction was relatively cheap on the clay plains, the scheme was designed on an extensive model. While crop rotations varied, some 40 to 60% was intentionally fallowed, as a method of maintaining fertility and crop hygiene. During the 1960s, after the construction of the Roseires Dam on the Blue Nile, the area of the scheme was almost doubled to 800,000 ha. At the same time, the cropping intensity was raised; the new extension, the Managil, had a planned 100% intensity, while the main Gezira was raised to 75%. Commercial crops now included wheat and groundnuts, while sorghum remained important for local consumption, and as part payment for wages of cotton pickers.

During the 1970s the scheme began to decline, partly due to the age and disrepair of its facilities, but also due to economic management problems at the national level. Plans for a major rehabilitation were put in hand, and are being implemented slowly and with difficulty. The total area cropped was 685,000 ha in 1975, and this had declined to 474,000 ha in 1987-8 (in both cases excluding a relatively small area under vegetables), (derived from Ishag, 1989, Table 3.4).

The original financial basis of the scheme was that the cotton profits should be divided 40% to the tenants, 35% to the government, and 25% for the SPS (Gaitskell, 1959, pg 70-72). These allocations, and the definitions of profits, were changed from time to time, particularly after 1947, when the Tenants' Union was established and became quite a powerful political force. By 1981, the division was 47% to the tenants, 36% to central government, and only 10% to the Board (Ishag, 1989). The World Bank was amongst those who thought that putting the entire burden of water and management costs on the cotton crop alone, together with a 'joint account' system which averaged out costs, distorted economic incentives.

In 1981-2 the system was changed to a charge per hectare, for each crop which is cultivated, varying according to the number of irrigations it is supposed to get. The charge is raised annually in accordance with inflation. It is supposed to cover all necessary costs of operation and management, including both those of the SGB on the agricultural side and the Ministry of Irrigation for water delivery and maintenance. Farmers in addition pay for other services delivered by the SGB, such as fertiliser provision, mechanised ploughing, aerial spraying, etc.

There are prolonged annual negotiations with and between Ministries and involving the Tenants' Union, over the prices for services and for cotton output, which may continue well into the season concerned. Farmers are obliged to accept services without necessarily knowing their cost, nor agreeing that they are necessary. There is much unclarity in all financial accounts, partly because the cotton price and the price of many other services are set by negotiation rather than by the market, and partly because the Sudan has a complicated system whereby inputs and outputs are valued at different foreign exchange rates.

Although water releases to the scheme have increased from 3.6 milliard m^3 in 1962 to 7.3 milliard m^3 in 1988 (Ishag, 1989, pg 52), the supply available in the Minors has been reduced because of failure to keep them clear of silt and weeds. Ishag quotes Fakki as estimating that only 60% of the silt was removed in the mid 1970s. There was an effort to catch up on the back log in the early 1980s, but since then, the position has again worsened. The Earthmoving Corporation of the Ministry of Irrigation suffers from shortage of foreign exchange and other revenues for the operation of its machines.

During 1985-1989 several organisations concentrated on research to understand the problems of the Gezira through detailed investigations by several disciplines along one of the 1498 Minors, Hamza canal. These included water measurements carried out by Hydraulics Research, Wallingford, UK, (HR), and the Ministry of Irrigation, Hydraulics Research Station, Wad Medani. ODI was invited to suggest socio-economic research to complement these, and as a result, three other research programmes were inaugurated. These included a Farm Management Survey, to establish incomes in 1985-6 and 1986-7, carried out by Khairy Ishag of the Socio-Economic Resarch Unit of the Sudan Gezira Board, and a quick attitudinal survey in 1985, carried out by Dr Abdelgadir M Ahmed of the University of Gezira and Dr Mary Tiffen of ODI. (Other parts of the programme, funded in large part by the Ford Foundation, included agronomic and anthropological investigations by the University of Gezira.)

The attitudinal survey proved very useful in concentrating attention on the weeds and silt, for it became quickly apparent that the farmers blamed most of their problems on the condition of the canal (Ahmed & Tiffen, 1986). The hydraulics investigation, which had originally been planned to contribute to the controversy over whether the system of using the Minors for night storage, with irrigation in the day only, should be restored, was expanded to include a survey of the canal bed, which revealed how far it was from its design condition (Francis & El Awad, 1989). (Night storage had been introduced in the 1930s, but had broken down as farmers changed under their own initiative to a method of irrigation involving continuous slow flows.) A quick survey of nine other Minors showed a general siltation problem, and a frequent lack of coincidence between requests for water supply, authorised releases and water received. The general pattern was that oversupply was apparent at the tail of the primaries, but at the level of the secondaries and tertiaries (known as abu ashreens), the more usual pattern of shortages concentrated towards the tail prevailed (Francis et al 1988). These findings confirm an earlier study based on an analysis of cotton yields, which found that at major canal level the highest yields were at the tail (even through this area receives less rainfall than the head), but the usual top-tail decline at the level of the Minors and the abu ashreens (Faki et al, 1984).

The Farm Survey brought out very clearly the effect of the condition of the Minor canal on incomes. Cotton is normally the most profitable crop in the Gezira, provided it can be planted at the optimum time, and receives adequate water subsequently. The first effect of water shortage is that only the tenants at the head of the canal receive enough water to plant their cotton at the correct time and to maintain it; knowing this, tenants lower down put more effort into sorghum and groundnuts, which are planted slightly earlier, and which need less water in total. Ishag made observations on 3 tertiaries which took off respectively from the head, middle and tail of the Minor. He found that those at the head of the first tertiary planted within 5 days of the optimum date; those on the tail of this tertiary planted 15 to 20 days late. In the second tertiary, and at the top of the third tertiary, farmers were planting about 30 days late. At the tail of the third tertiary they were 40 days late. The planting pattern for wheat was similar. The tail end farmers are forced to gamble on sorghum for income. Unfortuately for them, the price of sorghum is very dependent on the amount of rain in the rainfed farming areas of Sudan; when the rains are good, the price is low and irrigated sorghum is not profitable.

The consequences are shown in Table 1, which gives the net farm income for the modal farm which normally has 2 ha cotton, 2 ha wheat and 2 ha of groundnuts or sorghum.

It is interesting to note also the difference between the two years, since this shows the value of a crisis management plan. The Nile, equipped with major dams and reservoirs, is normally reliable, but in 1985 the reservoirs were so low that, on Ministry of Irrigation advice, the SGB ordered farmers not to plant wheat, (late rains in Ethiopia actually provided more water than first expected). Without the wheat rotation, average yields in the Hanza area were better for cotton, groundnuts and sorghum, and with better sorghum prices, incomes were much better in the middle and tail reaches of the canal. In the following year, 1986-7, cotton and wheat were cut from part of the middle reach; the income figures in Table 1 are based on those farmers in this reach who were growing cotton and wheat. It is worth emphasising that Gezira farmers do not have the choice not to grow cotton; they have to plant it unless the SGB cuts it from their rotation, and whatever the state of the crop, they have to pay for the applications of fertiliser and insecticide organised by the Board. Thus, some of them are obliged to make losses. There is no consultation with the farmers concerned. (See Wallach, 1988, for the Board's comprehensive use of its powers in changing rotations and if it considers necessary, reallocating land).

Table 1: Average net return for a modal farm on the Hamza Canal with 6 ha under cultivation, in Sudanese pounds, LS*

	1986-7			1985-6		
	Head	Middle	Tail	Head	Middle	Tail
Cotton	2935	275	-435	830	-440	-640
Wheat	205	-480	37	-	-	-
Groundnuts	419	850	368	917	914	354
Sorghum	-84	-67	-116	690	302	963
Total	3475	578	-102	2467	776	677

Source: Ishag, 1989, Tables 6.1 and 6.2.
+ Applies to only half the farmers on this Abu Ashreen; the remainder were forbidden to grow cotton and wheat.
* US$1 = LS2.5 in 1986 at standard exchange rate

Amongst the farmer's costs, deducted before we arrive at the net return shown in Table 1, are his land and water charge. This was LS 400 for 2 ha of cotton in 1986-7. Total charges for farmers growing 2 ha of cotton, 2 ha of wheat and 1 ha each of groundnuts and sorghum amounted to LS 870. The income figures shown above assume that the farmers paid both this charge and for the other inputs supplied by the Board. In fact, many of them fail to do so and the amount of indebtedness is rising to frightening proportions. The figures shown above show that most farmers in the middle and tail are unable meet the charges, if they wish to retain a minimum income for the subsistence of themselves and their families.

The consequence of indebtedness is further pressure on government revenues and the resources available to the Ministry of Irrigation and the Sudan Gezira Board. This pressure is felt mainly by the Ministry of Irrigation. The SGB is responsible for collecting the land and water charges. It retains the amount needed for its own costs, and hands the remainder over to Government, which is responsible for allocating financial resources to the Ministry of Irrigation. In current circumstances in the Sudan, the Ministry of Irrigation has experienced cuts in its real income. Both bodies are dependent on central government for allocations of foreign exchange for purchase of essential inputs, spares, etc.

Although the income findings relate to only one canal, it is believed they are not untypical. They demonstrate the inter-year variation in incomes, and the geographical variation within the scheme, and the effect this has on the farmers' ability to pay charges and to provide the revenues for maintenance. Without maintenance, farmers have inadequate water to provide them with incomes from which they can pay for maintenance, and this vicious circle has to be broken. The figures also demonstrate the value of a contingency plan which re-allocates water when shortages are foreseen.

Because of the Sudan's precarious economic state, it depends on donors for the financing of the huge rehabilitation programme. Several donors are involved. The elements of the rehabilitation programme executed first seem to depend on the availability of donor funds ear-marked for particular aspects of the project, rather than on an analysis of the main causes of poor performance and a sequential elimination of bottlenecks. Silt removal seems to have a low priority in the eyes of funders. The farmers not only have no say in the choice of crops to grow; they also have no voice in the analysis of defects and the priorities for remedial steps.

4 THE ZIMBABWE CASE-STUDY

The Zimbabwe case study is of a 400 ha run of the river scheme, Nyanyadzi, in a very arid area of the country. It was established in 1935 and expanded from the 1950s onward. Like so many small schemes in Africa, it followed the Gezira model, in that until Independence in 1980 farmers were supposed to follow a set cropping pattern and to follow instructions on input use. However, unlike the Gezira, the management has no financial autonomy;

indeed, the scheme manager has no information on many local costs. Farmers pay a maintenance charge, which is paid into the central treasury. Operations and maintenance are carried out by government staff, paid from the central budget.

The scheme consists of 4 blocks of uneven size, A, B, C and D. The main supply comes from the Nyanyadzi river. Shortages occur frequently in October, a crucial month since the recommended time for planting the main crop, maize, is October 25. Planting often has to be delayed till the onset of rains, which may not occur till late in November. Late planting has an adverse affect on yields. Part of Block A can usually plant early, since it gets the benefit of a supplementary pumped supply from the Odzi river, which normally has water all the year round. Here the main difficulty has been the unreliability of the pumps; recently only one of the six has been working. Block C is at the head as far as the main canal from the Nyanyadzi is concerned; it is a considerable distance from the other Blocks and takes off its supply before major losses have occurred due to seepage from the 11 km unlined main canal.

The study was conducted in two parts by Hydraulics Research (HR), Wallingford, Agritex (the Department of the Ministry of Agriculture, Zimbabwe, which is responsible for small-scale schemes in what are known as the communal lands) and ODI. HR conducted measurements of the water flows over 4 years, 1983-4 to 1987-8 (Pearce & Lewis, 1988). ODI, with Agritex, carried out interviews with a sample of farmers over the 4 blocks, at three points in the crop year 1986-7. We investigated the general household structure, farm incomes and assets, attitudes to scheme management, as well as questioning farmers on their irrigation methods and problems, their planting dates, and the intervals between irrigations. Four reports give full details of the results (Tiffen et al, 1990).

It so happened that 1986-7 proved to be a year of acute shortage. The rains started late, and those not reached by the pumped supply could not plant the summer maize crop at the optimum time. Over most of the scheme water ran short unusually early, and the majority of farmers either did not plant, or failed to harvest, the subsequent normal winter crop of beans. However, Block C, and a small area of Block A, were able to put a proportion of land under the profitable second winter crop, tomatoes. Our measurements were therefore of incomes in a bad year, even worse, according to the farmers, than the previous very bad year, 1983-4. Agritex collects, on an annual basis, information on crop acreages, yields and fertiliser inputs from all farmers. We used this information, together with some of the data taken from our sample, to construct probable incomes in a normal year like 1985-6.

The difference in yields on the main crops between the two years was as follows:

Table 2: Yields by block (tonnes/ha)

	a) Maize		b) Beans	
	1985-6	1986-7	1985-6	1986-7*
Whole scheme	5.38	2.40	1.07	0.52
Block A	5.16	4.12	0.95	0.48
Block B	5.64	1.64	1.05	0.51
Block C	4.46	2.78	1.05	0.48
Block D	6.20	1.20	0.99	0.55

Source: ODI sample survey for maize 1986-7; Agritex census for maize 1985-6 and beans 1985-6 and 1986-7. *The Agritex yield figures relate to those who harvested beans in 1987; in our sample only 25 of the 57 farmers planted beans, and only 6 of these harvested. In the sample, the average yield for those planting was 0.116t; for those harvesting, 0.415t. Because of small numbers, it is not possible to give average Block results for the sample.

The measurements taken by HR showed that Blocks A and C had 50 to 100% more irrigation water than B and D in the summer; however, in normal summers, irrigation water plus rain was enough for B and D and possibly, excessive for A and C. In the bad summer of 1986-7, the total amount of water available to the 4 Blocks was not very different from normal; what was different was the rainfall distribution, with shortages causing late planting and stress at the tasselling period. In the normal winter, A received 1373mm/ha, and C least, with 737mm/ha. In the bad winter, A and C got 550 and 650mm/ha respectively, and B and D only 198 and 155mm/ha. To simplify, this meant most farmers in B and D did not get enough to harvest a winter crop; the farmers who did best in these Blocks were those who did not begin to plant. Farmers in C, who know they depend only on the Nyanyadzi, made a good judgement to plant only part of their farms, mainly to tomatoes. A number of farmers in A, who expect to have the pumped supply, made losses on their winter crops, but they had done better than most Blocks on the summer maize crop, because many of them had been able to make an early start with the pumped supply.

The figures in Table 3 include the value of crops retained for household use. They should be compared with the legal minimum agricultural wage, which was Z$1050 in Zimbabwe in 1986, and with the Poverty Datum Line used by the University of Zimbabwe, which was Z$1680. Nyanyadzi family heads estimated family food costs at Z$1800.

In addition to the variation in water supply and incomes by year, and the significant differences at Block level, we also found evidence of great variation in incomes and water supply within each Block. This was most clearly demonstrated by the distribution of sowing dates for maize within each Block, shown in Table 4. The three variables which in combination had the greatest explanatory power for the differences in maize yields and margins in the summer of 1986-7 were:

- Block (which we took to represent the nature of the Block water supply, since there is no essential difference in soils or other conditions);

- relative planting date (earliness or lateness in relation to other plots in the same Block);

- and fertiliser use.

Of these, the most dominant was Block, but all were significant (Tiffen et al, Report 1).

Table 3: Net irrigated farm incomes, by block, bad year and normal year Z$*

	average plot size	crop income	mainten- ance equipment	overheads depreci- ation, equipment	irrigation charge	net irrigation income
	ha	Z$	Z$	Z$	Z$	Z$
Bad year						
Block A	0.93	924.09	5.42	112.76	134.85	670.88
Block B	0.81	117.57	4.29	72.29	117.45	-76.90
Block C	1.00	811.68	9.05	94.60	145.05	63.02
Block D	1.01	210.17	2.78	51.18	146.45	9.59
Normal year						
Block A	1.12	2029.84	10.84	112.76	162.40	1743.84
Block B	0.92	1600.15	9.80	72.29	133.40	1384.66
Block C	1.07	1957.74	18.10	94.60	155.15	1689.89
Block D	0.97	1620.42	5.56	51.18	140.65	1423.03

Source: Tiffen et al, Report 2, 1989.

Table 4: Distribution of sowing dates within blocks: number of farmers planting in each block by week, summer 1986.

	October				November				December
Week	1	2	3	4	1	2	3	4	1
Whole scheme	1	5	6	6	9	11	8	5	5
Block A	1	3	4	3	2	1	1		
Block B		1	2	2	3	5	4	4	2
Block C					1	5	1	1	1
Block D		1		1	3		2		2

Source: ODI/HR/Agritex Survey, 1986/7. The recommended time of planting is the 4th week of October.

Farmers were asked whether they had been able to plant when they wanted to. It appeared that most farmers in Block C were satisfied with their planting date (these farmers are most likely to grow tomatoes, and may deliberately delay maize planting in order to continue harvesting late tomatoes). In Blocks B and D most farmers reported they had been obliged to plant later than they wished, due to water shortage. Other questions related to the interval between irrigations experienced; the answers to these questions confirmed that there was not only a difference in the average interval at Block level, but also differences in supply within each Block.

Production of the main summer crop, maize, was so low that many farmers were unable to meet family subsistence needs, and certainly could not sell enough to repay credit taken for inputs. The result was that they would have no credit for the next year's inputs.

In addition to this medium term effect, the water shortages have a long term effect. Because the incomes of farmers in B and D had been severely affected by the shortages not only of 1986-7 but also of previous short years such as 1983-4, they had been unable to save and invest in livestock and farm equipment to the same extent as farmers in A and C. Amongst the most important farm equipment are ploughs and carts; amongst livestock, cattle are most important since they supply draught power and manure. Livestock are also important as a source of income and as a profitable investment for savings. Farmers in Blocks A and C owned an average of Z$2,500 to Z$3000 of equipment and livestock. Those in B and D owned only Z$1,500-Z$1,800. We took the possession of a cart as an indicator of adequate capital resources. There was a clear suggestion that those with a cart spent more on productive inputs such as fertiliser, and got higher yields and incomes than those without a cart. In this way, bad water distribution has longterm effects; farmers who cannot make good profits are under-equipped and, because they have to hire equipment, become even less able to make good profits.

One of the objectives of the Zimbabwe government in setting up irrigation schemes in arid areas is to provide employment and income that will limit migration to the towns. There was evidence that where the water supply is unreliable and incomes variable and low, this social objective is not achieved. In Blocks A and C 70% of the farms were male-headed; in Blocks B and D there were clear signs of male out-migration, with only 40% of farms male-headed. Average household size was 10-12 in Blocks A and C; 7-8 in Blocks B and D.

In Nyanyadzi the water supply will never be as reliable as in the Gezira. However, we concluded that there were things that could improve the situation. The basis of scheduling was unsatisfactory, since each farmer was allowed to take what water he needed when it was his turn. This lengthened intervals when there were shortages. It created problems and stresses when the first planters demanded water for their germinating crops, rather than allowing the turn to go to farmers who had not planted. There was no plan for a different scheduling system which could be put into operation in bad seasons, and which would allow each farmer to plant part of his or her farm. There were also problems on maintenance, mainly in relation to the long feeder canal, the night storage dam and the pumps, and there were some design faults. A major problem, in view of the government's need to reduce subsidies, was that the total costs of operation and maintenance were very high, probably amounting to Z$500 per hectare, partly because of the pumps, and partly due to the high staffing costs (over 50 staff for 400 hectares). The clearest way to reduce operating and maintenance costs to a level that the farmers could afford to pay out of their variable incomes, is to remove most of the staff and give the farmers the responsibility for management. At the moment farmers are not in favour of this, partly because they know the scheme is heavily subsidised, and partly because of the difficulties in controlling quarrels in a situation where water shortages cannot be prevented.

5 CONCLUSION

The two cases show how important it is to avoid a supply that is inequitable as between geographic areas, both for welfare reasons, and because it has a clear impact on production and ability to meet the costs of operation and maintenance. It is therefore essential to pay great attention to regular maintenance, and to ensure that the financial structure of irrigation is such that the necessary resources are available for maintenance. This is most likely to be the case in an financially autonomous irrigation agency, dependent upon revenues from the farmers, and sensitive to their incomes and ability to pay. Their ability to pay depends on the agency's ability to provide adequate, regular and equitable water supplies. Where the variable supply is due to the nature of the water resource, it is very important to realise that farmers' incomes will inevitably be lower than would be the case with a more regular supply, that farmers will need to make provision for bad years and will have a reduced ability to invest in essential farm capital, and that, therefore, if they are to meet operations and maintenance costs, the scheme must be designed in such a way that these are kept as low as possible. In small schemes, less than 1000 ha, this probably means they require design for farmer management. In such schemes, not only is it important to have good maintenance, but also, there is a need for a contingency plan to share water fairly in the bad years that are certain to occur.

Finally, the two cases suggest that an interdisciplinary approach to investigation of the causes of poor performance, which includes consultation with the farmers, is the most effective method of research and diagnosis. In both these cases, the analysis of the agricultural production figures on a geographical basis (i.e, by Block, by canal type and top-tail criteria) could delineate the broad areas affected by water shortage. This is to be expected, since cropping patterns and yields are conditioned by water supplies to an important extent. Thus, in Zimbabwe, once the agricultural production figures were broken down on a Block basis, it became clear that tomatoes were only grown in Blocks A and C, a good indication that their winter water supplies were different in nature to those of Blocks B and D. The farmers there have all along declared that one of the major reasons why they opposed the government's increase in the irrigation service fees was because the charge was doubled in 1983-4, a year when they were unable to pay. One of the results of the interviews carried out in 1986-7 was to show that they were willing to pay higher rates, provided the supply was reliable. "If the water is there, the land can stand it" as one farmer said. Thus, consultation with the farmers brings out quickly and clearly the importance of the year to year variation in supply. In the Gezira, the analysis of the cotton production figures (Faki et al, 1984), clearly indicated problems at the tails of the Minor. Consultation with the farmers (Ahmed & Tiffen 1986) brought out clearly the problem of siltation and weeds. Once these broad areas of difficulty are identified, detailed, and more expensive, investigations to define and quantify the nature and causes of the water shortage, to identify other bottlenecks and their interrelationships, and to experiment with remedial measures, can be focused on central rather than peripheral issues.

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THE OPERATION AND MAINTENANCE OF A PILOT REHABILITATED ZONE IN THE OFFICE DU NIGER, MALI

J Jaujay

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THE OPERATION AND MAINTENANCE OF A PILOT REHABILITATED ZONE IN THE OFFICE DU NIGER, MALI

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THE OPERATION AND MAINTENANCE OF A PILOT REHABILITATED ZONE IN THE OFFICE DU NIGER, MALI

J Jaujay

1 OFFICE DU NIGER

The Office du Niger was established to manage a projected large irrigation scheme in 1932, using the Gezira irrigation scheme in Sudan as its model. It implemented and operated a very large gravity system covering some 60,000 hectares in the old interior delta zone of the river Niger. It was originally designed to supply cotton to French mills, but was later redirected towards supplying West Africa with cereals, particularly rice. The Office, serving more than 5000 farming families, rapidly became a powerful administrative body, which used up large sums for investment, equipment and operational costs.

Since 1980, the bad financial results of the Office, which have been coupled with a dramatic decline in farmers' living standards (shown both by a drop in their cash incomes and in falls in their consumption of self-produced cereals, and which has been accompanied by uncertainty over their tenure rights) has driven the Malian government to seek multinational and bilateral financial and technical support for the physical, institutional and financial rehabilitation of the Niger Office.

2 THE RETAIL PROJECT

The Caisse Centrale de Cooperation Economique (French bilateral aid) financed a pilot project during 1986/88, which aimed at verifying the viability of intensified rice production through a pilot scheme, as a stage towards assessing the economic justification for the rehabilitation of the whole scheme.

The objectives of the pilot project were:

i. to improve the living standard and incomes of the families living on Office land;

ii. to increase the production and productivity of irrigated land by intensifying rice production;

iii. to assure the long-term financial stability of the Office by recovering service fees from the farmers.

In the pilot scheme, an area of approximately 1,350 hectares commanded by Retail Primary Canal was rehabilitated at a cost of 2 million FCFA/ha, i.e. US$ 6,700/ha. The physical rehabilitation works were focused upon the control structures, the primary, secondary and tertiary irrigation and drainage networks, and the levelling of field plots.

This was accompanied by intensive agricultural extension work to carry out the agricultural program which comprised a reduction in plot size and the introduction of transplanting and double-cropping. The farmers' share of responsibility was increased through the formation of village groups to undertake threshing, marketing, and to a certain extent, the operation of an agricultural credit fund.

The results of the first year were very encouraging with yields of more than 5 t/ha (tonnes/hectare) in the rainy season against 1.8 to 2 t/ha before the project commenced, and 3.5 t/ha in the dry season, when no crop was cultivated before the project.

3 WATER MANAGEMENT

3.1 Description of the Operation

The technical rehabilitation was designed to keep the main features of the existing system of operation. The upstream regulation of the primary, secondary and tertiary canals was kept. However, a Neyrpic control gate of the type known as "module à masque" was introduced at the head of the tertiary canal for the control of water flow. This module, which delivers 30 to 90 litres/second, is managed by the group of 5 to 10 farmers taking water from the tertiary canal.

Staff of the Irrigation Department of the Office manage the control gates of the primary and secondary canals, keeping to the theoretical irrigation schedule, which was adjusted as far as possible according to demand. Irrigation runs 24 hours a day, 6 days a week.

A careful study of the surface water profiles calculated after plot levelling had been done showed that downstream regulation, that is regulation by demand, was possible and the following operation system was implemented:

8 am Waterman unlocks the padlocks of the modules of the tertiary canals.

Each farmer responsible for the operation of a tertiary canal adjusts the gates of his module in order to achieve the desired flow for the day and the following night.

8.30 am Padlocks of the modules are locked by the waterman who then progressively opens the head gate of the secondary canal to the required flow rate. This is obtained from the total sum of the flow rates of the modules, and the level of the water in the Retail canal, with reference to a simple head - flowrate chart[1].

The gate-keepers responsible for the gates of the Retail Primary then adjust the gate so that the downstream water level remains between a minimum level (indicated by a black mark), and a maximum level (indicated by a red mark).

11 am The water-levels are stabilised and the adjustments completed. From this time on, the waterman must constantly check that the downstream water-level is maintained, and that his canal continues to function properly. He must also watch the flow in the drains.

This system, because it is partially regulated by downstream control, and is within the technical capacity of the staff, ensures farmer satisfaction so long as the water in the primary canal does not fall below the minimum critical level. The system has the additional

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[1] A copy, together with diagrams of the system layout,can be obtained on application to the Irrigation Management Secretary at ODI.

advantages of saving water (which is not in short supply of the present time) and improving the performance of the drainage system by reducing water loss. It will also eventually enable the implementation of a procedure in which charges to the farmer are derived from the amount of water used, based on the total of the daily flow rates passing through the module.

3.2 At Field Level

The watercourse outlets, which occur at 100 m intervals along the length of the tertiary canal, permit the irrigation of 2 hectares, with a discharge rate of 30 1/s. The water-level in the tertiary canal is at least 10 cm above field level. The watercourse provides for both water distribution in the sub-plots (20 x 100 m) and their drainage.

The longest tertiary canals (1200 m) feed 12 outlets. In order to make the implementation of the water rotation easier, the outlets were painted 6 different colours corresponding to each day of the week. This allows one day for the Sunday market in Niono.

However, the water rota, despite the training and extension programme, is rarely respected by the farmers. They tend to help themselves to water as and when they require it.

3.3 Operating Staff

The operation of the network is ensured by:

7 gatekeepers (operating gates on the main Retail canal)

9 watermen (operating outlets on the secondary canals)

These work in two teams from 8 am to 11 pm under the leadership of a manager from the Irrigation Department.

The watermen fill in a daily record sheet, noting the demanded flow rate per distributary canal, and the total amount of water used. They also point out any apparent requirement for repairs in the canals, headworks, and drains to the maintenance team (Appendix, Figure 1.1).

The gatekeepers have a record book where they note, every 30 minutes, the opening of the gates (number of visible teeth on the cog), the difference between the upstream and downstream levels, and the flow rate of the canal according to the chart (Appendix, Figure 1.2).

3.4 Performances, Problems & Perspectives

The modules used offer the possibility of measuring the quantities consumed fairly accurately. The results from the latest seasons gave the following typical figures:

Campaign Consumption	Dry season 1987 (91 ha)	Rainy season 1987 (1350 ha)	Dry season 1988 (250 ha)
Average	13,800 m^3/ha	20,000 m^3/ha	25,000 m^3/ha
Minimum	9,000 m^3/ha	11,000 m^3/ha (1 single user with 20 ha)	16,500 m^3/ha
Resident farmers' average (1)	11,750 m^3/ha	-	-
Non-resident farmers' average (2)	18,000 m^3/ha	-	-

(1) Full time farmer living in a neighbouring village
(2) Part-time farmer (eg, civil servant, merchant) using hired labour

These results should be compared with the consumption levels before the project of 30,000 m^3/ha. The box also illustrates the large wastage of water by non-resident farmers who use more than 50% more than resident farmers. Large savings could be made, at least 30%, by better use of the farmers' own organisation and by respecting the water rota.

It has been decided to set up in the next rainy season a penalty for the groups of farmers who have large over-consumptions of water, as a first step towards a tariff based on water consumption. This has two objectives:

- to save irrigation water. Although water is at present plentiful, it may become limited, particulary in the dry season;

- to relieve the drainage network, which is still grossly overfed by excesses of irrigation water.

Because of the difficulty of implementing the water rota, it is suggested that when the project is extended, a few distributaries should be tested with a discharge rate from the outlets limited to 20 or 10 1/s. This would allow, with a lower flow, better control of the flow, and simultaneous irrigation from several outlets, thereby introducing greater flexibility.

4 SYSTEM MAINTENANCE & SERVICE FEES

Prior to the project there was a period of poor maintenance or total neglect. The project provided the opportunity to establish new procedures which would provide financial resources to ensure that maintenance was carried out.

4.1 Responsibility Sharing

Three levels of maintenance for the irrigation system, drains and roads, were identified:

- Farmer responsibilities - tertiary canal, drain and feeder road (cleaning canals, reinforcing and filling the embankment, filling ruts, etc);

- Niger Office responsibilities - structures, primary canals and drains, and secondary roads (bringing in embankment material, filling and levelling of roads, etc);

- National responsibilities - diversion dam and feeder canal.

4.2 Maintenance Financing

The farmers' maintenance contribution generally takes the form of one working day allocated to maintenance. If the routine maintenance is not done, the Office has the right, after a warning, to get the work done by paid workmen and to charge the cost either to the tertiary canal farmer group, or to the village association into which the groups are federated.

At scheme level the project provided the opportunity to create a Special Maintenance Fund into which is paid 70% of the service fee which the farmers pay in kind. The service fee in the rehabilitated pilot area is 600 kg/ha for the rainy season. This money is kept in an account opened in the bank at Niono, the nearest town. This fund is jointly managed by the Project Manager (an expatriate agronomist) and the Area Manager of the Office. The farmers are already being informed about the budgets and work carried out, and they will eventually be given joint management of this fund. This fund is expected to guarantee the finance for network operation and maintenance. Costs were estimated and established after the completion of the site works, and they must be periodically updated. (The remaining 30% partially covers the costs of the management staff at the zone and in headquarters.)

4.3 Maintenance Work

The following methods have been selected for the present:

(a) **Dyke and embankments**

erosion gullies on the banks, manual maintenance as soon as required

laying laterite, once every 5 years with heavy plant equipment;

(b) **Irrigation and drainage gates and structures**

small concrete repairs, manual maintenance as required;

(c) **Hydromechanical equipment**

lubrication, welding, serviced manually at the beginning of each agricultural season;

(d) **Irrigation canals**

erosion of the embankments, manual maintenance;

removal of the shrubs, bushes and weeds, manual maintenance;

(e) **Internal drains**

manual scything to be started when the flood level is reached (maintenance of the water profile below a critical level, functioning of transmitted flow rates, measurement place and level to be determined);

desilting, once every 3 years using machinery, shovel dredger, and lorry;

(f) **Roads**

Laterite road

- manual filling in of potholes
- reprofiling ditches, by the grader once every 3 years
- occasional work, reprofiling and laying down of laterite once every five years by mechanical means;

Feeder road

- same work but compacted earth used instead of laterite.

Heavy traffic on the rehabilitated irrigation road system was expected, and a resulting rise in cost of maintenance. It would be useful to distinguish, within the maintenance costs of the roads, between, (a) an 'agricultural' cost, and (b) a public service cost.

4.4 Methods & Means of Maintenance

A team of three equipped with an agricultural tractor and trailer carries out routine, preventative or emergency maintenance. From information obtained from the waterman, the team carries out maintenance on structures and gates, fills in eroded sections of the embankments and roads and cleans canals. This is done with the support of an additional paid workforce, recruited from the villages directly involved with the scheme.

It seems to us that a higher standard of maintenance can be achieved by getting farmers, farmer groups and village associations to assist staff in identifying needs for maintenance and in carrying out maintenance.

The graders and bulldozers needed for the heavier work are operated either by private companies or by a decentralised Office service, on the basis of the quotation and unit prices they offer when an order is made. The first maintenance work on the roads was carried out after the 1987 rainy season by the graders of the contractor responsible for the rehabilitation work, using the maintenance fund.

4.5 Maintenance Costs

The first statistical data shows that the irrigation service fee covered most of the normal operation and maintenance costs for staff and materials. It also provided a large reserve to pay for the maintenance work which will be contracted out in due course. The possibility of making the irrigation service fee cover part of the cost of the capital investment is being studied at present.

5 CONCLUSION

The simple, practical measures adopted in the Retail project appear well suited to the technology available within the region. However, it is necessary to monitor carefully the implementation of these pilot measures, before proceeding first with rehabilitation of a larger zone, and then of the whole Office, attempting to avoid all technocratic and/or administrative problems.

However, in our opinion:

1 The quality and continuance of the maintenance operations can only be assured if the present land tenure system is modified. A transformation from the present system, where the farmer is given a seasonal permit to cultivate which can be taken away at any time by Office's staff, to a more efficient one is required, under which ownership can be inherited so as to encourage farmer investment in their own farms;

2 Success in operation and maintenance tasks depends on an proper balance between services offered, work done, and irrigation service fees paid. This requires an annual discussion between the Office and the union of village associations on the budgets and on the provisions to be made for large works.

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Figure 1.1

AN EXAMPLE OF A WATERMAN'S RECORD SHEET

DISTRIBUTARY = N3

Date							
Hour							
N3.1d	60						
N3.2d	60						
N3.3d	60						
N3.4d	60						
N3.5d	60						
N3.6d	60						
N3.1g	60						
Total							
OUTLET STRUCTURE							
Outlet flow							
Upstream level							
Downstream level							
ΔH^2							
Opening							

Figure 1.2

AN EXAMPLE OF A LOCK KEEPERS RECORD SHEET

WORK: ______________________________

Day	Hour	Upstream	Downstream	Headloss	Opening	Flow

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IRRIGATION MANAGEMENT NETWORK

THE DESIGN OF FARMER MANAGED IRRIGATION SYSTEMS: EXPERIENCES FROM ZIMBABWE

J M Makadho

ODI/IIMI Irrigation Management Network Paper 90/1d April 1990

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THE DESIGN OF FARMER MANAGED IRRIGATION SYSTEMS: EXPERIENCES FROM ZIMBABWE

J M Makadho

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This paper was a contribution to the International Workshop 'Design for Sustainable Farmer-Managed Irrigation Schemes in Sub-Saharan Africa', Agricultural University, Wageningen, The Netherlands, 5-8 February 1990.

THE DESIGN OF FARMER MANAGED IRRIGATIONS SYSTEMS: EXPERIENCES FROM ZIMBABWE

J M Makadho

1 SUMMARY

This paper discusses experience with the design of farmer managed irrigation systems in Zimbabwe. In the National Farmers Irrigation Fund (NFIF) programme farmers meet the costs for infield infrastructural development, operation and maintenance. Farmers have participated in various ways in the process of planning, design and implementation of projects. Initially, formal and informal discussions are held through which the farmers' willingness to irrigate is assessed. Farmers are given a chance to express their opinions about the crops they want to irrigate, and the methods of irrigation they prefer. Farmers are also physically involved by providing labour for some activities like fencing, trench digging, pipe laying, refilling trenches, bush clearance and canal construction.

The government, through the Department of Agricultural Technical and Extension Services (Agritex), provides engineers and extension officers who assess irrigation potential and hold discussions with farmers on alternative irrigation methods and cropping patterns. As much effort as possible is put into consultations with farmers to see that the majority agree on the course of action to be implemented.

It has been observed that participation by farmers through discussions shapes the farmers' attitudes and prepares them for the hard work involved in irrigation. Their physical involvement in some of the scheme works has built in them a feeling of belonging and responsibility for the scheme.

Irrigation engineers have, through discussions with farmers worked out design alternatives that suit the farmers' needs and expectations. When the designs are implemented the observations made so far have shown that the farmers respond well to the management procedures introduced. Because of the two way communication between farmers and engineers/extension officers in the process of developing farmer managed irrigation schemes, problems and misunderstanding that affect scheme management are minimised.

2 INTRODUCTION

It is becoming increasingly accepted that small-holder irrigation development, being concerned with people and not just land, water and money, requires a human approach. This human approach, in the context of this paper, refers to maximum farmer involvement in every possible way throughout the planning, design and implementation phases.

Many projects in Zimbabwe have been established with very little prior involvement by the beneficiaries. These projects are managed by a structured government organisation on behalf of the settled small-holders. This approach gives rise to numerous problems that are a result of lack of commitment and responsibilities by the farmers. Farmers look on the irrigation scheme as belonging to government in which case their commitment is very superficial. Lack of farmer participation has been documented as one of the major contributory factors to poor performance (Bagadion 1986, Canewatte 1988, IIMI 1986). Involving farmers is an approach that has been tried in many third world countries and has proved promising and appropriate. Perhaps the question that has to be asked is: "how and when to involve farmers?"

This paper will specifically discuss the following issues under Zimbabwean conditions:

i. activities in which farmers and government can get involved at some stages of the project cycle, i.e. planning, design and implementation;

ii. factors that facilitate the mobilisation of farmers and enhance maximum farmer involvement in developing 'their' project;

iii. some advantages and disadvantages of involving farmers;

iv. the benefits for involving farmers.

3 BACKGROUND INFORMATION ON SMALL-HOLDER IRRIGATION SCHEMES IN ZIMBABWE

Some 74 small-holder schemes were established by government in communal areas between 1912 and 1980. These range in size from 2 to 400 ha. More schemes have been built after independence in 1980 and today small-holder schemes cover about 5,500 ha or 4% of the total irrigated area in Zimbabwe. In 1988 only 54 schemes were operational, i.e. operating all or part of their command area. Various factors have contributed to the non-operational status of the 22 schemes which have been abandoned. These range from non-availability of spare parts for diesel engines, silted dams, the security situation in some parts of the country and general dissatisfaction by the irrigators.

The maintenance charges currently applicable range from Z$145/ha/year for schemes with an assured water supply and growing two crops in one year to Z$30/ha/year in all sand abstraction schemes.[1] An investigation done by government through a study carried out by consultants has shown that in the 1985-86 financial year, total operation and maintenance costs on the small-holder schemes averaged Z$780 per irrigated hectare. Therefore the present irrigation fee of Z$145/ha/year covers 19% of the average operation and maintenance costs. This is indicative of the level of government subsidy requirements in running the small-holder schemes.

Subsidies for investment in irrigation schemes are a one off item which can be increased or decreased depending on availability of government funds. Subsidies of the operation and maintenance (O&M) costs of irrigation schemes are on-going commitments which increase with inflation. Government is committed to increasing the pace of irrigation development on one hand and is also committed to reducing subsidies on the other. Since farmers are not able to pay for all the capital costs for irrigation development, subsidies for scheme investment will continue to be needed. But the costs of O&M cannot be subsidised forever. This highlights the necessity for handing some of the financial responsibilities to the farmers; and this has to cover a greater part if not all the O&M costs. Therefore a funding procedure had to be

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[1]1989: One US dollar is equivalent to 2.25 Zimbabwe dollars.

developed which removes the financial commitment to O&M costs by government.

4 THE NATIONAL FARM IRRIGATION FUND (NFIF)

In view of the high development costs and the inevitable government subsidies to sustain the schemes, a new funding approach was introduced by forming the NFIF in 1985. This is a revolving fund administered by the Agricultural Finance Corporation (AFC). The fund is designed in such a way that farmers have a role to play by meeting part of the capital investment costs and all the O&M costs. The provisions of the fund under small-holder development are as follows:

a. government provides a grant for head works, i.e. from source to field edge under the Irrigation Support Fund (ISF);

b. farmers borrow for infield infrastructural development for new projects from the NFIF;

c. the scheme has got to be financially viable to be eligible for funding under the NFIF;

d. farmers should organise themselves into groups and borrow as a group - individual borrowing is not encouraged;

e. the interest rate for the money borrowed is 9.75% payable over 10 years, (this rate of interest is lower than the usual rate of 13% under normal AFC programmes);

f. the farmers should grow some crops marketed through statutory bodies like the Grain Marketing Board, so that AFC can make a stop order arrangement and recover their money on a regular basis;

g. payment should be effected soon after the first crop, i.e. no grace period is granted for either interest or repayments of capital.

5 EXPERIENCES ENCOUNTERED IN LAUNCHING THE NFIF PROGRAMME

Initially farmers were not keen to embark on the programme. For at least two years no scheme was implemented under the NFIF programme. This could be attributed mainly to the following:

i. irrigation is a new style of life to most communal area farmers. The condition of group borrowing was not popular since many felt they can not trust each other when put in a situation where they owe large sums of money as a group. Group borrowing is a new concept to the farmers. A lot of farmers need some time to organise themselves and fully understand the provisions of the fund because group borrowing could badly affect their families in cases of sudden death, for example;

ii. the majority of existing small-holder schemes have been fully funded by government including more than 80% of the O&M costs. The introduction of the NFIF is contradictory in a way to the precedent already set. It is not easy to convince farmers to borrow money under the NFIF when the existing schemes are fully funded by government grants.

iii. the lack of a grace period and the commitment to grow crops marketed through statutory bodies, are some of the factors that make the fund less attractive on first hearing.

However, despite the above constraints, to date (October 1989) the Irrigation Division of Agritex has planned and designed 22 schemes, 10 of which are fully operational. These are fully operated and managed by the farmers. The Irrigation Division under the NFIF programme is responsible for identifying irrigation potential, planning, designing and implementation of irrigation projects for the small-holder farmers. In view of the experiences encountered in launching the NFIF programme, the Irrigation Division adopted the approach in which farmers participated as much as possible in all activities of developing the project. This approach is described below as follows:

After having identified the water resources and irrigable area in a given district, a series of farmer meetings are arranged to discuss with farmers as openly as possible the identified irrigation potential in their area. The benefits of irrigated agriculture are explained to them. In some cases field trips are arranged to visit existing schemes and let the farmers see for themselves and discuss with other fellow farmers and share experiences.

The provisions of the NFIF programme are explained to the farmers. Cropping programmes and marketing outlets for the produce are determined in consultation with the farmers. If farmers' crop choices are not agronomically feasible in terms of rotations and disease control, further discussions are held to make the farmers appreciate the inappropriateness of their choices.

The hard work involved in irrigation is discussed, for example that it entails at least two crops per year, carrying out the irrigation properly, weeding, maintenance of the infrastructure, operating equipment and managing activities that require communal effort. The levels of financial and labour requirements are mentioned in general.

After several meetings with farmers to discuss the above aspects, they are given time to digest and discuss among themselves.

Further meetings are then scheduled to assess the genuine interest and commitment by the farmers. Farmers, with the assistance from extension staff, draft a constitution and bye-laws that would guide the members in handling the day-to-day affairs of the project. An irrigation management committee is formed, members of which are voted in by the farmers. This committee will be a representative body for the farmers. The major positions are: Chairperson, Secretary and Treasurer. All the bye-laws and disciplinary measures will be enforced by the Committee. The willing farmers show their commitment and acceptance by putting their signatures on paper.

Once the farmers have committed themselves the engineers from the Irrigation Division start on the topo-surveys and detailed soil survey and analysis. Detailed designs for infield works with bill of quantities for alternative irrigation systems are prepared. The alternative designs are explained to the farmers, i.e. the advantages and disadvantages of each in terms of method of operation, capital cost (which farmers have to borrow under the NFIF programme), replacement costs, operational costs and management requirements. The alternative designs usually include drag-hose, semi-portable sprinkler system and where possible a surface irrigation option. Designs are made in such a way that they accommodate the farmers expectations as much as possible. For example, with a cooperative approach irrigation takes place in a block system whereby all sprinklers are located in one block of land at a time. Although this increases the number of lateral lines or hydrants in comparison with the drag-hose and semi-portable systems it allows the farmer to irrigate one crop efficiently. With individual plots under a sprinkler drag-hose system each farmer has his/her own equipment for which he/she is responsible. Each plot receives the same volume of water regardless of its location within the irrigated area. With surface options farmers have the choice of one individual plot for all crops along one field canal or having one crop grown together with other farmers along one field canal - in a block farm - but still maintaining small individual plots.

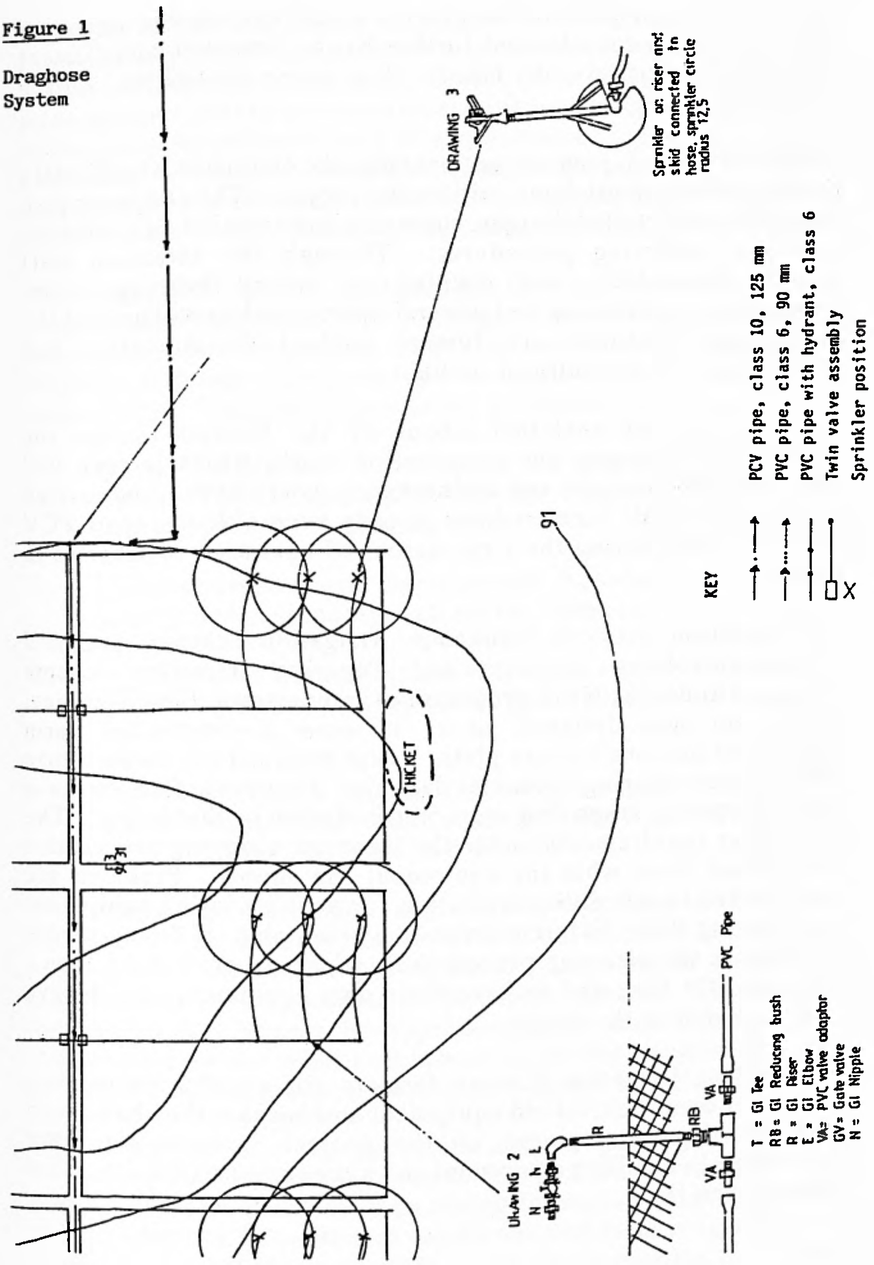
The reasons for choosing a particular design alternative by farmers can be many and include capital and operation costs, previous experience with certain system of irrigation, whether equipment is shared or not. The drag hose system is very popular with most farmers because they prefer to own and use their own equipment in the field without sharing. It should be emphasised that in both cases, the systems are locally manufactured in Zimbabwe, although they use imported materials. In the drag-hose system, the main pipeline and the distributaries are buried pvc pipe. The farmer connects his own sprinklers to the risers with his own flexible pvc hose, which he can drag to other positions in order to water his whole plot. The infield costs of this system, illustrated in Figure 1, are Z$2,000-3,000 per ha (about US$900 to $1,300 per ha). The semi-portable system has aluminium piping and has 3 sprinklers attached. It can be moved, in cooperation with others. It would cost Z$4,000-5,000 per ha if each farmer was provided with his own equipment, so sharing is advisable to reduce the cost.

When the most appropriate design is finally chosen by the farmers, their physical involvement is called upon. They provide labour for fencing the scheme and bush clearance. They dig trenches for piping if need be and provide labour for canal construction.

The discussions with the farmers are important for shaping their attitudes through which they develop a feeling of ownership for the project. Because farmers will have contributed by giving their opinion in the process of developing the irrigation they feel they

Figure 1

Draghose System



are an important part of the process of developing the irrigation scheme. This is consolidated further by the financial commitment and the provision of labour for some activities during implementation.

On the other hand, government provides the engineers who identify the irrigation potential and initiate the project. The engineers plan the project to detailed designs, supervise construction and make the necessary tendering procedures. Through the extension staff farmers get advice and training on record keeping, water management, agronomy and general operational procedures of the equipment. Farmers are further advised on marketing and procurement of agricultural inputs.

The provision of unskilled labour by the farmers teaches the farmers how to carry out construction works which in turn will help them when repair and maintenance works have to be carried out. For example farmers have already been able to repair PCV and A/C pipes during the first seasons of operation in schemes in Mutoko.

A comparison between Insukamini Irrigation Scheme (designed without involving farmers) and Tagarika Irrigation scheme (designed under the NFIF programme) demonstrates the difference. Insukamini was designed as if it were a commercial farm subdivided into one hectare plots. It was designed for monoculture with farmers sharing sprinkler laterals. However, farmers have started growing crops that were not included in the design. The crop water requirements under the 'farmers' cropping programme is different from what the equipment can supply. Problems are encountered in scheduling irrigation for people sharing equipment and growing three different crops in a given plot. If farmers were involved in the planning process their wishes to grow more than one crop at a time and to have their own equipment would have been included in the design.

At Tagarika Irrigation Scheme farmers are growing crops they want, they own their infield equipment and because they have been party to the development of the project farmers are more responsible in handling equipment and more responsive to extension advice given them.

When the scheme is finally implemented farmers are trained in running the pump house, irrigation cycles and scheduling. During the first season efforts are made to visit the scheme on a daily basis by extension staff; to give technical advice on irrigation, agronomy and organizational issues such as acquisition of inputs and disposal of produce to market. The yields obtained during the first year of operation are encouraging: maize up to 8 tonnes/ha, potatoes up to 20 tonnes/ha, onion 30 tonnes/ha, cabbage 40 tonnes/ha.

The farmer participatory approach has been applied at 22 different schemes involving some 484 families. Ten of the schemes have been constructed in which some 240 families are engaged in irrigated farming. The observations made in these schemes are encouraging. These are given below as follows:

i. the level of farmer commitment and responsibility is fairly high. This is evidenced by the fact that none of the irrigators have outstanding debts;

ii. all the equipment and infrastructure have been operated and maintained reasonably well by the farmers;

iii. farmers have been able to make minor repairs on their own on broken pipes, leaking canals and hydrants.

6 FACTORS THAT FACILITATE THE MOBILISATION OF FARMERS AND ENHANCE MAXIMUM PARTICIPATION IN DEVELOPING THEIR PROJECT

The foregoing discussion has highlighted that a two way communication between farmers and government professional officers is an important prerequisite. The farmers have to be convinced of the importance of their participation. This was put forward to the farmers by expressing their importance of their involvement so that what ever scheme is finally implemented they understand and appreciate why certain decisions were taken.

The irrigators have to get motivated to participate and the incentives for participation have to be visible, tangible and achievable. This is achieved by taking farmers to existing schemes to appreciate the benefits that can be accrued from irrigation. The Department provides transport to and from the existing scheme but it does not supervise the visit. The visiting farmers are left here for a week by themselves, so that they have plenty of time for observation and discussion with the host farmers. After their return home they are left to talk with their colleagues for a week or ten days, before the Department staff return to continue the dialogue. After seeing what other farmers can do and achieve, the farmers in the new project got motivated and gained confidence in their new venture.

Problems emerge where close integration of technical, and institutional activities is lacking. The irrigation system should be developed simultaneously with the management capabilities and organisational skills among the irrigators. Farmer involvement in the planning, design and construction activities enhances the farmers' understanding of how the scheme would operate. Furthermore, farmer participation in making decisions and carrying out certain tasks is the basis for building group solidarity and imparting technical and social skills that will make the group activities effective in the long run.

Farmers can be easily motivated by looking forward to some benefits in various forms that can be obtained from the project. Motivation of government personnel is a neglected issue. Government personnel should be motivated enough to be wholeheartedly committed in promoting farmer participation. The question is: "how can government personnel be made accountable for effective farmer involvement, and what incentives are available for government personnel?" This is an area where government can play a significant role.

7 CONCLUSION

Government has started on the right course of action through which grants and subsidies are reduced by placing financial responsibility into the hands of farmers. The question is: "can the farmers sustain the system when wholly handed over to them, and what does the future hold for these newly developed farmer managed irrigation systems?" This is only the beginning, all the parties concerned are still in a learning situation and what has transpired so far is promising and encouraging. A monitoring and evaluation programme to look into these schemes as they grow has been set up. The observations of the Monitoring and Evaluation unit will generate information that will be useful in developing future schemes. Problems and constraints that affect farrmer managed systems will be highlighted and their causes identified. The good aspects of the systems that should be maintained and replicated in other locations will be noted.

Already, we can make certain observations from the Zimbabwean case which are worth highlighting:

i. organising people is not easy because the process, in this Zimbabwean case, involves changing the peoples' culture, habits and values. Irrigation is a new style of life which seeks to evolve people's lives from subsistence agriculture to cash-cropping. This calls for maximum commitment from all parties concerned. Farmer participation does not involve only physical work, it also has a lot to do with the psychology of the farmers, their attitudes, and level of motivation. A high level of motivation is required;

ii. the cooperative approach to design and management, which involves sharing equipment has not proved popular in the NFIF programme. Farmers prefer individual responsibility for using and replacing infield equipment. The accountability inherent in the drag-hose system, designed so that sharing of infield equipment is eliminated, encourages farmers to use equipment more carefully. This can only be decided by the farmers themselves after discussing alternative designs with them;

iii. on schemes that have been implemented so far, there is some evidence to show that farmer participation through the provision of information on their needs and expectations enables the designer to do the following:

a. produce a design that can accommodate the farmers needs and requirements in terms of crops, ownership of equipment, labour availability, operational procedures such as irrigating at night, etc;

b. produce a design that when finally put on the ground can be operated and maintained by farmers with minimum supervision.

These are some of the contributory factors to management problems and poor scheme performance if they are not clarified with the farmers during the planning and design stages.

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IRRIGATION SERVICE FEES IN ASIA

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IRRIGATION SERVICE FEES IN ASIA

Leslie E Small

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IRRIGATION SERVICE FEES IN ASIA

Leslie E Small

In 1985 IIMI conducted a Regional Study on Irrigation Service Fees with support from a Technical Assistance Grant from the Asian Development Bank (ADB). The primary objectives of the study were (1) to develop a conceptual framework for evaluating irrigation financing policies, and (2) to review the procedures and rationale for irrigation financing mechanisms in five Asian countries: Indonesia, Korea, Nepal, the Philippines and Thailand. The study also included a literature review of conditions in other parts of the region. Emphasis was placed on examining mechanisms for financing recurrent expenses of operation and maintenance (O&M), and their relationship to the quality of irrigation performance. The study was discussed at a Regional Seminar in Manila, in July 1986.

1 GENERAL CONCLUSIONS

A. Irrigation services can be financed by a wide variety of mechanisms: water pricing, based on demand determined consumption; irrigation service fees assessed with reference to irrigated area; general taxes levied without specific reference to irrigation services; implicit taxation through control over prices of inputs and regulation of the market sector; and supplemental income to an irrigation agency through other revenue generating activities.

B. Mobilising resources through irrigation service fees and other mechanisms involving direct or indirect payments by water users or other beneficiaries is not an end in itself, but is only important:

Table 1: Summary of Potential Consequences of Irrigation Financing Mechanisms in Relation to Financing Objectives

Financing Objectives	Institutional Context and Financing Mechanisms						
	Financial Autonomy: Funds controlled by irrigation agency			Financial Dependence: Funds controlled by non-irrigation agency; irrigation agency financially dependent on government budget allocation			
	Irrigation Service Fees	Water Prices	Secondary Income	Irrigation Service Fees	Water Prices	Taxes	Implicit Taxation
1. Improve Irrigation Performance							
a. More efficient operation of irrigation facilities							
- improve funding of O&M	yes	yes	yes	no	no	no	no
- improve managerial and financial accountability	yes	yes	no	no	no	no	no
- improve involvement of water users	yes	yes	no	no	no	no	no
b. More efficient utilisation of water	no	yes	no	no	yes	no	no
2 Improve Irrigation Investment Decisions	?	?	no	no	no	no	no
3 Improve Fiscal Position of	yes	yes	?	yes	yes	yes	yes
4 More equitable income distribution	?	?	?	?	?	?	?

first, in so far as it results in improved irrigation performance through:

(a) more efficient O&M of irrigation facilities (by improving O&M funding; by improving the accountability of irrigation managers to water users; and by encouraging greater cooperation and involvement of water users in O&M);

(b) more efficient use of water by farmers; and

second, in so much as it promotes other objectives of government by:

(a) leading to better investment decisions;

(b) easing the government's fiscal burden;

(c) resulting in a more equitable distribution of income.

The effects of alternative resource mobilisation mechanisms in relation to various government objectives are summarised in Table 1.

C. The effects of irrigation service fees on irrigation performance and on investment decisions depends on the institutional framework of the irrigation agency. In particular, it depends on whether the agency has a significant degree of financial autonomy or is centrally financed by the government (see Table 1). The key elements of financial autonomy are (a) that the irrigation agency must rely on user charges for a significant portion of the resources used for O&M, and (b) that the agency have expenditure control over the use of the funds generated from these charges.

D. Financial autonomy is the more appropriate institutional framework to obtain improvements in irrigation performance. The fact that the autonomous agency must be able to collect direct payments for irrigation services is likely to lead to greater involvement of farmers in decisions regarding actual expenditures on O&M, including staffing levels. Furthermore, if farmers are expected to repay some capital costs, then there is a rationale for increasing their involvement in decision-making processes during planning and construction as well as in regular operation and maintenance.

E. Irrigation agencies with a significant degree of financial autonomy are often able to reduce the amount of direct payment required from farmers through institutional arrangements whereby the agencies earn secondary income from sources other than charges on water users. Types of secondary income include interest on deposits, rental of assets owned by the irrigation agency, sale of water for non-agricultural purposes, and the sale of fishing rights in reservoirs.

F. The impact of irrigation service fees and other resource mobilisation measures on the government's fiscal burden and on the equity of income distribution depends on, and is generally dwarfed by, the effects of other agricultural sector policies (such as fertilizer subsidies, rice price controls and trade restrictions) designed to promote broad social objectives such as regional development, employment creation, rural-urban income parity and food self-sufficiency.

G. Pricing water deliveries to individual farmers is likely to be prohibitively expensive in most gravity systems serving large numbers of small farms. The cost is not merely in terms of measurement of flows, itself a difficult task, but in the administration, reporting, billing and collection procedures. Pricing is only likely to be effective if groups of farmers, say at the tertiary level, can be served with a single bill.

H. In the absence of a water-pricing mechanism, the argument that user charges for water will increase the efficiency of water use by the farmers loses most of its validity. Even if water pricing were possible, its benefit in terms of increased water use efficiency by farmers would be much less than is sometimes suggested. Much of the current 'wastage' of water can be attributed to poor supply control rather than excessive demand in the absence of water prices. But effective supply control is a prerequisite for a system of water pricing. It is likely that once this prerequisite exists, the amount of 'wastage' will be greatly reduced, thus lowering the potential efficiency gains from any subsequent attempt to introduce water pricing.

I. Indirect benefits of irrigation are often quite large, and in some cases may even exceed the direct benefits. Although it is rare to find cases where indirect beneficiaries are directly assessed, they may be subject to indirect taxes that go to the central government.

2 COMPARATIVE EXPERIENCES IN ASIA

2.1 Pricing Policies

Within the five countries studied there are wide variations in policies and approaches towards mobilising resources to finance irrigation services. Financial autonomy is found in Korea with decentralised Farmland Improvement Associations[1], and in the Philippines with a centralised National Irrigation Administration. Decentralised financial autonomy is also found in the tertiary portions of systems in Indonesia, while financial dependence prevails at the main system level. The national irrigation agencies in Nepal and Thailand are also financially dependent on funds allocated by the central government.

In Korea, Nepal and the Philippines, and at the tertiary level in Indonesia, resources are mobilised from the water users through irrigation service fees. Fees are also being imposed in a few areas in Thailand that have undergone land consolidation. In all cases, these fees are assessed at a flat rate per hectare of irrigated land, but with some adjustments possible according to season and crop type. Because of the decentralised nature of the irrigation associations in Korea and at the tertiary levels in Indonesia, the rate per hectare in these countries can vary both within and among associations. By contrast, the centralised approach to the assessment of fees used in Nepal and the Philippines results in much greater uniformity of fees in these countries.

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1 See ODI Network Paper 12d: K S Park, 'Institutional Aspects of Operation and Maintenance in Korea', November 1985.

Table 2: Estimated Benefit Recovery Rations Under Alternative Financing Policies (%)[2]

Country	Actual	Actual Modified to Set Irrigation Service Fees Equal to O&M	Actual Modified to Set Irrigation Service Fees Equal to O&M plus Full Recovery of Capital Costs	
			Moderate Capital Cost	High Capital Cost
Indonesia				
low estimate[3]	8	10	56	114
high estimate	21	27	154	313
Korea[4]				
low estimate	26 (54)	27 (58)	141 (297)	203 (429)
high estimate	33 (70)	36 (75)	183 (387)	264 (557)
Nepal	5	10	74	122
Philippines	10	7	43	98
Thailand[5]	9 (30)	31 (53)	155 (176)	279 (300)

[2] A benefit recovery ratio is the ratio of all increases in direct and indirect famer payments for irrigation services to the incremental net farm income resulting from irrigation.

[3] Low and high estimates result from alternative estimates of the net benefits of irrigation.

[4] Figures in parenthese represent the estimated benefit recovery ratios that would prevail if domestic prices of paddy were allowed to drop to a level consistent with 1983 world prices (estimated to be 239 won/kg paddy), while all other prices and input amounts remained constant.

[5] Figures in parentheses represent the values that would apply if the implicit tax on the farmgate price of paddy were 22%, as estimated for the late 1970s in World Bank, 'Thailand: Case Study of Agricultural Input and Output Pricing', Staff Working Paper No 385, 1980, p 50.

In addition to mobilising resources directly from the water users, the financially autonomous irrigation agencies in Indonesia, Korea and the Philippines also rely on secondary income as an important source of funding for irrigation services. In Korea the irrigation associations derive an average of 25% of their income from secondary revenue. In the Philippines secondary income is as much as 60% of actual O&M expenses; however, much of this is tied to the construction activities of the irrigation agency. The financially dependent irrigation agencies in Indonesia, Nepal and Thailand have no significant secondary income.

Other mechanisms to mobilise resources are also found in Indonesia, Nepal and Thailand. Taxation, in the form of a land tax, is used in both Indonesia and Nepal. Thailand relies on indirect taxation, primarily through the depressed price of rice resulting from its structure of rice export levies.

If irrigation service is satisfactory, then the benefits derived by farmers are more than adequate to cover O&M costs in all of the five countries, but they cannot cover more than a small portion of the capital investment (Table 2). In Korea there is a specifically defined portion of the fee set aside for capital recovery, even though total fees assessed and collected may not cover the full cost of O&M. In the other countries no separation of the fee is made.

2.2 Fee Collection

Korea obtains the highest rate of fee collection, over 98%, in part because great importance is attached by agency staff to meeting the 100% target. Considerable efforts are made in administering the fee collection process. In the Philippines, where the National Irrigation Administration has switched from a financially dependent to financial autonomous body only in the past few years, increased importance is now also being attached to fee administration and collection. Reflecting this change, collection rates have increased somewhat from past years, and are now about 60% of the amounts assessed. In contrast, Nepal collects only an estimated 20% of fees due. This reflects the lack of importance of fee collection to the irrigation agency, which is dependent on the central government for its entire budget.

In Korea and Nepal irrigation fees are assessed in cash, although in Korea the maximum amounts which can be charged are established in terms of paddy. In the Philippines the fees are assessed in terms of paddy but can be paid in cash based on the official price. In Indonesia water user associations have both cash and in-kind contributions. The primary advantage of a crop-based assessment is that there is a built-in adjustment for inflation: if crop prices rise, or are increased by central government, the agency is able to increase its revenues without facing the political pressures associated with requesting an increase in fees.

The relationship between actual O&M costs and the rate set for irrigation service fees varies greatly among the five countries (Table 3). Only in the Philippines is the rate set higher than actual O&M costs; however, because collections are only about 60% the revenues actually collected are considerably less than total O&M costs.

2.3 Cost Reduction

Although there is a tendency for agencies to try to raise fees if income falls below expenditure, there are also some efforts made in all countries to reduce costs. These may be dictated by central government, as is the case in Indonesia, Nepal and Thailand, because requests for annual appropriations are not fully met during budget allocations. In the Philippines the irrigation agency both prepares budgets and funds them. With lower than desired fee collection rates, secondary income has become a crucial source of financing O&M. Still, funds are limited, and efforts have been made to cut costs by reducing staffing levels. In Korea the decentralised water user associations generally earn adequate revenue to support O&M; however, the resulting levels of irrigation fees are quite high, and the associations' expenditure budgets are subject to strict government control.

3 DISCUSSIONS AT THE REGIONAL SEMINAR ON IRRIGATION SERVICE FEES

A Regional Seminar on Irrigation Service Fees, jointly sponsored by the Asian Development Bank (ADB) and IIMI, was held in Manila from 21-25 July 1986. Participants included 25 representatives from 13 of the Developing Member Countries (DMCs) of the ADB, one observer each from the World Bank, the FAO and the United

Table 3: Estimates of Average Operation & Maintenance Costs, and of Revenues Collected by Irrigation Organisations in Five Asian Countries

		Indonesia	Korea	Nepal	Philippines	Thailand
1	O&M Costs ($/ha)	22	211	10	14	27
2	Irrigation Service Fees Assessed					
(a)	Amount per ha ($)	[6]	196	6	17	0
(b)	% of O&M Costs	[6]	93	60	121	0
3	Approximate % of Fees which are collected	[6]	98	20	62	-
4	Revenues Collected from Irrigation Service Fees					
(a)	Amount per ha ($)	15	192	1	10	0
(b)	% of O&M Costs	68	91	10	75	0
5	Revenues from Secondary Income ($ per ha)	[6]	59	0	36[7]	0
6	Total Revenues					
(a)	Amount ($ per ha)	15	251	1	46[7]	0
(b)	% of O&M Costs	68	119	10	329	0

[6] Information not available.

[7] Includes $28 of interest and management fees derived from and mostl utilised for construction activities.

States Agency for International Development, three researchers from IIMI and 10 Bank staff. The primary purpose of the Seminar was to examine how national policies for internally generating funds for irrigation operation and maintenance (O&M) could help the DMCs achieve more cost-effective O&M of irrigation systems. The seminar discussions were organised around key findings of the IIMI study on Irrigation Service Fees described above. Country papers were presented from each of the DMCs.

As has been shown, a key conclusion of the IIMI report was that the potential effects on irrigation performance of a system of irrigation service fees depended on whether the irrigation agency possessed a significant degree of financial autonomy, or whether it was financed by the government. The Country Papers presented at the Seminar indicated that agencies operating with partial financial autonomy exist in Fiji (for drainage projects), the Republic of Korea, the People's Republic of China[8], the Philippines and Vietnam. Elements of financial autonomy are found in Water Users' Organisations at the tertiary level in Indonesia, in agencies responsible for lift irrigation in Karnataka in India, and in some irrigation projects in Sri Lanka. On the other hand, irrigation agencies operating within the context of central financing are found in Bangladesh, Fiji, Indonesia, Malaysia, Nepal, Pakistan, Sri Lanka and Thailand. In general, participants from countries where central financing prevails felt that administrative considerations would preclude any move toward financial autonomy. Some participants from these countries also expressed reservations about the desirability of financial autonomy. They were concerned that financially autonomous agencies, responding to user pressures to limit O&M costs, might fail to properly maintain the infrastructure of the main irrigation system.

The IIMI study concluded that in situations where the irrigation systems were functioning satisfactorily, farmers could pay for the full O&M costs from their incremental income. Although the Seminar participants were in favour of recovering O&M costs from the farmer, they emphasised the need to monitor the magnitude of the benefits received by the farmers. Some participants felt that it

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[8] See ODI-IIMI Irrigation Management Network Paper 86/3b, Xu Guohua, 'The Irrigation Water Charge in China', November 1986.

was unlikely that the benefits would be great enough to permit the farmers to cover the full cost of O&M in the near future, and that some additional funds from the government budget would be necessary.

The IIMI study suggested that one approach to increasing the accountability of irrigation managers to water users would be to decentralise the administration of irrigation projects. One specific approach suggested is that of the bulk sale or 'wholesaling' of water to decentralised Water Users Organisations (WUOs) which would then be responsible for the subsequent distribution and 'retailing' of the water to individual farmers. Information from the Country Papers and from the Seminar discussions indicates that WUOs of various types exist in many of the DMCs, although their specific responsibilities and authority vary greatly. Arrangements for the bulk sale of water exist in the People's Republic of China and in Vietnam.

All but two of the countries represented at the Seminar use some form of irrigation service fees to mobilise resources for operation and maintenance of irrigation systems directly from the farmers who benefit from the projects. In nearly all cases the fee is an area-based charge, although there is considerable variation among the countries with respect to the details of how the fees are computed. Assessment and collection procedures also differ among countries. There are very few cases of fees based on water pricing. Thus the fees are generally used to recover the costs of irrigation services from farmers, but not as a means of allocating water.

Note: Previous Network papers on this subject were:

10f 'Introduction to Discussion on Water Rates'
11e **M Tiffen** (ed), 'Cost Recovery and Water Tariffs: A Discussion'

86/1c **I Carruthers**, 'Irrigation Pricing and Management'

86/2b **M Svendsen**, 'Meeting Irrigation System Recurrent Cost Obligations'

These are still available at ODI.

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IRRIGATION MANAGEMENT NETWORK

DESIGNS FOR SUSTAINABLE FARMER-MANAGED IRRIGATION SCHEMES IN SUB-SAHARAN AFRICA

J J Speelman

ODI/IIMI Irrigation Management Network Paper 90/1f April 1990

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90/1a: Newsletter
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DESIGN FOR SUSTAINABLE FARMER-MANAGED IRRIGATION SCHEMES IN SUB-SAHARAN AFRICA

a compilation of results of recent international meetings

compiled by J J Speelman

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DESIGN FOR SUSTAINABLE FARMER-MANAGED IRRIGATION SCHEMES SUB-SAHARAN AFRICA

a compilation of results of recent international meetings

compiled by J J Speelman

(Footnotes by Mary Tiffen)

1 INTRODUCTION

This paper gives a concise overview of the findings of seven recent international meetings on irrigation in sub-Saharan Africa. Their proceedings and publications are listed in the bibliography. Given the widespread decline in per capita food production in Africa, all the meetings unanimously assigned important roles to irrigation development[1]. However, they all stressed the need to learn from past failures. The common objective of these meetings was to identify various features of irrigation development and irrigation technology that are likely to be most appropriate to regional needs in the future. Most of the discussions contained the message that irrigation schemes should be regarded as socio-technical systems where neither social nor technical aspects can take automatic priority. Furthermore, efforts were made to identify the key areas of interface between both domains.

This paper also summarises some implications for irrigation design that resulted from these meetings.

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[1] *As the meetings were attended by those with a professional interest in irrigation development, this is not surprising. There is a need, perhaps, for governments to take a harder look at the circumstances in which they could achieve their objectives of increased food production or export-orientated production through the development of rainfed agriculture, through the encouragement of traditional forms of water management in low-lying areas and swamps, or of water harvesting in arid areas.*

2 THE KEY ISSUES ADDRESSED AND THEIR RELEVANCE TO THE PRESENT WORKSHOP

In all these meetings there seemed to be a consensus on some of the major drawbacks of irrigation projects and the future challenges they face.

2.1 Policy, Planning and Donor Roles

It was repeatedly stated that the process of systematic irrigation planning and policy formulation has not yet started in many sub-Saharan countries. Irrigation planning requires knowledge on numerous physical, economic and social variables and on their interrelations. It also requires that priorities be set for national and community objectives which change in time, and this makes it essential to have feedback to policy and planning levels. A need was identified for clear objectives, clearly formulated agricultural policies framed in the national and regional context, the development of project-planning and implementation capacity, and training and research addressing both the physical and the social conditions for development.

Supportive and complementary actions from international donors are needed to contribute to project sustainability, for example, by technical assistance in training, and with management and administration of irrigation development activities, long-term financial commitments and short-term acceptance of recurrent cost deficits. The local, national and international information base needs improvement from a systematic feedback from past experiences.

These issues should influence the broad strategies for irrigation development. 'Modern' capital-intensive irrigation within Africa is seen as the least cost-effective option. Furthermore, it creates a series of potential conflicts of interest between users and irrigation agencies. For countries without substantial irrigation experience it seems more remunerative to learn from small-scale developments. However, small-scale development does not guarantee better performance than large-scale, if similarly conceptualised. Irrigation should be based on a concept that initiates a development process rather than that plans a development action. Moreover, in the documents studied there is a general agreement about the need to include more than a one-sided consideration of the Economic Internal Rate of Return[2] in irrigation planning by giving greater weight to human and social advantages or disadvantages of specific options.

The above clearly indicates the need for approaches to irrigation design that take different socio-economic and socio-political factors into consideration. What remains unaddressed in the reports under review is the fact that the objectives of national governments and donors often prevail over those of future users in irrigation planning. Therefore, external biases characterise the role that designers often unintentionally and almost always unwittingly play.

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[2] *As an initiator of the discussion on the role of the EIRR, I have been surprised by the way the debate has developed in the irrigation community in Africa. The research upon which my papers were based showed that it is extremely important for the sustainability of irrigation schemes that designers satisfy themselves first on the soundness of their* ***financial*** *analysis. By this is meant first that the scheme must provide much more attractive incomes to farmers, in cash and in kind, than their present or alternative occupations, to reward them for the extra work irrigation entails, and that there must be an assurance of regular financial resources at the scheme level if the maintenance of the scheme is to be guaranteed. Only if these two financial analysis are positive, will there be an economic benefit at the national level, which is what the EIRR measures. My argument was that the financial analysis must be regarded as the first test of a project's viability; only if this could be assured was it worth proceeding to an estimate of the EIRR. It is also true that unless the farmers find the scheme financially attractive, and unless some organisation has the resources to operate and maintain it, there will not be any* ***social*** *benefits, such as increased security of food supplies, less migration to towns, etc, because the scheme will collapse or perform badly. It has been pointed out that in some village schemes in Sahelian countries (and probably elsewhere) the costs of irrigation are provided by the remittances of migrant workers, while the scheme exists to provide food for their families. Such family separation is hardly an ideal social situation, although it may be the best solution currently available to the problem of rural poverty.*

2.2 Local Farming Systems

Most forums agreed that irrigation development may disrupt the family economy by imposing rapid transformation of subsistence farming into competitive commercial farming[3], rather than innovations in or improvements of pre-existing activities. Also, irrigation schemes that impose uniform production patterns on many farmers may be unpopular. The newly introduced component to the local farming system should be brought into balance with other food-producing and cash-earning activities, in a combination attractive to farmers and acceptable to other actors. For instance, if rainfed farming increases, the productivity of irrigated plots sometimes drops. This underlines the symbiosis between rainfed and irrigated agriculture. Many farmers prefer combining these types of agriculture rather than depending solely on irrigated production.

Therefore, irrigated agriculture should not compete for pre-existing resources (land, labour, capital and water) beyond the extent acceptable to farmers. For example, farmer preferences and irrigation project pre-suppositions frequently diverge in regard to the labour input required by irrigation. For farmers, labour shortages are important. There may be wide variations between households, but at peak periods labour supply emerges as a key constraint because of the marked seasonality in African farming. Overstretching labour and other resources should be prevented by taking account of the complementarity that exists among productive activities.

Access to land is another example of why plans should be based on an in-depth farming systems analysis and consultations with farming families. By wishing to impose crop choices, cultivation techniques and timing of operations, governments cause those tilling the land to become more like tenants rather than landowners.

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[3] *Of course in many parts of Africa farmers have been combining subsistence farming with the sale of farm products for many decades, and in these cases they may be already well integrated into the commercial economy, either through traditional trading networks or through linkages developed by governments or external firms.*

Leases allow project authorities to control the production process, because these authorities have the power to remove a person's tenancy rights. However, conditional tenancy diminishes the farmer's commitment to modern irrigation. Furthermore, customary laws are still very much in operation. It seems appropriate that irrigation planning should take these traditional arrangements for the management of land-use into account, particularly to avoid conflicts between different groups of people.

In general, all the documents reviewed underline that for better irrigation performance one has to get to the roots of the social, organisational and motivational aspects from a farmer's perspective. A first requisite in this respect is to know how male and female farmers choose, combine, manage and rank the various activities they engage in.

The complementarity of different activities has implications for irrigation design:

- plot sizes and land allocation principles should enable households of different size and composition, and changes over time to be accommodated;

- plot sizes should only be chosen after farmers' budgets have been financially appraised. The plot size should guarantee an acceptable income without eliminating other important productive activities (even if this means modifying the size to allow for a small supplementary activity);

- low cost irrigation systems or methods that can give acceptable returns when used only for supplementary watering of traditional crops should be identified;

- land-use systems that integrate crop production and livestock rearing should not be ignored;

- anything that can make a system more reliable, robust and simple should be adopted, to minimise requirements for farm labour;

- the design should anticipate irregular periods of absence of the farmers, otherwise it may prove to be inappropriate in real-life conditions;

- designers should search for design options that can reduce the labour demands of the operation of an irrigation scheme without increasing the capital-intensiveness of production.

Apart from advising that location where land and water rights are already contested should be ignored, the documents reviewed contained no recommendations that designs should take land tenure/land rights into account[4]. Furthermore, resources like water, cash, agricultural equipment and knowledge were barely discussed, if at all.

2.3 Irrigation Management

There is general awareness that irrigation management has been weak in many African farmer-managed and agency-managed schemes. In the African setting three areas have proven problematic in farmer management time and time again; achieving corporate identification and accountability on a non-kinship basis, managing money, and managing equipment shared between more than one operator. Unfortunately, irrigation projects require fairly high levels of proficiency in all three domains. However, many have observed that outsider-staffed scheme management does not necessarily promote development, due to the lack of government funds and an ineffective and top-heavy bureaucracy. Therefore, discussions on institutional constraints generally come down to the recognition of the need to delegate scheme management to water users' associations as much as possible.

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[4] *There is, however, an extensive section on land tenure and its implications by Mary Tiffen in ed Moris and Thom, 1990,* ***Irrigation Development in Africa****. Note that this is the full version of the summary* ***African Irrigation Overview****, 1985, with valuable new material that was not incorporated in the summary document. There are also a considerable number of new studies, reviewed in the accompanying Newsletter.*

As regards the three problematic domains mentioned above, water users' associations should preferably be formed on the basis of traditional forms of cooperation. Organisations of people involved in irrigation systems are **not** implemented in a social vacuum. Therefore, preparatory studies should devote time and energy to finding and assessing what form of organisation will fit in the existing local socio-political network, given the prevailing traditional forms of cooperation and mutual aid. Knowledge of local community structure and of village or clan leadership relationships is necessary for this aspect of institution-building.

Existing local organisational structures should be modified as little as possible, while at the same time ensuring that the project revenues be recognisably fair to all, with safeguards to prevent progressive loss of economic and political power by the relatively poor in favour of the relatively wealthy.

The design implications for irrigation design most often made is that schemes should be laid out as a series of modules, each of which is capable of operating semi-independently and which is adjusted in size according to the number of irrigators in a group. The optimal group size mainly depends on the degree of social cohesion in the local community. Furthermore:

- designs should be such that they can realistically be maintained by local irrigators and, if necessary, can operate reasonably well even under sub-optimal maintenance;

- designs should allocate/distribute water in such a way that is **locally** perceived to be equitable. For example, division of water in fixed proportions, irrespective of its availability;

- design and construction methods have to be better adapted to local capacity for operation and maintenance, for example by requiring minimal adjustment during the cropping season.

2.4 Women and Irrigated Agriculture

Statistics suggest that women provide two-thirds of all working hours invested in African agriculture. However, the factors that matter to women - legal security, access to credit, to land, to water, to labour available for productive activities, and a share in profits - tend to be ignored in irrigation planning. It was agreed that it is incorrect to assume without investigation that the farming family is a homogenous unit, with a single purse, and with freely interchangeable or free family labour. A false assumption can contribute to the phenomenon of women 'losing out' in the transition from traditional to modern forms of agricultural production. Especially when projects seek to commercialise what was originally subsistence food production, women risk ending up with the best land, that they formerly used, passing into the hands of men, and they themselves being left with marginal areas or working as labourers on men's crops. The development of irrigation may have a differential impact on the various categories of women within a community, depending on the traditional socio-economic status of their families, and within one family (age, marital status)[5].

All the documents reviewed mention that balance should be rectified and more attention should be given to women's needs, problems and potential, which for cultural, religious and economic reasons may be different from men's and less visible.

The various meetings concurred that in addition to a sensitivity to women's issues, irrigation design also requires knowledge of the existing social structure in the project area and an alertness to the processes that may arise as a result of development measures. Some general recommendations are to identify target groups by gender, to collect data on the socio-economic organisation of farming, giving special attention to the gender-based divisions of labour and responsibilities, to assess the likely impact on men and on women both inside and outside the irrigation scheme, and to make specific

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[5] *The documents perhaps put insufficient emphasis on the way the rights, role and wishes of women may vary between countries and within countries, according to local social and cultural conditions.*

plans to ensure that both men and women are given access to land and water, equipment and services[6].

Only a few recommendations directly concern irrigation design. For example irrigation can alleviate women's workload by incorporating facilities for non-agricultural use of water. The location and size of the household plots should be carefully considered, and forage options and livestock movements maintained.

2.5 Irrigation and External Factors

Irrigation is highly sensitive to external factors. The level and nature of food demand, countries' economic situation, actions of financing agencies, population growth, increase in rate of urbanisation all encourage the demand for irrigation. Other factors impede it (deterioration in earnings of foreign exchange, reduction of external aid).

More direct influences on the performance of irrigation relate are those linking irrigation with the region and the nation. For example, if the output delivery system, comprising roads, rivers, railways, transport, power supply, spare parts, maintenance and competent operation, is defective, farmers are unable to respond to signals emanating from the market place. Inadequacy in the input delivery system can also be a constraint. The provision of inputs has proved difficult for some governments to arrange, especially where irrigation has become very sophisticated and external inputs of credit, seed, fertilizers, pesticides, pump and tractor fuel, spare parts, and mechanical maintenance are needed. Project strategies based on introducing intensive, modern techniques are even more vulnerable in small-scale projects, since their smallness and scatteredness brings them more problems in securing inputs, services and timely technical advice than their larger-scale equivalents.

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[6] *One has to note, however, that this may conflict with the recommendation on page 10 that designs should respect what is locally perceived as equitable.*

The same applies to extension and training services. It is often unquestioningly assumed that farmers will, spontaneously, become expert managers, accountants, and mechanics without adequate and sustaining training. Furthermore, as the success of small-scale irrigation has generally depended on the cooperation of a large range of government institutions and individuals, small schemes tend to have more budgetary and institutional problems than major schemes. Almost all the above mentioned services require capable and enterprising managers, who are currently likely to be extremely scarce.

Most recommendations on this subject deal primarily with institutional and policy reform, developing training capacities, etc. Only a few recommendations deal with irrigation design; for example, that irrigation schemes should rely on simple design of pumps and other items of small-scale equipment that can be manufactured locally. This is to avoid failure as a result of a technology that cannot be serviced ('orphan' equipment). Loan financing for infrastructural costs should also be avoided. Intensive preparatory work with farmers can often stimulate them to generate simple structures from their own resources. Projects should refrain from being involved in the operation and maintenance of irrigation infrastructure and re-designs are needed to simplify the management tasks. Furthermore, production practices that minimise cash costs (external inputs) and indebtedness should be promoted.

The central questions, whose importance has now become clear, are how input supply, marketing, extension and external management are arranged, and to what extent this could/should be arranged by the state, the private sector or by the farmers themselves. The risks arising from the farmers' dependence on external factors beyond their control should be minimised as far as possible by modifying physical designs of irrigation schemes. Designers have made over-optimistic assumptions on the reliability with which external relations can be arranged.

2.6 The Design Process

There is a need to distinguish between poor technical irrigation design and inappropriate 'system architecture'. By 'system architecture' is meant the imaginative piecing together of the various parts of an irrigation system by a multi-disciplinary group including local farmers. The major factors signalled as leading to poor irrigation performance as a result of inappropriate designs are:

- Time pressure caused, for example, by unrealistic timetables for implementation; technical assistance units' overriding impulse to show immediate results; governments and donors wishing to minimise the duration of their involvement; and the disregard of the importance of incorporating elementary socio-economic conditions, creating a tendency to move to action before the situation warrants. Time pressure impedes the participation of the beneficiaries in the preparation of project proposals and design.

- Poor preparatory studies caused, for example, by feasibility studies conducted under pressure to produce high EIRRs; poor communication between researchers of different disciplines; and shortcomings of survey procedures. A feasibility study should include an assessment of the sustainability of the project, in which constraints at farm level and farmers' priorities primarily dictate the content of the applied research, and not only economic criteria. The study should ultimately lead to sound criteria for the final design of the project.

- Premature decision-making: crucial decisions on Terms of References (TORs) and projects' scope, size and institutional form are made **before** the main feasibility study is undertaken and may preclude the best solutions. The TORs of consultants may require them to design a particular type of project as decided centrally, even if it appears not to be the best alternative given local objectives, resources and constraints.

- A communication gap between policy-makers, field officers and farmers.

Some of the recommended modifications in the design process are dealt with as follows.

The project concept of fixed targets to be reached within a fixed time-span should be replaced by a phased development in which irrigation is extended or introduced only after it has been thoroughly tested in pilot schemes. The latter is especially important in areas with little or no experience of irrigation. The advantages of phased development include the ability to implement projects in stages, with the possibility of correcting problems with the initial design during implementation, the ability to spend much more time talking to local people before commitment is made to a final project design, and the lack of adequate institutional capacity for alternative, but very demanding approaches. The advantages of flexibility are likely to apply particularly to the development of small-scale irrigation. Beginning with moderately sized schemes allows for the programme to be fanned out satisfactorily as knowledge, experience and qualified local manpower become available.

Dividing the project cycle into stages tackled by different specialists breaks the connection between design and its consequences. The persistence of many social and economic problems in African schemes is evidence that a sharp discontinuity between designers and implementors inhibits the accumulation of useful experience. Donors will need to allow for more flexible, organic, evolutionary pre-design study. This will reduce their ability to control the scheduling of project design and implementation, but will increase the continuity of staffing and institutionalise memory.

It is generally recommended that the design process be reversed. Rather than begin with the design of the irrigation system based on what is technically and economically optimal, designers and planners should begin with the participants and institutions responsible for implementation. Only after the strengths and weaknesses of each of these have been identified and the structure of incentives clearly understood, should technical design begin. This process can then proceed in iterative fashion as governments and farmers decide which changes they are willing and able to make. Thus, first and foremost, design considerations should centre around what is feasible and acceptable to government and farmers and what impact this will have on project performance.

It is very difficult to ascertain just what is feasible in a particular context. Therefore, not only do project designers have to solicit the views of farmers and executing institutions, they also have to understand and appreciate what these are saying and what they mean. This is why the development of indigenous capacity for project design that includes meaningful participation by all involved in the project, is of the utmost importance.

From the above it may be concluded that irrigation projects need **time, continuity and meaningful interaction between the actors involved to arrive at desirable change.**

2.7 Participation

As discussed in the foregoing sections, farmer participation is a prerequisite for the adequate management of irrigation schemes and for the establishment of an appropriate 'system architecture' in which the irrigation and production technologies harmonise with the experience and resources of farmers and their existing land use. The reports reviewed, moreover, recognize that the erosion of traditional knowledge and skills should be prevented, and that western agricultural knowledge not only has definite limitations but sometimes also has definite negative effects on the development of agriculture in tropical areas. Few reports, however, address the question of **how** local farmers can be actively and effectively involved in different stages of the project cycle.

The concept of participation is frequently ignored (for example, for fear that it will delay the project completion) or is misinterpreted (being seen primarily as a way to reduce costs of operation and maintenance). As a result problems occur because users have not been consulted during the design phase. Others regard participation as a ruse used by outsiders to obtain information to use themselves, in order to diagnose problems **for** the farmers. This as opposed to the approach of trying to help the farmers to consider their situation and diagnose their own problems, to build up their ability to analyse their situation and to decide what further actions to take. It is the latter aspect that should be regarded as the essence of participation.

Moreover, it has been recognised that the willingness of the intended beneficiaries to allocate land to irrigated agriculture, and also their participation in terms of finance and labour should be regarded as a precondition for **any** government involvement in development. Proposals should be presented, discussed and compromised on with farmers, and their support and commitment for the agreed project should be solicited. Negotiated designing is regarded as possible, particularly in rehabilitation, since farmers will have detailed knowledge of the faults in the existing system and some ideas of its potential should improvements be made.

2.8 Environmental and Health Issues

The environmental implications of irrigation development in Africa have been significant. The construction of reservoirs and canal systems for irrigation without adequate drainage, for example, has tended to lead to higher water tables in some regions and to create waterlogging and soil salinity. The introduction of perennial irrigation has also substantially increased the incidence of water-borne diseases. Most of the international meetings reviewed here have recognised the importance of considering these environmental and health aspects of irrigation. The gravity of these topics merits separate attention, not merely passing reference.

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odi-IIMI

IRRIGATION MANAGEMENT NETWORK

NEWSLETTER

ODI/IIMI Irrigation Management Network Paper 90/2a July 1990

Agricultural Administration Unit, Overseas Development Institute, London

The Overseas Development Institute (ODI) is an independent, non-profit making research institute. Within it, the Agricultural Administration Unit (AAU) was established in 1975. Its mandate is to widen the state of knowledge and flow of information concerning the administration of agriculture in developing countries. It does this through a programme of policy-orientated research and dissemination. Research findings and the results of practical experience are exchanged through four Networks on Agricultural Administration (Research and Extension), Irrigation Management, Pastoral Development, and Social Forestry. Membership is currently free of charge to professional people active in the appropriate area, but members are asked to provide their own publications in exchange, if possible. This creates the library which is central to information exchange.

The International Irrigation Management Institute, Colombo

The International Irrigation Management Institute (IIMI) is an autonomous, non-profit making international organisation chartered in Sri Lanka in 1984 to conduct research, provide opportunities for professional development, and communicate information about irrigation management. Through collaboration, IIMI seeks ways to strengthen independent national capacity to improve the management and performance of irrigation systems in developing countries. Its multidisciplinary research programme is conducted on systems operated both by farmers and by government agencies in many co-operating countries. As an aspect of its dissemination programme, it has joined ODI in the publication of the Irrigation Management Network papers, to enable these to appear more frequently to an enlarged membership.

The ODI/IIMI Irrigation Management Network is sponsored by:

ODA

The Overseas Development Administration (ODA),
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IRRIGATION MANAGEMENT NETWORK NEWSLETTER

Linden Vincent

1 RESEARCH AND NETWORK ACTIVITIES AT ODI

Linden Vincent and Mary Tiffen are both now undertaking research programmes for which they request help and information from Network members.

Linden Vincent has funds from the Ford Foundation to undertake a literature review on 'Hill Irrigation'. This review is designed to draw together existing material, and permits comparisons of issues across and between regions so that policies on hill irrigation are better informed. She welcomes contacts with other Networkers involved in this topic and information on any written material produced.

Mary Tiffen is developing a study on irrigation staffing levels in conjunction with Lucas Horst at Wageningen Agricultural University. If this is a topic where you have interests, please write to her directly at ODI or Lucas Horst at Wageningen, Netherlands. Mary will be involved in a wider study that crosses the various Networks at ODI, on an historical evaluation of environmental management and farming systems in Machakos district, Kenya. However, she will be continuing this work on irrigation staffing during 1991.

There have been two lunchtime meetings so far this year. Mary Tiffen, the AAU Chairman, presented the first on *Farmers' Water Knowledge, Attitudes to Water Charges, and to Farmer Management: Illustrations from Zimbabwe and the Sudan.* This meeting looked at farmers' decisions in water use and contributions to water management, and has been published as IMN Paper 90/1b.

The second lunchtime talk, given by Dr Richard Palmer-Jones, lecturer at the School of Development Studies, University of East Anglia, was on *Food Self-Sufficiency and Water Resource Developments in Bangladesh.* The main objective of the talk was to explain the expansion of groundwater irrigation and the achievements of, and future prospects for control and irrigation developments.

The IMN has now published its first Newsletter and set of papers on African Irrigation: M Tiffen, 'Variability in Water Supply, Incomes and Fees: Illustrations of Vicious Circles from Sudan and Zimbabwe', 90/1b; J Jaujay, 'The Operation and Maintenance of a Pilot Rehabilitated Zone in the Office du Niger, Mali', 90/1c; J M Makadho, 'The Design of Farmer Managed Irrigation Systems: Experiences from Zimbabwe', 90/1d; Leslie E Small, 'Irrigation Service Fees in Asia', 90/1e; J J Speelman, 'Design for Sustainable Farmer Managed Irrigation Schemes in Sub-Saharan Africa', 90/1f.

If you wish to register for the African papers, please contact Amanda Barton.

2 NETWORK PAPERS FOR DISCUSSION

The four papers presented in this set contribute to two themes at opposite ends of the spectrum of irrigation development. The papers by Smout and Millican look at practical procedures to involve farmers in irrigation development and management. The papers by the FAO Investment Centre and Palanasami look at criteria for selecting and developing irrigation policy, and for selecting between modernisation strategies.

Paper 90/2b, 'Farmer Participation in Planning, Implementation and Operation of Small-Scale Irrigation Projects', by Ian Smout, recommends practical methods for executing small-scale irrigation projects through farmer participation, and for the development of water user associations. The paper draws on the author's experience from Indonesia and Bhutan, but has wide general application.

Paper 90/2c, 'Reading, Writing and Cultivating: The Role of Literacy in Irrigation', by Juliet Millican, considers the critical role of appropriate literacy and numeracy skills when irrigation management devolves to the farmers themselves. The paper looks at how situations in irrigated farming can be used as training material in literacy classes, but also examines the essential differentiation between the literacy trainer and extension workers in irrigation techniques. The paper is based on programmes developed for literacy training in Senegal.

Paper 90/2d, 'Estimating the Economic Profitability of Irrigation: The Case of Brazil', by the FAO Investment Centre, provides information on the recent review of irrigation development policy undertaken in Brazil, which has reinforced a major change in government policy towards low-cost privately-financed irrigation. While the paper focuses on a description of economic methodology used to rank policy options, it recognises the need for analysis of the distribution of costs and benefits consequent to such decisions.

Paper 90/2e, 'Tank Irrigation in South India: What Next?', by K Palanasami, looks at the potential strategies to modernise tank irrigation in South India, and at the different criteria which can be adopted to rank various interventions. The paper also carries results of a simulation study on a tank in Tamil Nadu, which looked at different financial, productivity and equity criteria to help select optimal modernisation strategies.

3 NEWS FROM NETWORKERS

Anthony Bottrall will be leaving the Ford Foundation's New Delhi office at the end of September and returning to England. He will be a visiting fellow at Queen Elizabeth House, Oxford, for one year, and plans to write, among other things, about water resources policy, planning and management in the Indian subcontinent, with particular emphasis on micro-watershed and groundwater development in drought and flood prone areas. John Ambler, who has been with the Foundation's Southeast Asia Office in Jakarta, will take over as Program Officer in charge of water management in New Delhi.

John Hennessy, a board director of Sir Alexander Gibb and Partners, has been elected as the new President of the International Commission on Irrigation and Drainage (ICID). Since joining Gibb in 1960, Mr Hennessy has worked on irrigation, drainage and hydro-electric power projects in over 20 countries throughout Africa, the Middle East and Asia.

Commenting on the challenges facing ICID during his presidency, Mr Hennessy said: "Increasing agricultural production in the Third World in a sustainable manner is the key to alleviating poverty and famine. The ICID is focusing on providing the necessary framework to achieve this goal while preserving and protecting the environment. This year, with the backing of The World Bank and UNDP, ICID has already launched an initiative to increase research and development into irrigation and drainage technology in developing countries. In addition, through closer links with famine relief and intermediate technology groups, we aim to ensure that none of the available expertise and knowledge is overlooked."

Mr Roy Stoner will take up the post of Director at the Institute of Irrigation Studies, University of Southampton in August 1990. Mr Stoner was formerly a senior partner with Sir M MacDonald and Partners, Deputy

Chairman of the Mott MacDonald Group, and Chairman of Mott MacDonald International. His specialisations are water resources development and groundwater engineering, and he is author or co-author of several publications in these fields. Dr Rydzewski, who steps down from the post, will remain in Southampton University to "concentrate on the actual problems of irrigation development in the Third World".

The Department of Irrigation and Soil and Water Conservation at Wageningen Agricultural University have initiated a research project on *Privatisation in Irrigated Agriculture*. A short position paper has been prepared identifying aspects of interests and possible case studies. Wageningen would like any Network members with an interest in privatisation to contact them, and they welcome opinions and information on past or current initiatives on this topic. If you have views to share, or would like a copy of the paper, write to Ir J Slabbers, Department of Irrigation and Soil and Water Conservation, Wageningen Agricultural University, Nieuwe Kanaal 11, 6709 PA, Wageningen, The Netherlands.

Are you interested in rain water harvesting techniques? If so, then write in to join the Rainwater Harvesting Information Centre (RHIC). RHIC maintains an information database on rainwater harvesting and publishes *Raindrop*, a periodic newsletter. RHIC is maintained by the Water for Sanitation and Health Project (WASH), funded by USAID. To join the network write to Dan Campbell, Librarian, WASH, Room 1001, 1611 North Kent Street, Arlington, Virginia 22209, USA. Please also send him any relevant publications. If you would like advice, please try to be as specific as possible.

An International Association for the Study of Common Property is being coordinated from Duke University. They are holding a Conference *Designing Sustainability on the Commons*, 27-30 September 1990. If you have interests in this area, and want their newsletter, write to Margaret McKean, Department of Political Science, Duke University, Durham, North Carolina 27706, USA.

The Centre for Irrigation Engineering at Leuven in Belgium is also publishing a newsletter called *Siphon*, documenting the work of staff and visiting fellows. Newsletter No 5 contains short papers on the use of pitcher pots for localised irrigation by Raubir Chhabra, and on gated pipelines to improve irrigation efficiency by Dan Eisenhauer. To obtain the newsletter, write to Paul Campling, Siphon Newsletter, Centre for Engineering, Katholieke Universiteit Leuven, Kardinaal Mercieriaan 92, B-3030 Leuven, Belgium.

Hydro Power - Hydraulic Rams: Consumer Guide. The Department of Civil Engineering at Delft has carried out a comparative study of 12 commercial and newly designed ram pumps. The guide can be obtained free of charge from CICAT, PO Box 5048, 2600 GA Delft, The Netherlands.

A test facility has been developed at the Division of Energy Technology, Asian Institute of Technology in Thailand, to provide manufacturers of energy-related equipment with the means to evaluate the performance of their products in the humid tropical climate. Products mainly related to solar and thermal applications have been extensively tested. For further details of testing facilities, and the terms and conditions of testing a specific project, contact Mr P Bouix, Division of Energy Technology, GPO Box 2754, Bangkok 10501, Thailand.

If you are working with solar energy, then you may be interested in the photo-voltaic information service which assists in answering queries on the use of photo-voltaic energy in developing countries. Write to German Appropriate Technology Exchange (GATE/GTZ), PO Box 5180, D-6236 Eschborn, Federal Republic of Germany.

John Merriam is continuing his work on flexible irrigation supply managed by farmers. He has recently completed a report on a pilot project on 'Farmer-Managed Variable Delivery Irrigation System' in the Gadigaltar Tank, Madhya Pradesh, India, and started another pilot project in Pakistan. Please write to him if you are interested in this work or are doing research and development in this area. John Merriam, California Polytechnic State University, San Luis, Obispo, CA 93407, USA.

Important developments are taking place in the field of calculations to determine crop water requirements. FAO held an Expert Consultation in May 1990 to review the current FAO methodologies outlined in the Irrigation and Drainage Papers. They plan to produce a technical report with revised calculation procedures for estimating reference crop evapotranspiration by November 1990 which we hope to document in the next Newsletter. Additional studies and revisions are planned for 1991. For more information contact Martin Smith, Technical Officer (Water Management), AGLW, FAO. The American Society of Civil Engineers have published a new text 'Evapotranspiration and Irrigation Water Requirements', which completely revises their 1974 text on 'Consumptive Use of Water and Irrigation Water Requirements'. More details on this report is given in section 7 of the Newsletter.

The Department of Agricultural Economics at Wye College is starting a three year research programme in Morocco, assisted by ODA, in collaboration with the Institute Agronomique et Vétérinaire Hassain II, Rabat. The programme will be headed by Professor Ian Carruthers on the English side, and Mr M Ait Kadi in Morocco. The project has 5 components: (1) irrigation policy development, especially the effects of crop pricing on irrigated output; (2) management information systems; (3) expert systems applied to irrigation problems, looking first at crop protection; (4) environmental monitoring; (5) development of training materials in these areas. The Wye team are keen to hear from any Network members with interests in these areas. For item (1) contact Laurence Smith or Ian Carruthers; (2) Jonathan Kydd; (3) Paul Webster; (5) Julian Bertlin at Department of Agricultural Economics, Wye College, University of London, Ashford, Kent TN25 5AH, UK.

Developments in Irrigation and Drainage Technology

A new initiative is underway to promote the application of improved irrigation and drainage technology, through an international programme which will support thematic research as well as education in this area. This initiative has been developing since 1987, via a series of meetings organised by The World Bank, UNDP and ICID, designed to canvas opinions on both needs and possible administrative structures.

Earlier this year, The World Bank/UNDP, together with ICID, published a proposal *Irrigation and Drainage Research*, setting out ideas for an internationally funded programme to enhance research and development in irrigation and drainage technology in developing countries. These proposals were discussed at a meeting in April, sponsored by The World Bank, which firmly endorsed the need for such an initiative. As a result, a small Secretariat has been established in The World Bank, under the guidance of Guy Le Moigne, Senior Adviser, Agriculture and Water Resources, and with Ashok Subramanian as the interim Executive Secretary. The next step will be preparation of detailed proposals of structure and functions of the Secretariat, for further discussion by potential donors and participants. The proposal sets out the following ideas as potential themes and actions by the Secretariat:

(1) **Modernising irrigation and drainage systems.** This theme focuses on the need to modernise existing systems and to adopt new approaches to the design of new systems relevant to current and future needs. In particular, it would include research and development related to the technology of regulation of canal networks and its consequences for improved system efficiency and water conservation.

(2) **Ensuring sustainability of land and water use.** Sustainability is a subset of issues, but the proposed research and development initiative focuses on technological problems associated with waterlogging and salinity. It would also address the reuse of sewage and drainage waters.

(3) **Improving technology for maintenance.** This theme emphasises effective research on relevant design and management of maintenance, for example, that might lead to in reduced sedimentation, weed growth, vector survival and bank erosion.

In addition, action is proposed for the implementation of these proposed initiatives:

(a) **Human resource development.** In order to develop skills for technology assessment, to promote technology adaptation and adoption, and to build local capacity for research and development activities;

(b) **Networking.** To improve collaboration between institutions and individuals.

All themes recognise the need for, and benefits from, collaboration with the work of other national and international agencies involved in irrigation research, so that the proposed initiative in research and development technology is complementary to ongoing efforts, cost effective and directed at the solution of operational problems. For further details, write to the International Program for Technology Research in Irrigation and Drainage, Agriculture and Rural Development Department, The World Bank, 1818 H Street, Washington DC 20433, USA.

4 NEWS FROM IIMI

The International Irrigation Management Institute (IIMI), with the approval of its 13 member board, is moving to a new, three storey headquarters building in July. IIMI will lease the building and will retain a one year option to purchase. The Institute may be still be reached by addressing mail to IIMI, PO Box 2075, Colombo, Sri Lanka.

In early 1990, the Institute underwent its first ever External Review when a 5 member, international panel presented its findings after studying IIMI's operations for several months. The panel was unanimous in its findings that IIMI had made the progression to a mature institution with results that were having a considerable impact on improving irrigation management efficiency in developing countries. The panel did recommend that IIMI consolidate and concentrate on its core activities and not expand into other geographical areas too soon.

Additionally, an extraordinary meeting of the Board of Governors was held in February 1990 at which the Board received the panel's report and discussed ways to implement its suggestions and recommendations. Chaired by David Bell, the Board said the External Review Panel had validated IIMI's role in agricultural development, and had also helped to lay the foundation for future goals and work programmes.

IIMI is also moving toward establishing projects in Latin America and in Egypt. The Institute participated in and led a mission to the 14th International Congress of the International Commission on Irrigation and Drainage. In addition to its representation at the Congress, IIMI made a joint presentation, together with the ICID, to Latin American experts on irrigation management. In Egypt IIMI is gearing up to participate in a USAID funded project.

Earlier this year IIMI sent a four person team to Cairo to discuss a long-term programme of cooperation with the Government of Egypt. The programme is likely to include a series of action-research activities to be undertaken collaboratively with the Water Research Centre in Cairo, and various other Egyptian irrigation and agricultural organisations. Some illustrative topics include decision-support systems for managing water distribution in canals, conjunctive management of surface and groundwater, attitudes, motivation and behaviour of the farmer community, and systematic priority setting for channel maintenance.

A second visit will be made in October to complete the design of what is expected to be an initial 3 year effort, starting in early 1991. IIMI anticipate that an important spin-off benefit of establishing a resident research team in Egypt will be to help forge new links among the irrigation communities in arid and semi-arid countries.

5 IIMI PUBLICATIONS

Leslie E Small, Marietta S Adriano, Edward D Martin, Ramesh Bhutia, Young Kun Shim, and Prachanda Pradhan, 1989, *Financing Irrigation Services: A Literature Review and Selected Case Studies from Asia.*

This book provides a very useful synthesis of material on the financing of current costs, which has been a key research theme at IIMI. In addition to the literature review, there are chapters on irrigation financing policy and practices in Indonesia, Korea, Nepal, Philippines and India.

The studies conclude that the quality of irrigation system operation and maintenance is affected not only by the amount of resources made available to operate and maintain systems, but also by the institutional arrangements under which they are provided. It is important that an agency responsible for operation and maintenance, and its staff, be given appropriate incentives to achieve improved, cost-effective management of irrigation facilities. Financially autonomous agencies, dependent for a significant portion of their revenues on farmers' payment of irrigation service fees, have a greater incentive to provide good irrigation service than do financially dependent agencies that receive their budget from the national treasury.

Most financing mechanisms employed in the study-countries do not promote efficient investment decisions nor efficient use of water. For a financing mechanism to improve investment decisions, an institutional linkage is needed between the investment decision process and the financial viability of agencies (both national and international) responsible for investment decisions. In most institutional settings, this condition is lacking.

Water pricing, requiring volumetric measurement of water and the ability to turn supply on or off at farmers' requests, can influence farmers' water use decisions. However, this requires a higher degree of physical control over distribution of water than is typically found in systems in the countries considered in the IIMI studies. Water pricing is generally not found in irrigation systems characterised by large numbers of small farms on which rice is a predominant crop, as under such conditions water pricing is difficult to implement and costly to administer.

The principal direct financing mechanism, observed in the study-countries, involves irrigation service fees charged at a flat rate per unit and are sometimes differentiated to account for factors such as cropping intensity and type of crop. These area-based fees rather than promoting efficient water use, generally provide incentives for overuse of water by those farmers able to obtain it.

Another important conclusion of the studies is that, under conditions of reasonable irrigation service, the incremental benefits derived by farmers from irrigation will be adequate to make it possible for them to pay the full cost of operation and maintenance, while still retaining significant increases in net incomes due to irrigation. However, the benefits of

irrigation are typically not great enough to permit the full recovery of operation and maintenance, plus full capital costs from the water users. The literature review also showed that throughout the world, government-assisted irrigation projects involve large subsidies for capital costs.

Merry, Douglas L and Somaratne, P G, 1989, 'Institutions Under Stress and People in Distress: Institution-Building and Drought in a new Settlement Scheme in Sri Lanka', *IIMI Country Paper - Sri Lanka No 2.*

This paper reports on research carried out in the Kirindi Oya Irrigation and Settlement Project, southern Sri Lanka, during one season, **maha** (wet season) 1986/87. During this particular season the rains failed, causing a severe drought and leading to crop failure in most of the newly settled parts of the scheme. The impact of this disaster was compounded by the fact that this was a new scheme, and for farmers in the newly settled areas, this was only the first or second cultivation season. The paper analyses the irrigation operational problems that characterised the early part of the season, related organisational and management weaknesses, and the response of the various institutions and participants in the system to the drought, and the impact, particularly on the credibility of institutions, of the drought and the way it was handled. It is suggested that in addition to the real poverty, anger, feelings of helplessness, and general distress of the new settlers, the drought further weakened the fragile new farmers' organisations, and led to a loss of faith in the official management organisations, and officials themselves. The conclusion suggests some specific management innovations that may improve the development process and overall performance of the Project.

Panabokke, C R, 1989, 'Irrigation Management for Crop Diversification in Sri Lanka', *Country Paper - Sri Lanka No 3.*

The need to understand the technical and socio-economic constraints in irrigation management for diversified cropping underlies this study. The interdisciplinary studies conducted by the research staff of IIMI have helped to clarify some of the more important technical and socio-economic constraints, and the potential for more intensive cropping with other food crops during the dry season. The results of these studies provide an essential first step towards identifying future management intervention approaches and the proper directions in which they could be tested and adopted. This would enable possible future strategies and policies to be based on an objective body of tested information.

Stanbury, Pamela, 1989, 'Land Settlement Planning for Improved Irrigation Management: A Case Study of the Kirindi Oya Irrigation and Settlement Project', *Country Paper - Sri Lanka No 4.*

This paper analyses the impact of settlement policies on irrigation management, based on field research in 1988. It documents the process of implementing a set of land-settlement activities designed to improve irrigation management in a new irrigated settlement scheme. The site selected for research was the Kirindi Oya Irrigation and Settlement Project (KOISP) in southern Sri Lanka. The study provides policy recommendations for improvements on this scheme and in future schemes.

Pradhan, Prachanda, 1989, 'Patterns of Irrigation Organization in Nepal: A Comparative Study of 21 Farmer-Managed Irrigation Systems', *Country Paper - Nepal No 1.*

This comparative study was conducted to identify and describe the organisations that have evolved over a period of time to meet the farmers' needs; to attempt to identify the factors that stimulate farmers to become organised for irrigation activities; and to examine key issues relevant to government policy for intervention and formulation of development strategy. The tremendous variations in environmental conditions that exist in Nepal have contributed to the development of a wide range of irrigation organisation patterns. 29 different irrigation management tasks are also identified. The valuable experiences of farmer-managed systems suggest that certain management principles could be applied to government-managed systems for improved performance.

Pradhan, Prachanda, 1989, 'Increasing Agricultural Production in Nepal: Role of Low-cost Irrigation Development Through Farmer Participation', *Country Paper - Nepal No 2.*

This book reveals that Nepal irrigation policy directives and resources must be channelled to encourage the participation of beneficiaries, and to focus the functions of the Department of Irrigation on management perspective. Nepal needs to develop an alternative strategy and low-cost approaches for increased agricultural production. The low-cost approaches recommended in the paper include incorporating farmer participation in operation and maintenance, considering lower cost structures in surface irrigation and underground water development, and improving the management of irrigation systems.

Johnson, Robert, 1989, 'Private Tube Well Development in Pakistan's Punjab: Review of Past Public Programs/ Policies and Relevant Research', *Country Paper - Pakistan No 1.*

Although Pakistan's surface irrigation development has a long history, it is only about 30 years ago that the development of groundwater resources was begun. During the past decade, government policy has been reoriented towards private, instead of public, tubewell development in fresh groundwater areas. This paper examines the policies that have affected tubewell development, and reviews past literature on the subject.

Kijne, Jacob W, 1989, 'Irrigation Management in Relation to Waterlogging and Salinity', *Country Paper - Pakistan No 2.*

This paper presents an overview of the current state of knowledge on the relationship between irrigation management in Pakistan and the incidence of waterlogging and salinity. It is emphasised that management research should focus on the whole system, including surface and groundwater resources. This paper also highlights key management questions that need to be addressed such as salt and water balance, and water loss from canals, watercourses and field channels.

Weerakkody, P, 1989, 'Farmer-Officer Coordination to Achieve Flexible Irrigation Scheduling: A Case Study from System H, Sri Lanka', *IIMI Case Study No 3.*

The institutional and irrigation infrastructure of System H of the Mahaweli Multipurpose Development Project provides adequate opportunities for achieving a high standard of water management. A coordinated approach for achieving close cooperation between agency officials and farmers at the field channel and distributary channel levels, combined with a flexible delivery schedule, resulted in an improved field water use efficiency within the H5 sub-system. An equitable allocation of water to each field channel command area and an effective utilisation of rainfall have also been achieved.

Small, Leslie E, et al, 'Study on Irrigation Systems, Rehabilitation and Improved Operations and Management', for *ADB Regional Technical Assistance, Vol 3, Activity C: Financing the Costs of Irrigation.*

This report complements the volume by Leslie Small et al. It documents additional studies in Sri Lanka and Korea on irrigation financing at the national and project level. This is also a literature review on water wholesaling.

6 UN ORGANISATION PUBLICATIONS

(a) FAO

The Food and Agriculture Organisation (FAO) have several recent publications likely to be of interest. They are developing a series of training manuals in English, French and Spanish, intended for use by local field assistants who want to increase their ability to deal with farm-level irrigation issues. Manuals published so far:

1 *Introduction to Irrigation (Introduction à l'irrigation)*
2 *Elements of Topographic Surveying (Topographie pratique élémentaire)*
3 *Cropwater Needs (Les besoins en eaux d'irrigation)*
4 *Irrigation Scheduling (Pilotage des irrigations)*
5 *Irrigation Methods* (Mèthodes d'irrigation)

The latest publication in the Irrigation and Drainage Paper Series is Walker, W R, 'Guidelines for Designing and Evaluating Surface Irrigation Systems', *Irrigation and Drainage Paper 45*, 1989. This publication provides a summary of the characteristics of water distribution systems, discusses related design formulae and describes field data required for these design procedures. For further details contact the Land and Water Management Division, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

(b) FAO/UNEP/WHO

The Panel of Experts on Environmental Management for Vector Control (PEEM) was established in 1981 as a joint activity of the Food and Agriculture Organisation (FAO), the United Nations Environment Programme (UNEP), and The World Health Organisation (WHO). They have now published the following Guidelines:

Tiffen, M, 'Guidelines for the Incorporation of Health Safeguards into Irrigation Projects through Intersectoral Cooperation', *PEEM Guidelines Series No 1*, 1989.

Birley, M H, 'Guidelines for Forecasting the Vector-Borne Disease Implications of Water Resources Development', *PEEM Guidelines Series No 2*, 1989.

(c) UNESCO

Cox, W E, 'Water and Development: Managing the Relationship', 1989.

This paper provides a general overview of the role of water in socio-economic development, covering the interactions between water and other factors in the development process, and policy and management issues necessary to assess these interactions and plan socially desirable responses. The text is simply written in order for the paper to have a wider circulation between nations and within many levels and sections of government. This is obtainable from Division of Water Sciences, UNESCO, 7 Place de Fontenoy, 75700 Paris, France.

(d) The World Bank

Plusquellec, H, 1990, 'The Gezira Irrigation Scheme in Sudan: Objectives, Design and Performance', *World Bank Technical Paper No 120.*

This report is part of a series of case studies on the performance of irrigation systems in different countries. For the Sudan Gezira Scheme, the 1980s have been a decade of missed opportunities. Despite considerable momentum on rehabilitation, the scheme is operating well below its potential. This report gives a description of water distribution and management in the Gezira, and then reviews performance in operation and maintenance, and achievements in agricultural production before concluding on the rehabilitation measures and design revisions needed to improve performance.

Other case studies include Mexico, Morocco, Thailand, Philippines and Colombia. We mentioned the study on Colombia in the previous Newsletter (Hervé Plusquellec 'Two Irrigation Systems in Colombia: Their Performance and Transfer of Management to Users' Associations', *World Bank Working Paper 264*), which provides a rare example of a relatively large scheme (27000 ha) managed entirely by a Water User Association.

O'Mara, G T, 1990, 'Making Bank Irrigation Investments More Sustainable', *Policy, Research and External Affairs Working Paper 420.*

This report examines the difficulties which the Bank has faced in defining objectives for its lending policy on irrigation projects. Until 1976, Bank policy emphasised recovery of all costs on irrigation projects, or at least complete recovery of operation and maintenance costs. Subsequently policy specified three pricing objectives for the design of irrigation service fees - economic efficiency, income distribution and public savings.

However, these objectives either had unclear instructions or were framed in unworkable or irrelevant terms. O'Mara proposes 6 points as a basis for a new policy framework. These include acceptance of flexibility in irrigation institutions consistent with local cultures, a focus on the physical sustainability of irrigation investments and associated natural resources, and basing cost recovery policy on the total complex of government interventions (including indirect taxation on agricultural commodity output).

7 OTHER PUBLICATIONS RECEIVED

Jurriëns, R and De Jong, K, *Irrigation Water Management: A Literature Survey*, 1989. Available from the Department of Irrigation and Soil and Water Conservation, Agricultural University, Nieuwe Kanaal 11, 6709 PA Wageningen, The Netherlands.

Huppert, W, *Situation Conformity and Service Orientation in Irrigation Management*, GTZ, 1989. For distribution write to GTZ GmbH, 6236 Eschborn, Federal Republic of Germany.

Both these books express a desire to guide the reader through the large volume of literature on irrigation management, and distil out key concepts in management. It is a reflection, however, of the breadth of irrigation management interests, that the two books are completely different in orientation and style. Whereas Jurriens and de Jong provide an overview of research to see what this has taught us about irrigation management, Huppert is concerned to see how management science could improve approaches to irrigation services.

Jurriens and de Jong set out to provide a syntheses of ideas and key references, in order to provide a study for the large numbers of irrigation personnel who will never have time or access to study original texts. The book provides an overview of issues debated in English 1970-1986, moving through general studies of the role of irrigation, schools of thought in irrigation management research, irrigation typologies, objectives and performance, to more specific topics of management issues in design, organisation, water distribution at main system and tertiary level, and farmer participation. The result is a highly informative and readable text.

The material discussed does have a bias towards larger schemes and Asian material (although this is also a reflection of English published material in irrigation during this time), but much of the general material is relevant internationally, and to all sizes of scheme.

Huppert's book is a more formal analysis of management issues in irrigation. As irrigation systems are extremely heterogenous, management experiences cannot be transferred uncritically, so it is useful to discuss 'situation conformity' where management principles and guidelines are adapted to a range of situations and needs. The author aims to redress the weak development of comparative organisational research in irrigation to date, by moving between general management models and initiatives and irrigation. The author looks both at the way published information on irrigation fits with general management theory, and the way this general body of ideas on management could be a framework for future research and development in irrigation management. The result is a rather theoretical text full of a lot of ideas, but also a lot of specific management vocabulary which would not be very accessible to a field worker. It is, however, a book to be noted and read by those researching irrigation management, and by those involved in training programmes in irrigation management.

A *Review of Studies on Shallow Tubewell Irrigation Management in Bangladesh* has been published by Dr Syed Z Sadeque and Mr M A Hakim. This review summarises key findings of 21 studies in order to identify achievements and problems of shallow tubewell irrigation, and consider areas for future policy action. The discussion covers issues of productivity, changes in cropping patterns, command area, equity, employment, tenurial relations, shallow tubewell markets, privatisation, and profitability of shallow tubewell irrigation. The Review was organised through the Bangladesh Agricultural Research Council and the Winrock Institute for Agricultural Development. To obtain copies, write to Dr Syed Z Sadeque, Associate Professor, Department of Sociology, Rajshahi University, Bangladesh, or Mr M A Hakim, Joint Director, Rural Development Academy, Bogra, Bangladesh.

Amer, M H and de Rider, N A (eds), 1989, *Land Drainage in Egypt*, Drainage Research Institute, Cairo. US$ 35.

This book discusses the advances made in Egypt in the field of land drainage since the establishment of the Egyptian-Dutch Advisory Panel on Land Drainage in 1976. Chapters examine the history of water management and drainage in Egypt, the quality of drainage water and its reuse in the Nile delta, tubewell drainage in the Nile Valley, mathematical models and associated monitoring methods use to assess water quality, the methodology for economic justification of drainage projects in Egypt, drainage management, and the institutional impact of the work of the advisory panel.

Vaidyanathan, A and Jankaraja, S, *Management of Irrigation and its Effect on Productivity under Different Environmental and Technical Conditions*, 1989.

This monograph presents a detailed study of irrigation management, agrarian structure and productivity, in two surface irrigation systems in Tamil Nadu, India; one on a storage-based canal system, and the other operating via a series of tanks. Both systems have well developments in their command areas and thus a high degree of conjunctive use. The research data, largely based on questionnaires and farm surveys, brought out the importance of the physical environment and the conditions of water supply in determining productivity. However, the character and functioning of institutions was also important. Both systems have practical operating schedules which are considerably different to declared procedures, and which have evolved in a highly ad hoc manner. Functions are operated through a mixture of government and local representatives, but groundwater development has weakened both local institutions and the overall management of surface water. The authors are aware that greater use of anthropological research methods would have provided more insights into institutional factors affecting the distribution of benefits from irrigation, and would be pleased to hear from Network members who are interested in such research methods. For more information, please write to the authors at Madras Institute of Development Studies, 79 Second Main Road, Gandhinagar, Adyar, Madras 600 020, India.

'Training Needs Assessment - Maharashtra Minor Irrigation', *Technical Report 17*, 1990.

This report documents methods and questionnaires used to assess training needs within government departments involved in small-scale irrigation development in Maharashtra, India. Discussions with employees are summarised and knowledge deficiencies identified in self-assessment and co-workers. (In Maharashtra, minor schemes assisted by state government departments are those in the range 100-1000 ha.) For more details contact Tom Kajer, Winrock International, Irrigation Management and Training Project, 213 Ansal Chamber 11, Bhikaji Cama Place, New Delhi 110 006, India.

Pandey, Vikash N, Shah, Tushaar and Singh, Katar, 'Common Property Resources Management', *Cases in Rural Management No 1, 1990.* Available from the Publications Officer, Institute of Rural Management, PO box 60, Anand 388 001, India.

This collection of four case studies addresses various issues characteristic of managing common property resources (CPR). These studies cover: (1) management issues in three villages in a saline tract where a voluntary agency failed to motivate villagers to clean and desilt a village tank or cooperate in social forestry activities; (2) problems in the allocation of communal funds to assist an individual in digging a well; (3) encroachment onto a tank bed for paddy cultivation by an influential farmer; and (4) problems in operating a communal savings scheme based on earnings from social forestry activities. The collection is designed to be used for the 'case method' for studying practical political issues, so that participants learn to think like the managers of rural organisations. People interested to find out more about the instruction method and the instructor's notes designed to accompany each case, should write to the Coordinator, Case Development Programme, at the above address.

Wright, E P, et al, 'Final Report of the Collector Well Project 1983-1988', *British Geographical Survey Technical Report WD/88/31*, 1989.

This report summaries research by British Geological Survey into the behaviour and development potential of Basement Complex rocks in Africa and Asia. The project has included theoretical and simulation (modelling) studies, in addition to experimental programmes in Zimbabwe, Malawi and Sri Lanka. The report documents text procedures for large diameter wells and collector wells, and their costs and development potential, and looks at the relative performance of large diameter wells, collector wells and borewells. Obtainable from the British Geological Survey, Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB, UK.

Batchelor, C H, et al, 'Development of Small-Scale Irrigation Using Limited Groundwater Resources', *First Interim Report No 3/90*, Institute of Hydrology, 1990.

This report documents findings from a programme at the Low Veld Research Station, Zimbabwe, which is studying the feasibility of basement aquifers for small-scale irrigation, and the potential of high-efficiency, low-cost technology. The equipment studied included locally-produced emitters and spaghetti tube for low-head drip irrigation, pitchers and subsurface irrigation by slotted PVC pipe and clay drain pipes. For further details contact C Batchelor, Institute of Hydrology, Wallingford, Oxon OX10 8BB, UK, or Low Veld Research Station, PO Box 97, Chiredzi, Zimbabwe.

The Institute of Hydrology have also published a series of reports on their drip irrigation investigations in Mauritius, looking particularly at production of sugar cane under drip techniques. A summary of findings is given in the report 'Drip Irrigation Research'. More detailed findings are given in a series of interim reports on the MSIRI-IH project. For further information write to Henry Gunston, Institute of Hydrology, Wallingford, Oxon OX10 8BB, UK.

Jensen, M E, Allen, R G, and Burman, R D, (eds), 1990, 'Evapotranspiration and Irrigation Water Requirements', *Manuals and Reports in Engineering Practice No 70*, pp 360, American Society of Civil Engineers (ASCE). Within USA $66, outside USA $79.20 (25% discount to ASCE members).

This manual is a complete revision of the 1974 ASCE Report 'Consumptive Use of Water and Irrigation Water Requirements' and incorporates many years of experience with the 1974 Report and recent advances in the physics of evaporation from plant and soil surfaces. It has the same organisation as the Report and all sections have been updated and several new sections added. Data sets used for comparative purposes have been revised based on new information. The manual provides basic information and state-of-the-art techniques for estimating crop and irrigation water requirements. Example calculations for all estimating methods are presented and along with a detailed analysis of results obtained using various methods for estimating evapotranspiration. The appendices contain tables for converting various units, and basic data on solar radiation, net radiation, vapor pressure-temperature, thermodynamic constants, and air density-pressure relationships.

8 JOURNAL ARTICLES

Water Resources Management Vol 3, 1989
Jermar, Milan K, 'Water Management for Food Production: Strategy Plan', pp 299-313. A study based on the Kirindi Oya Irrigation and Settlement Scheme, Sri Lanka.

ICID Bulletin Vol 38 (2), 1989
Pereira, L S, 'Mitigation of Droughts' 1. Agricultural, pp 1-15; 2. Irrigation, pp 16-34.
Humphreys, A S, 'Surge Irrigation' 1. An Overview, pp 35-48; 2. Management, pp 49-61.

Irrigation and Drainage Systems 3 (3), 1989
This entire volume is devoted to discussion of training for irrigation managers, and description of several 'games' for training purposes.

IIMI Review Vol 4(1), March 1990. Looks at irrigation in India, with comments on progress in food production, training, groundwater and poverty alleviation and water markets. It also carries articles on small farmers associations in the Dominican Republic and on training needs assessment in Malaysia.

ODU Bulletin No 17, January 1990. Contains a selection of articles on the environmental impacts of irrigation, and a list of related ODU publications. Available from Hydraulics Research Ltd, Wallingford, Oxfordshire OX10 8BA, UK.

Appropriate Technology Vol 16 (4), March 1990
Pandey, Bikash and Cromwell, Godfrey, 'Monitoring Microhydro in Nepal', pp 8-9.
Chambers, Robert, 'Rapid and Participatory Rural Appraisal', pp 14-16.
Scoones, Ian, 'Researching Water Resources in Zimbabwe', pp 28-29.

Waterlines Vol 8 (3), January 1990
Wirojanagud, Prakob, 'The People's Volunteer Weir Programme: A Three-Way Collaboration (Thailand)', pp 24-26.
Vol 8 (4), March 1990
Vincent, Linden, 'Environmentally Sound Irrigation Projects', pp 3-6
Goodland, Robert, 'Environmental Aspects of Dam and Reservoir Projects - The World Bank's New Policy', pp 7-10.

Irrigation and Drainage Engineering Vol 116 (2), 1990
Biswas, A K, 'Monitoring and Evaluation of Irrigation Projects', pp 227-242.

Wamana Vol IV, October 1989
Sundar, A, 'Planning Strategies - A New Direction', pp 1-5
Singh, Satnarayan, 'Warabandi - An Overview', pp 6-9
Patil, R K, 'Water Management System in Major Irrigation Projects in Arid Zones - An Indian Experience', pp 10-17.
Narayanamurthy, S G, 'A System Design for Managing Canal Water Delivery', pp 18-27.
Des Bouvrie, C, 'Irrigation Management in India; Then, Now and in the Future', pp 28-32.

Water Resources Development Vol 5 (4), 1989
Farid, M S F, et al, 'Technical-Economic Screening for Groundwater Planning: A Case Study in the Eastern Nile Delta', pp 259-272.
Eswaramoorthy, K, et al, 'Integrated Use of Water Resources in the Lower Bhavani Project in India', pp 279-286.

Vol 6 (1), 1990
Rodger, P A, and Bhuiyan, S I, 'Ricefield Eco-System Management and its Impact on Disease Vectors', pp 2-18.
Falkenmark, Malin, et al, 'Coping with Water Scarcity: Implications of Biomass Strategy for Communities and Policies', pp 29-43.
Rao, N H, 'Seepage Losses from Canal Irrigation Schemes, Influence of Surface and Sub-Surface Conditions and Implications for Conjunctive Use', pp 55-62.
Vol 6 (2), 1990
Chaube, U C, 'Water Conflict in the Ganga-Brahmaputra Basin', pp 79-85.
Kees Ton and Kees de Jong, 'Pump and Flood Irrigation: Complements for Sustainable Development in North Mali', pp 122-128.

9 FORTHCOMING CONFERENCES

4-10 August 1990, Urumqi, Xinjiang, China
International Conference on Karez (Qanat) Irrigation. For details, write to Mr Song Yudong, Xinyiang Institute of Biology, Pedology and Desert Research, Academia Sinica, Urumqi, Xinjiang, China 830011.

5-9 August 1990, Manaus, Brazil
International Seminar on *Hydrology and Water Management of the Amazon Basin.* Details from B P F Braga, Centro Tecnologico de Hydraulica, PO Box 11014, 05499 Sao Paulo, SP, Brazil. Facsimile 55(11)-8154272.

20-24 August 1990, Enschede, The Netherlands
International Symposium on *Remote Sensing and Water Resources.* Contact the Secretary, International Symposium on Remote Sensing and Water Resources, ITC (BPC), PO Box 6, 7500 AA Enschede, The Netherlands. Telephone 31(53)-320330 or facsimile 31(53)-304596.

27-30 August 1990, Saskatchewan, Canada
Conference on *Aquatic Systems in Semi-Arid Regions: Implications for Resource Management*, sponsored by the National Hydrology Research Institute and the Rawson Academy of Aquatic Science. For information, write to the Scientific Information Division, National Hydrology Research Institute, 11 Innovation Boulevard, Saskatoon, Saskatchewan, S7N 3HS, Canada. Telephone 1(306)-975 4022 or facsimile 1(306)-975 5143.

27-31 August 1990, Hyderabad, India
The 16th *WEDC Conference on Infrastructure for Low-Income Communities.* Includes a set of papers from those actively involved in the planning,

management, construction, operation and maintenance, and use of the infrastructure for low-income communities in rural areas. Details from Professor John Pickford, WEDC, Loughborough University of Technology, Leicestershire LE11 3TU. Telephone 44(509)-222390.

27 August-1 September 1990, Lausanne, Switzerland
The 22nd Congress of IAH and International Conference on *Water Resources in Mountainous Regions*. Information from Aurele Parriaux EPFL, GCBB (Ecublens), CH-1015, Lausanne, Switzerland. Telephone 41(21)-472355.

6-8 September 1990, Cranfield, UK
International conference sponsored by ODA and UNDP/World Bank on *The Monitoring, Maintenance and Rehabilitation of Water Supply Boreholes and Irrigation Tubewells*. Contact Mrs Mary Northwood, Silsoe College, Silsoe, Bedford MK45 4DT, UK.

10-14 September 1990, Amsterdam, The Netherlands
International trade fair and conference on water technology *Aquatech 90*. Contact Rai, International Tentoonstellings en Congrescentrum, Europaplein, 1078 GZ Amsterdam, The Netherlands. Telephone 31(20)-549 1212 of facsimile 31(20)-46 4469. Consisting of a trade exhibition, related conferences, and embracing Enviro 90 (concerned specifically with environmental engineering and water management), sectors covered with include waste-water treatment, water supply, storage and transportation, and irrigation.

10-14 September 1990, New Delhi, India
Conference on *Global Consultation on Safe Water and Sanitation for the 1990s*. Contact Dr Martin Beyer, Executive Secretary, Global Consultation New Delhi, UNICEF, 3 United Nations Plaza, New York, NY 10017, USA. Telephone 1(212)-326 7000.

12-19 September 1990, New Delhi, India
1990 UNDP World Bank Conference hosted by the Indian government, this global conference on Water supply and sanitation for low-income populations will focus on strategies for extending sustainable services to everyone in the 1990s. For information write to the UNDP, 1 UN Plaza, New York NY, 10017, USA.

5-7 November 1990, Bangkok, Thailand
International Seminar on Groundwater Management. Contact Professor Asit K Biswas, President, IWRA, 76 Woodstock Close, Oxford, OX2 8DD, UK. Telex 83147 VIA ORG.

17-19 February 1991, Alexandria, Egypt
African Regional Symposium on Techniques for Environmentally Sound Water Resources Development. Contact the Water Research Centre, 22 El Galla Street, Bulak, Cairo, Egypt, telephone 20(2)-756972, or to Hydraulics Research, Wallingford, OX10 8BA, UK.

13-18 May 1991, Rabat, Morocco
The 7th World Water Congress of the International Water Resources Association. Contact Professor Asit K Biswas, President, IWRA, 76 Woodstock Close, Oxford, OX2 8DD, UK. Telex 83147 VIA ORG.

June 1991, Vienna, Austria
The 17th International Congress on Large Dams. Information from International Commission on Large Dams, Secretariat, 151 Boulevard Haussmann, 75008, Paris, France.

4-9 August 1991, Taiwan
The 5th International Conference on Rain Water Cistern Systems. Contact Professor Show-Chyuan Chu, Department of River and Harbour Engineering, National Taiwan Ocean University, Keelung, Taiwan 20224, China.

18-23 November 1991, Bangkok, Thailand
The 8th ICID Afro-Asian Regional Conference on Land and Water Management in Afro-Asian Countries (provisional). Contact International Commission on Irrigation and Drainage, 48 Nyaya Marg, Chanakyapuri, New Delhi 110021, India. Telex 031 65920 ICID IN.

5-11 July 1992, Budapest, Hungary
The 16th ICID European Regional Conference. Contact International Commission on Irrigation and Drainage, 48 Nyaya Marg, Chanakyapuri, New Delhi 110021, India. Telex 031 65920 ICID IN.

10 CONFERENCE REPORTS RECEIVED

A *Workshop on Irrigation Performance*, sponsored by IIMI and IFPRI, and facilitated by Hydraulics Research, was held at Pangbourne, UK, February 1990.

The meeting was an outgrowth of work being done by the IFPRI (International Food Policy Research Institute), and IIMI to develop and apply a sound and coherent approach to irrigation system performance assessment, and to begin to build a database of irrigation performance information. The primary purpose of the meeting was to gain outside perspective on, and reaction to, the framework of concepts relating to the assessment of irrigation system performance which project participants have been developing. Important distinctions in a number of areas were laid out and discussed. These included: (a) varying purposes of performance evaluation; (b) different types of performance assessments (and associated audiences); and (c) the different functions of irrigation systems that can be evaluated (i.e. design, construction, system operation, and irrigated agriculture).

Two extremely critical distinctions in performance assessment were highlighted. The first is appreciation of the difference between **output and impact** measures of performance which relate to things which the irrigation system produces and transfers across its boundaries, and **process** measures, which relate to the internal workings of the irrigation system. Keeping these two classes conceptually separated is critical if cause and effect relationships are to be established and understood in the quest to improve system performance.

Secondly, one must distinguish between the **measured quantity** in a performance indicator and the **standard** against which it is judged. For example, the use of a coefficient of variation statistic in measuring equity of water distribution assumes per unit area equality of water supplied as the equity standard. In both cases alternative standards are common in practice, but are seldom employed in measuring and assessing performance. The failure to recognise and adapt, conceptually and methodologically, to these two types of differences was seen to be the source of a great deal of the disagreement and confusion which characterises current discussion of irrigation performance.

Further steps to be taken include the revision and publication of a set of papers laying out the framework and describing the family of indicators proposed to assess selected types of performance. The revised conceptual framework paper is nearly completed and should be available shortly.

Work on the paper dealing with performance indicators is continuing and additional work is being conducted on a scheme for classifying the different types of irrigation systems into categories. Field work for a pair of case studies of the hierarchy of goals which govern irrigation system investment and operation in Zimbabwe and Tamil Nadu State in India has been completed, and write-up is in progress. In addition, existing IIMI performance systems in Indonesia, Pakistan, the Philippines, and Sri Lanka are being analysed using performance measures developed to test their workability, utility, and sensitivity to data availability.

This work will be followed next year by a second phase of the project which will apply the performance assessment methodology in a fairly large number of sample systems. The information developed will be used with the classification scheme of system types to create the beginning of a data base on system performance.

Mark Svendsen (IFPRI)

The ICID held its *14th International Congress* at Rio de Janeiro, April 29-4 May 1990. Papers were presented for two questions:

(42) The Influence of Irrigation and Drainage on the Environment with Particular Emphasis on the Impact on the Quality of Surface and Groundwaters;

(43) The Role of Irrigation in Mitigating Droughts.

There was also a special session on the Socio-Economic Consequences of Mechanised Irrigation Techniques.

IIMI organised an *International Workshop on Strategies for Developing and Improving Farmer-Managed Irrigation Systems* (FMIS), 15-17 May 1990. This workshop was designed as an initiative to encourage better regional exchange of information on irrigation management in North and West Africa, to promote research on FMIS in Africa, and to develop better contacts with experience in Asia and South America. Papers were given in French and English and have been reproduced in 3 manuals:

1 *Experiences in the North of Africa and in Western Africa.* Papers cover Nigeria, Tunisia, Algeria and Senegal;

2 *Fundamental Questions Concerning Irrigation Policy in the North of Africa and West Africa.* This volume contains papers setting out general comparisons of the two regions, as well as papers on Morocco, Tunisia, Burkina Faso, Niger, Mauritania and Mali;

3 *Transfer of Experience between Africa and the Rest of the World.* Papers presented examine the possibilities of transfer of experiences between Asia, South America and Africa; experiences in Himalayan mountain environments; the humid tropics of Asia; Sri Lanka and South India; Argentina and the IIMI Programme to assist FMIS.

For further information, contact Jean Verdier, IIMI, c/o SEHA, 461 Avenue Hassan II, Al Akkari, Rabat, Morocco.

11 TRAINING COURSES

A calendar of international short-courses and workshops, scheduled for 1990 and 1991 has been compiled by the Indo-US Water Management and Training Project. To obtain a copy, write to Tom Kajer, Winrock International, 213 Ansal Chambers - 11, 6 Bhikayi Cama Place, R K Puram, New Delhi 110 066, India.

10 September-19 October 1990 (6 weeks), Delft, The Netherlands
Senior Advanced Course on *Appropriate Modernisation and Management of Irrigation Systems*, organised by the International Institute for Hydraulic and Environmental Engineering (IHE), Delft, and the German Centre for International Training in Water and Waste Management (DZWA) in cooperation with the FAO and IIMI. For information, contact the Registrar, IHE, PO Box 3015, 2601 DA Delft, The Netherlands. Telephone 31(15)-784466 or facsimile 31(15)-122921.

The Colorado Institute for Irrigation Management (CIIM) has several short-term training programmes available in 1990. In addition, special courses have been designed to meet specific needs of sponsors and participants. All enquiries should be addressed to the Shortcourse Coordinator, Colorado Institute for Irrigation Management, 410 University Services Center, Colorado State University, Fort Collins, CO 80523, USA. Telephone 1(303)-491 2868, facsimile 1(303)-491 2293, or telex 9 10 9309011 CSU CID FTCN. Courses include:

July 23-10 August 1990 (3 weeks) *Modern Surface Irrigation Design and Management*; **August 13-7 September 1990 (4 weeks)** *Flow Regulation and*

Measurement in Irrigation Systems; **3-28 September 1990 (4 weeks)** *Monitoring, Evaluation, Feedback and Management of Irrigated Agricultural Systems*; **1-26 October 1990 (4 weeks)** *Training of Trainers for Irrigation Management*; **October 29-16 November 1990 (3 weeks)** *Water Users Associations in Irrigation Management*; **November 19-14 December (4 weeks)** *Irrigation Systems Rehabilitation.*

The International Training Centre for Water Resources Management (CIFIGRE) is running a number of short courses this year. For details write to CIFIGRE, BP 113 Sophia Antipolis, 06561 Valbonne Cedex, France. The courses include:

September 24-19 October 1990 (4 weeks), Bangkok, Thailand *Planning, Design and Implementation of Irrigation Schemes*; **October 15-2 November 1990 (3 weeks), Lome, Togo** *Participation Communautaire aux Projets de Developpement Rural (Community Participation in Rural Development Projects)*; **October 22-10 November 1990 (3 weeks), Cotonou, Benin** *Informatique et Gestion des Ressources en Eau Superficielles (Computer Science on the Management of Surface Water Resources)*; **5-23 November 1990 (3 weeks), Sophia, France** *Formation Pedagogique des Formateurs (Training for Trainers)*; **19-30 November 1990 (2 weeks), Sophia, France** *Enseignement Intelligemment Assiste par Ordinateur (EIAO) Dans le Domaine de l'eau (Practical Use of Computers in Training in Hydrology)*; **3-21 December 1990 (3 weeks), Niamey, Niger** *Technologies Nouvelles et Gestion des Grands Fleuves (New Technologies for the Management of Large Rivers)*; **3-21 December 1990 (3 weeks), Bangkok, Thailand** *Island and Coastal Water Resources Management.*

12 COMMENTS ON NETWORK PAPERS 89/2

We have received some feedback on papers in the 89/2 set which may interest Network members.

(1) Tubewell Irrigation in Bangladesh by James Morton, 89/2d

David Potten of Huntings Technical Services has written in with complementary findings from Thailand. He also notes a wide divergence between theoretical and actual water demand on groundwater irrigation projects, which led to a policy of promoting deep tubewells where shallow tubewells may have been appropriate. He makes the following observations:

"(a) Theoretical versus Actual Water Demands

The Sukhothai Groundwater Project in Thailand offers the (unusual?) case of target cropping patterns, intensities and yields being achieved on at least the first group of wells to be operated. A direct comparison can therefore be made between calculated pumping requirements (based inevitably on theoretical crop water requirements), and actual demand. As water is supplied by electric pumps and hours pumped are recorded carefully and billed to the farmer, the farmers pay something close to the marginal cost of water supply, and is in effect charged on the basis of volume consumed.

The resulting demand pattern differs substantially from that calculated earlier. An annex to a recent report (by myself) analyses this. The important data is for 15 lowland wells for 5½ years and shows:

- theoretically calculated demand averaged 47,600m per well, per month;

- the actual annual average monthly demand has not exceeded 17,500 m;

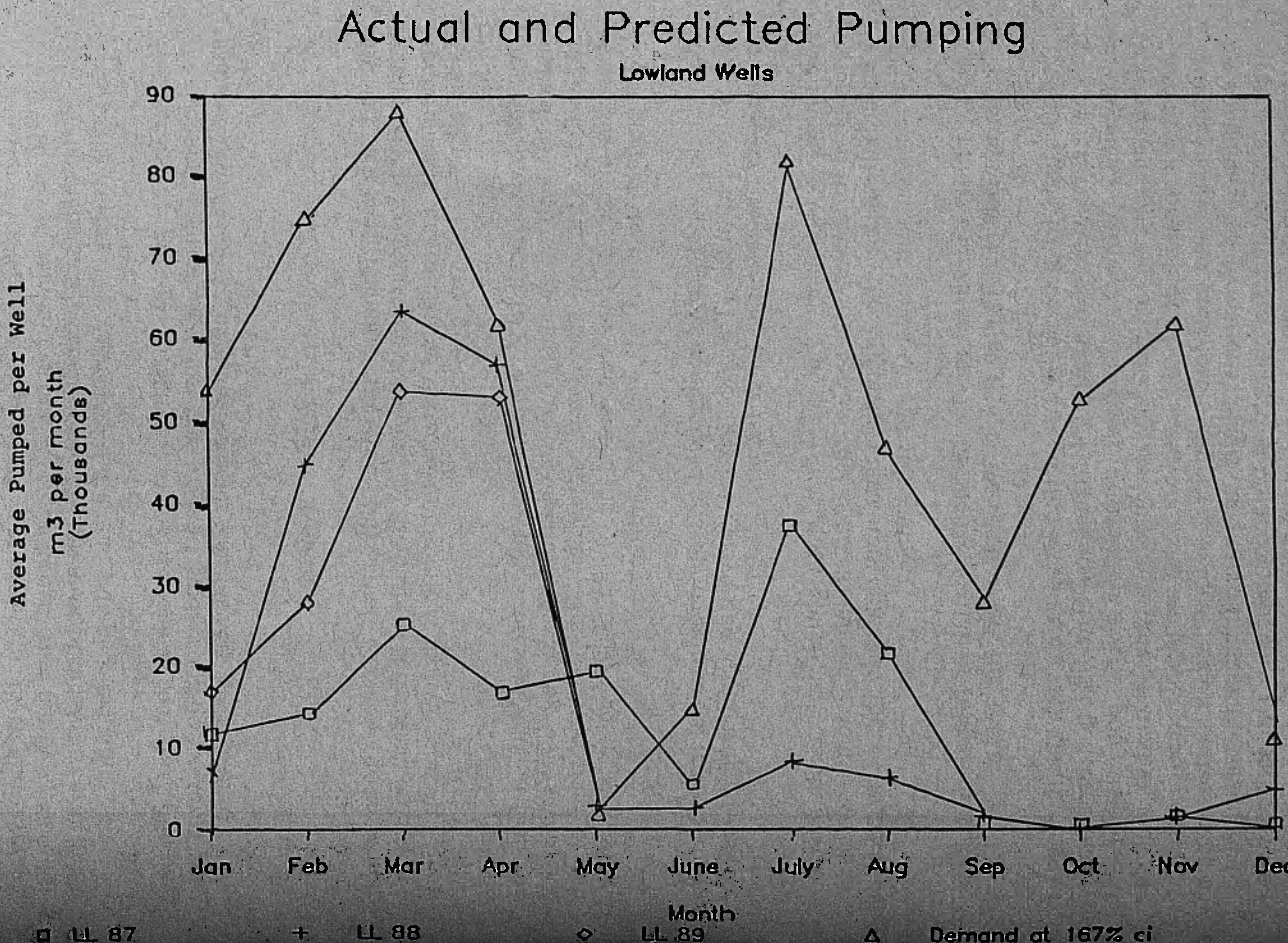
- the trimodal distribution of demand, predicted in the attached Figure, with peaks in March, July and November, is not at present being observed;

- the first peak, in March for the dry season HYV (High Yielding Varieties) rice crop is the main observed demand peak, but so far the March water requirement is only at about 60% of predicted levels, although in April 1988 and April 1989 the predicted level of pumping was close to the actual volume pumped;

- the second predicted peak, in July and August has been observed (strongly in 1984 and 1987) although peak pumping has never reached 50% of predicted levels. This peak coincides with the timing of land preparation, sowing and transplanting for the main (wet) season LV (Local Varieties) and HYV rice crops.

A comparison of the pumping results with rainfall figures for the 1984 to 1988 period does not undermine the above points, but explains some features of the pumping pattern. For example:

- in 1987, July rainfall was exceptionally low (25 mm compared to a long term mean of 152 mm) and this was associated with an observed peak in demand;



Actual and Predicted Pumping
Lowland Wells
Average Pumped per Well
m3 per month
(Thousands)
90
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
June
July
Aug
Sep
Oct
Nov
Dec
Month
□ LL 87
+ LL 88
◇ LL 89
Δ Demand at 167% ci

- overall 1984 and 1987 were wetter years than the average. However, rainfall has not differed enough from the figures used in the theoretical calculations to explain most of the differences in the Figure between predicted and actual pumping demand.

It appears at present therefore, to be probable that the pumping requirement figures used for the lowland rice cropping patterns may significantly exceed the pumping volumes that farmers are prepared to pay for.

(b) Deep Tubewell versus Shallow Tubewell

In the Project Planning for the Sukhothai Project, groundwater requirements for irrigation, estimated on the basis of theoretical crop water requirements, indicated that there was only one technical solution - deep tubewells.

The shallow tubewell (STW) option was not addressed and, in fact, the impact of deep tubewell (DTW) installation on existing STWs was not evaluated. This may have been excusable. Between the time of the feasibility studies and the commissioning of the DTWs, many new STWs were privately installed, for irrigation and domestic water supply.

Nevertheless, once DTWs commenced operation and started to draw down the watertable these STWs became ineffective and significant costs were incurred in compensating STW owners.

Although, it is unlikely that STW irrigation could have been a viable alternative to DTWs, it is certain that if actual pumping demands remain substantially below the originally calculated demands the economics of DTW development would change substantially".

(2) Equity Considerations in the Modernisation of Irrigation Systems by Gilbert E Levine and E Walter Coward Jnr, 89/2b

Philip Kirpich, from the USA has written in agreeing with the findings of this paper, but with two additional comments. The first concerns farmer involvement, particularly in water distribution. The potential of this involvement can be stimulated by in-depth interviews, but what is clearly needed is a corporation of public servants who are prepared to spend time in rural villages and exert leadership. These local level initiatives need to be complemented by national leadership; without these the management strategies advocated are unlikely to be accomplished. The second set of comments concern 'modernisation', and the caution against applying over-sophisticated technologies when existing familiar technologies can give adequate results.

Gilbert Levine has replied, welcoming these comments, and writes "... I am not sure that a formal procedure by which farmer inputs are explicitly obtained would be adequate, but it seemed a reasonable way to start. My experience with a number of irrigation departments suggests that even this would not be easily to initiate. Our experience with department reaction to 'irrigation organisers', individuals trained to assist the farmers in relating to the irrigation department, has been that it takes considerable time for the departments to see the value and even longer to find a 'place' in departmental or ministerial structure for them. I certainly agree with your observations about the need to use appropriate technology, and that much of the technology commonly specified for irrigation systems is inappropriate. We haven't been very successful in getting this idea across."

The Irrigation Management Network has 25% of its members working in public irrigation services. Can we hear from more of you to discover more of your own initiatives in working with farmers?

13 FUTURE NETWORK PAPERS

We hope that Network papers in the future can contribute to new themes emerging for the 1990s, or some less debated topics, a well as continuing to contribute to well-known issues such as farmer-management in irrigation, rehabilitation, water charges, etc. Topics we would like to debate during 1990/1991 include:

(a) groundwater development in risky environments (e.g. semi-arid, hard rock areas);

(b) management of water allocation in scarcity conditions;

(c) research methodologies for understanding current and prospective local institutions and organisation for irrigation management, especially with decentralised or privately-funded irrigation development and management.

Please send in potential contributions, or details of work you would like mentioned.

Topics on which we have published relatively little in recent years include:

(d) farm-level economics, incomes and marketing;
(e) land tenure, settlement and resettlement;
(f) irrigation agronomy, crop choice, flexibility;
(g) crisis management;
(h) environmental impact;
(i) choice and management of water delivery systems;
(j) bureaucratic relationships and staff management.

If you have interests in these areas, let us know, as we may be able to target themes to discuss specifically at a later date.

Where possible, please try to keep submissions brief, preferably around 4000 words, (5500 words is the maximum we can accept). Typescripts are acceptable, but if you can send material on disk, our preferences are for Word Perfect 5.0 (we can usually convert from other packages). Tables can be reproduced, but we ask that the number be restricted to three per paper. We cannot undertake to publish all papers sent in, but these will normally be held in our library collection.

If you wish to alert other Network members to a particular research interest or development, then a 3-4 line summary is helpful.

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IRRIGATION MANAGEMENT NETWORK

FARMER PARTICIPATION IN PLANNING, IMPLEMENTATION AND OPERATION OF SMALL-SCALE IRRIGATION PROJECTS

Ian Smout

ODI/IIMI Irrigation Management Network Paper 90/2b July 1990

Papers in this set:

90/2a Newsletter
90/2b Farmer Participation in Planning, Implementation and Operation of Small-Scale Irrigation Projects by Ian Smout
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90/2d Estimating the Economic Profitability of Irrigation: The Case of Brazil by The FAO Investment Centre
90/2e Tank Irrigation in South India: What Next? by K Palanisami

Please send comments on this paper to the author or to:

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Comments received by the Editor may be used in future Newsletters or Papers

FARMER PARTICIPATION IN PLANNING, IMPLEMENTATION AND OPERATION OF SMALL-SCALE IRRIGATION PROJECTS

Ian Smout

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FARMER PARTICIPATION IN PLANNING, IMPLEMENTATION AND OPERATION OF SMALL-SCALE IRRIGATION PROJECTS

Ian Smout

1 INTRODUCTION

1.1 Purpose and Scope

The aim of this paper is to recommend practical methods of executing small-scale irrigation projects through farmer participation. The key points are summarised in Table 1 (centrefold). These are discussed and expanded in the paper.

The paper is an attempt to integrate my consultancy experience as an engineer in Asia, published accounts of experience elsewhere, and discussions with colleagues (for example in the UK working group on small-scale irrigation). The main ideas were formulated during work on tubewell irrigation in Indonesia in the mid 1980s and more recently on hill irrigation in Bhutan. (Details of this work may be found in Smout, 1986 on the Madura Groundwater Irrigation Project and van Bentum et al, 1989 on the Chirang Hill Irrigation Project.) These projects are used as examples in the paper and their characteristics provide the focus of the discussion: both projects are implemented by government agencies and consist of numerous discrete irrigation schemes; on each scheme there are many households and a water user association (WUA) provides a structure for participation.

After introductory material on small-scale irrigation projects and participation, the recommendations for each stage of a project are discussed in rough chronological order in sections 2 to 5, starting with overall project organisation and then dealing with the preparation, implementation and operation of a particular scheme.

1.2 Small-scale Irrigation Projects

Small-scale irrigation has been defined (Carter, 1989) as:

> irrigation, usually on small plots, in which farmers have the major controlling influence, and using a level of technology which the farmers can effectively operate and maintain.

The concept of small-scale irrigation thus combines small *size with farmer* management. It covers a wide range of complexity from the small garden of a single household, to canal and tubewell systems which serve 50 farmers or more. It includes both 'traditional' irrigation schemes built from indigenous technology and new developments with external assistance.

Traditional schemes present numerous success stories of small-scale irrigation. Farmers have been constructing and operating these schemes successfully for centuries all over the world. In most African countries for example (except for Egypt and Sudan), the area of farmer-managed irrigation is much greater than the area of formal irrigation (FAO, 1987). Most traditional irrigation schemes have small command areas, but there are also some large schemes of several thousand hectares, for example the Chhatis Mauja in Nepal, a 150 year old system which irrigates 3000 ha. This is run by the farmers through a three tier representative structure, with rules and methods which have been developed for maintenance, detection and punishment of infringements, and allocation and distribution of water (Chambers, 1988; the scheme has also been studied by IIMI). This scheme illustrates farmers' capability over the range of *irrigation* management tasks and shows that farmer management is possible even on large schemes. However there are also farmer-managed irrigation schemes of various sizes in Nepal and elsewhere which seem to have failed or under-achieved from poor management, for example inadequate maintenance. Examples can be found in applications to government for the renovation of these schemes.

Farmer-managed irrigation has been neglected in the past, and small-scale irrigation in particular may still be under-estimated in government statistics, but both its existing contribution and its potential to improve agricultural production are now much better recognised.

As well as this greater recognition, governments and aid agencies are now attempting to promote and improve small-scale, farmer-managed irrigation through development projects, perhaps because of the high cost and disappointing performance of some recent large, formally-managed irrigation projects. This interest in developing small-scale irrigation has resulted in the involvement of professional staff, from government, non-governmental organisations (NGOs) and consultants, in the planning and implementation of small-scale irrigation, instead of these being carried out by the farmers alone. On some projects this process has excluded farmers' participation, but this loses the benefits of small-scale irrigation and is unnecessary. Practical ways are described below for professional staff to work with farmers effectively to produce farmer-managed irrigation schemes.

Small-scale irrigation projects cover both the improvement of traditional irrigation schemes and new developments to introduce small-scale irrigation on land which is not currently irrigated. Each project is assumed in this paper to include a number of individual irrigation schemes.

The main aim of these projects is to improve farmers' production where water shortage is a major constraint, by investments in irrigation infrastructure which improve water availability at the field. In general these projects work with the existing landholdings and structure of power. However in some cases small-scale irrigation is used to bring new land under cultivation, which can then be allocated to village families. Small-scale irrigation may also be directed to benefit disadvantaged groups, for example the programmes of various non-governmental organisations in Bangladesh, to provide landless groups with a tubewell or low lift pump so that they can sell irrigation water to farmers with land (Palmer-Jones and Mandal, 1987).

1.3 Participation

McPherson and McGarry (1987) define participation as the inclusion of the intended beneficiaries in the solving of their own problems. They describe the benefits of participation as:

- lower costs;
- a greater likelihood of user acceptance of the technology;
- appropriate and socially accepted designs;
- user care and maintenance of the facilities;
- the assumption by the users of part if not all of the responsibility for operations and maintenance.

These are strong arguments for a participative approach to small-scale irrigation projects, especially as the crucial long term operation and maintenance tasks will normally have to be carried out by the community for cost and logistical reasons. Participation of farmers in the earlier stages of the project then helps to ensure that they will be able to carry out these tasks successfully. However a flexible approach is needed to achieve this, and after reviewing user participation in water and sanitation projects, McPherson and McGarry (1987) reach the following conclusions:

> The degree of participation is really not the central issue. Ideally users should be involved in every phase of a project but this is sometimes not feasible for a variety of reasons. What is vital is that the participation should be an agreeable and beneficial experience for the users so that when the facilities are constructed they have a sense of pride in their ownership of them, are pleased with what they have accomplished and have learned how to care for the system.

Similarly for small-scale irrigation schemes, participation is not a fixed procedure to be followed strictly like a blueprint, but a general approach of joint work between the farmers and the agency. Forms of participation will therefore vary between projects and even between schemes on the same project.

Although valuable lessons can be learnt from experience on other community development projects such as water supply, participation in small-scale irrigation projects may be more complicated and difficult. Particular problems arise because farmers with larger landholdings will normally benefit much more than others from the scheme. This is one of the limitations of irrigation projects on existing landholdings compared to settlement projects with equal sized plots (though in practice settlement projects have often had difficulty providing reasonable benefits for the settlers and maintaining equity between top-enders and tail-enders and between early settlers and late settlers).

2 PROJECT ORGANISATION

2.1 Implementing Agency

Ideally the same agency should be responsible for the irrigation engineering and the development of farmer participation, so as to ensure that the participation feeds back into the engineering decisions. A key step in the Philippines seems to have been the combination of these functions in the National Irrigation Administration (Bagadion, 1989). This requires that the agency has the necessary expertise and commitment to farmer participation, which may be new to government irrigation agencies. NGOs however are often particularly well suited to implement small-scale irrigation projects because of their general grassroots approach (Carter, 1989).

For projects which work with the existing social structure, local technical staff are well able to implement a policy of participative development, given on-the-job training and support. However it is important that staff have a positive attitude towards participation. Problems are likely to arise if there is a wide difference in the relative status of project staff and farmers, in which case staff are unlikely to encourage effective participation unless they are really pushed by their superiors.

It is easier for a project to follow a participatory approach if this is the accepted policy of the agency. If participation is being introduced for the first time, it is important that the senior staff in the agency understand and support the participative approach. It would be unrealistic to expect junior staff to introduce a participatory approach without institutional support, or to pursue radical social objectives.

If there are difficulties adopting a fully participative approach, it may be possible to start with limited consultation, and use this as a learning process which leads to greater participation.

Important factors on the hill irrigation project in Bhutan have been:

- the government policy that farmers have to provide the unskilled labour required for rehabilitation work;

- the consensus on the participative approach among the project staff, project manager, technical staff and consultant;

- the rapport which has developed between the technical staff and the local farmers, particularly the village heads and the leaders of the water user associations (WUAs).

2.2 Choice

One way in which a project can approach participation is to provide the farmers with choices between different technical options. This process depends on decision-making by a group (except where each individual has an irrigation source, for example, a small pump project) on matters which affect individual farmers in different ways. It may be difficult to get agreement, and decisions may change erratically in some circumstances, but this problem applies to all forms of participation. Skilful project staff can lead the group towards firm decisions, with assistance from local leaders.

At its most fundamental, this approach entails explaining and demonstrating clearly what the project can offer, under what conditions (covering contributions of money or labour, responsibility for operation and maintenance, etc), and giving the farmer group the choice whether to apply for a scheme or not.

Some projects may be able to offer a choice of the type/size of development, possibly like a 'shopping list'. For example, a groundwater project might be able to offer choices between a shallow tubewell and a deep tubewell, a short-life and a long-life screen, a diesel and an electric motorised pump, and between a simple discharge box and a full distribution system with canals and structures. Farmers' choices on these will clearly depend on the conditions attached to each, such as costs, and these must be fully explained.

Other projects offer just one type of development and choice may be limited. For example, the Indonesian groundwater project used deep tubewells with diesel powered pumps, and standard canal and structure designs. The layout of the command area and canals and structures was the only area of choice in the design. (Nevertheless, as discussed below, the choice of this layout is extremely important to the farmers.) The Bhutan project covered rehabilitation of gravity canal systems within a budget limit, and the main choices here were the priority lengths of canal for rehabilitation, and the works to be constructed.

2.3 Replication

It is usually desirable for a small-scale irrigation project to cover a number of schemes, so that the total area which benefits is sufficient to justify the start up costs of outside assistance. Ideally the schemes are all close together, and of a similar type so that the same approach can be used on each. It is necessary to plan for this expansion and replication from the beginning, and develop the institutions which will carry it out. Four elements seem to be important:

- developing with the local staff, simple standard procedures and designs which are suitable for the project and acceptable to the farmers. This may take some time, discussions and trials, before a satisfactory package can be finalised;

- training local staff to carry out these procedures;

- allowing flexibility for local modification and bargaining with the beneficiaries where necessary;

- establishing good relations with the local communities, an understanding of the project's aims and activities, and a good reputation, so that there is a demand for schemes.

2.4 Project Timescale

It commonly takes some years to establish the project as described above and build up to a high rate of implementation. Each individual scheme may also have a long preparatory and design period, with a series of meetings, during which the farmers' understanding and decisions firm up. It is necessary to allow for this time in the overall project programme. The standard five year project term is often too short for the stages of establishment, build up and replication, and does not allow a project to achieve its full potential benefits.

Small-scale irrigation is little different in this to other types of participative projects for the construction of small works. Working on irrigation in Bhutan, the most valuable guide I found to organisation of a participative project was the account by Glennie (1983) of the development of an organisation to undertake participative rural water supply in Malawi. He describes the two year pilot phase and six year consolidation phase of the programme before it reached full development. Glennie emphasises that the rate of expansion was controlled at the level at which staff could be trained and the work properly supervised.

3 PREPARATION

3.1 Mobilisation and Leadership

3.1.1 Approach and Communications Methods

Communication and mobilisation are recurring activities, which arise at various times during the development of a scheme. Information about the project may be spread through the local administration and meetings with village leaders or directly in the villages themselves.

Early requirements are to spread information about the scope of the project and to raise the farmers' awareness and interest. These often involve the introduction of new ideas which are outside the farmers' understanding and experience, covering both the potential of irrigation and its limitations in the local situation. Development staff have the difficult task of devising a suitable way to communicate these ideas.

A practical, field-based and participative approach seems to be appropriate, and agricultural extension can provide some useful guidance for this, with its emphasis on simple messages and use of demonstration sites. My preferred approach is to get work started wherever there is interest from the farmers and local leadership, to learn from the initial schemes and thereby develop suitable standard procedures, and then to use the most successful of these schemes as demonstration sites to focus discussion on the project's approach with farmers from elsewhere. The key is to get started, and then to develop a successful package which is demonstrable and replicable.

In another paper in this set, Millican (1990) describes different ways of communicating with farmers groups through discussion, including the use of stories. These techniques are interesting both for mobilisation and for subsequent discussions with farmers as the scheme progresses. Health education workers also have considerable experience in community mobilisation, and Laver (1986) provides a valuable example of communication methods adopted at the different phases of a project for low cost sanitation in Zimbabwe. I found these useful for tubewell irrigation development in Indonesia. The methods include meetings with key leaders, group discussions, visits to demonstration sites, and use of various types of visual aid. Visual aids made for the Indonesian project comprised posters and videos to put over the project's messages in an attractive way, and we also used an existing film. Both the videos and the film were built around a story. In all cases the main purpose of the visual aids was to arouse interest, and the message itself was stressed verbally as clearly as possible, for example by a summary at the end of the video. Conveying messages through the pictures themselves is complex, requiring greater skills to prevent misunderstandings.

Some innovative training techniques have also been developed for health education, including song, dance, drama and role-play (Werner and Bower, 1982). These techniques have been tried for agricultural extension in a limited way, including, for example, the use of puppets in Nigeria and Bhutan, and they could also be used to generate interest in small-scale irrigation.

3.1.2 Institutions

In some countries (notably the Philippines), specialist Community Organisers have been posted to the villages for several months to facilitate the process of mobilisation. In principle they may be able to by-pass the existing power structure and encourage democratic participation, including the involvement of people who are often not consulted such as women and the poor. In practice however their success may depend on support from the large landowners. The Community Organiser may remain in the village throughout the preparation and implementation stages of the scheme. (Illo, 1989, gives an interesting case study.) This is an exciting approach, which could be a means of introducing real social change, but it requires substantial resources of educated personnel who are prepared to work in the villages. It may generally be easier for NGOs to work in this way than for government agencies.

Government agencies in other countries rely more on their usual technical and administrative staff, working through the existing social and administrative structure to mobilise farmer participation. This approach can also require a significant commitment of time for meetings, etc. In a cohesive community with good leadership and trust in the government staff, the approach can work well, but in other circumstances local divisions and powerful individuals can cause major problems, possibly resulting in the failure of the scheme.

These local forces can be seen as built-in hazards of farmer-managed irrigation. Three possible unifying forces are discussed below:

- the project staff;
- the local government structure;
- the group of beneficiaries organised in a water user association (WUA).

Project technical and administrative staff can carry out similar work to Community Organisers (but in a more limited way) provided they are well supported by their agency and can call in assistance from senior staff when problems arise. On-the-job training is needed initially. With continuity, staff can develop good relations with the farmers over the project period, which is very important for implementing the scheme.

Local government representatives and officials can provide leadership, endorsement of the project, and assistance in resolving the frequent misunderstandings and disagreements which arise among the farmers and between them and the agency. It is important that the local administration also respects the farmers' right to make decisions about the scheme.

A WUA can offer some countervailing power to any divisive forces in the community. The WUA is an organisation of the beneficiaries of the scheme, which holds meetings and co-ordinates farmers' activities such as operation and maintenance. Ideally it is run like a cooperative, with responsible elected officers, and written records of decisions made in the meetings and of WUA accounts. One of the important aims of the project staff should be to develop a strong and effective WUA (see sections 4.1 and 4.4).

In practice, local elites are often powerful and may have a strong influence over the WUA, but the structure of the WUA provides some constraints. As the consultants on a deep tubewell project in Bangladesh point out (MacDonald and Hunting, 1987):

> [The WUA] involves the placement of existing power groups within a framework of procedures and control and the development of their accountability within this framework...The clear advantage of this approach is that it makes use of scarce resources of management and leadership in villages.

Leadership is crucial, to overcome the inertia and wariness in the community, and persuade the farmers to work together for a sustained period before receiving the benefits which result from small-scale irrigation. This leadership may be developed by a Community Organiser, or it may come from a respected community leader or entrepreneur. Sometimes it can also be provided by a charismatic leader, such as the Aga Khan in parts of Pakistan.

3.2 Application for Development

It is important that the initiative for the scheme comes from the beneficiaries, and it is not imposed from outside. One way to do this is to start the development process with an application for a scheme. On the Bhutan project, villagers who want improvements to their canal must submit an application, in which they provide details of the farmers and their irrigated landholding areas on the canal, request improvement works, say how much unpaid labour they can provide each month, and commit themselves to maintain the works in future. This application must be signed by all the beneficiaries, so it encourages them to meet and discuss the project. The application can also be a valuable bargaining tool later, as the villagers (or the agency) can be reminded of the commitments they made, to provide labour etc.

3.3 Meetings Between Project Staff and Farmers

Project staff should try to establish a community consensus about the scheme at an early stage, and this requires that they clearly explain the proposals, the timetable, and the farmers' obligations if the scheme goes ahead. Similarly, farmers can be encouraged to explain their difficulties, for example over working on the scheme at certain times, or problems with land or water rights. It is important to determine whether there is real interest in the scheme, or if it is just being pushed by one or two powerful individuals without community support.

In initial meetings, farmers can advise project staff about the existing problems which need attention, and their priorities. It is important for the project staff to identify the constraints on the existing cropping, and how these may be overcome. On the project to improve existing canals in Bhutan, a 'problem area' approach was adopted, whereby work was concentrated on the problem sections of the canal which limited its overall conveyance capacity. The value of the materials and skilled labour to be used on each canal was limited to $450 per hectare in 1986, which was the average cost used at appraisal of the project. The per hectare cost limit is one of the few feasibility criteria available to a development agency in small-scale irrigation (see for instance Ansari, 1989); it requires the agency to make reasonably accurate estimates of cost before committing itself to undertake a scheme.

The problem area approach need not be applied only to the physical irrigation infrastructure. The constraints may lie elsewhere, possibly with the management (requiring work to strengthen the WUA), or agricultural services, or markets. In these cases, it is unlikely that farmers will be interested in working on irrigation development until these problems are solved.

In these early meetings, the command area boundary can be a major issue, and discussions need to be held with the farmers to decide the location of the boundaries of the command area, which farmers' land is to be included, and which excluded. Considerable change may be involved: Martens (1989) describes a project in Nepal where the farmers persuaded the engineers to increase the command area by 70% over the initial proposal.

KEY POINTS FOR FARMER PARTICIPATION IN SMALL-SCALE IRRIGATION PROJECTS

KEY POINT	EXPLANATION	POSSIBLE DIFFICULTY IF NOT DONE
PROJECT ORGANISATION		
Agency covers both engineering and participation	To enable dialogue between the farmers and the engineer	Confusion and inter-agency disputes
Senior agency and project staff support the policy of farmer participation	Agreement within the agency is necessary to provide consistent approach	Staff will tend to neglect participation as though it is unimportant
Procedures and designs are standardised	This makes it easier to understand the options and to reach agreements. Also necessary for replication	Extra time needed for design and for construction supervision. Wasteful mistakes. Slow progress.
Staff are trained in project procedures, etc (including newly appointed staff)	Participative procedures are likely to be new to many staff	Staff fail to implement the procedures as intended
Agency agrees basic project concept and division of responsibilities with local administrative leaders	The project should be consistent with other local programmes. The local administration can assist in resolving disagreements and disputes with the farmers	Disagreements with the local administration can cause disruption and confuse the farmers
Demonstration sites are set up and used for farmer visits	These provide a physical example of the project concept which farmers can see and understand	Farmers are likely to be uncertain about the project concept and its value
Project programme includes reasonable time allowance for start up and gradual expansion	Time is necessary to develop viable procedures and designs and train staff and implement maximum number of schemes	Project progress will be below target and emphasis on output may reduce standards
SCHEME DEVELOPMENT		
Staff hold open meetings in village to discuss project, including project scope; land and water rights; villagers obligations to contribute cash, labour, land, etc; responsibilities for operation and maintenance; timetable.	It is essential to clarify these issues before going ahead with the scheme	Farmers will be reluctant to participate and disputes may arise later about issues which were not explained in advance

Farmers groups submits application for assistance with irrigation development	The application requires prior discussion among the farmers and represents a commitment to the scheme	Agency may go ahead with a scheme which farmers do not want
Water user association is set up	Provides a structure for participation	Difficult for agency to liaise with farmers and get firm decisions
Staff hold discussions on site on preliminary design	Need to agree command area, canal layout, position of outlets, etc	Disagreements with farmers during construction and possible damage to works later
Technical staff retain responsibility for technical decisions	The training and experience of technical staff must be used to develop appropriate designs for farmers' needs	Waste of resources in unsuitable or short-lived works
Farmers contribute unskilled construction labour	This gives the farmers a direct involvement in the scheme and trains them for operation and maintenance	Farmers consider the scheme belongs to the agency
Farmers elect construction committee or leader to organise their construction labour	The difficult tasks of organising farmers' labour are best done by their own representative	Poor labour turnout and poor work performance. Waste of agency staff time
Project has separate base force of skilled and unskilled labour	The project labour force can then work independently of the farmers on complex tasks	Delays and inefficient use of skilled project labour
WUA is formalised and opens a bank account	The responsibilities of WUA officers are specified and procedures are standardised	Erractice WUA performance and unaccountable officers
Agency trains WUA officers	The officers' tasks are unfamiliar and need to be explained and demonstrated	Inactive officers
Scheme is handed over to WUA after commissioning and WUA is then responsible for operation and maintenance	The responsibilities of the WUA and the agency must be stated very clearly	Delays in hand over can cause confusion about the farmers' responsibilities
Agency monitors condition and performance of scheme	The role of the agency is to check and support the work of the WUA, not direct it	Preventive maintenance might be neglected or a weak WUA could become inactive

It is important to remember that the command area defines the group of people who will have to cooperate in the eventual operation and maintenance of the scheme, and the existing social relationships in rural communities are very relevant to this. As an example, in southern Bhutan there are numerous small, parallel canals, each constructed by a small group of about 5 to 10 families. In some cases, the canal crosses another canal to feed a lower command area. However, attempts to persuade the farmers to combine two traditional schemes into one improved scheme have failed, even where this has been a condition for providing government assistance. The farmers insisted that each canal should continue to serve the same group of beneficiaries as in the past, and they would not consider combining small command areas so that they would be served by one improved supply canal.

In the Indonesian tubewell project, the farmers' main concern was that the command area should all be in one village, to prevent the administrative problems which arose if two villages were involved. It may be noted that the project staff accepted the farmers' point but they could not comply with it without farmer participation; the relevant information was not shown on the maps.

These are examples of the general issue of land and water rights, and if these are not clear, farmers may be reluctant to participate. This happened on a small village scheme in Tanzania which was constructed to irrigate a particular area of uncultivated land, but it was unclear which villagers would eventually farm the land. An example of the importance of water rights comes from discussion with Indonesian engineers in East Java, who are reluctant to construct new diversion structures in the hill areas, because of the consequences for downstream users.

Following approval of the scheme, an agreement to implement it can be made between the farmers and the agency. It is important to include all relevant obligations: Martens (1989) reports that farmers on a project in Nepal objected to the introduction of a water charge because it had not been mentioned in the project agreement they had made with the agency. Similarly, if the farmers have to contribute the land required for canals, etc, without compensation, this should also be included.

4 IMPLEMENTATION

4.1 Water User Association

In order to create a structure for participation, a water user association (WUA) is usually set up on each scheme, with all the beneficiary farmers as members. The WUA is in principle independent of the agency and government, and responsible to its members. However it is usually set up with assistance from the agency and constituted according to standard agency regulations.

The appropriate time for setting up the WUA will depend on local issues, and in some circumstances this may be at the time that the scheme is commissioned. However there are strong advantages in starting the WUA at an earlier stage to assist with participation in design and construction.

It can then hold open meetings to discuss the scheme and elect committees to liaise with the survey and design teams, etc.

It is important that the WUA is orientated towards involving farmers in the immediate practical tasks, with flexibility to develop as the scheme progresses and the necessary tasks change, until eventually it takes on its long term operation and maintenance role. This facilitates participation, strengthens the WUA organisation, and encourages the recognition of capable individuals and their value as WUA officers. To some extent this may counter-balance the local power structure. Illo (1989) provides an interesting case study of this approach from the Philippines.

At the planning stage of a small-scale irrigation scheme in Nepal, the beneficiary group is identified, which can elect a construction committee, and later become a WUA. The committee has to raise a certain proportion of the estimated cost of the scheme, and deposit the cash in a construction committee account. The system has been described in a recent Irrigation Management Network paper (Ansari, 1989).

Another approach is to sell irrigation facilities to the farmers. For example, deep tubewells in Bangladesh are sold to village cooperatives at a subsidised rate, through a credit system. A weakness of the Bangladesh system is that the cooperative may be dominated by a few local families, and exclude many water users from membership, which limits its effectiveness as a WUA.

An issue which has arisen in Indonesia and Bangladesh is whether water user associations should be based on irrigation units (to facilitate irrigation management), or administrative units (to liaise better with the local government structure). In many situations this problem can be avoided at the planning stage, by choosing the command area to fit the administrative boundaries, for instance by designing each scheme to serve land in one village only. This may well be what the villagers themselves want. As far as accountability is concerned, it is my view that the WUA should be primarily responsible to its members, rather than the village leader.

Another important issue is the degree of formalisation which is appropriate for the WUA. At the early stages of a project when farmers are probably hesitant about participating, the WUA may best be fairly loosely structured for the immediate tasks, and may be based on a previous informal organisation. When trust has been established and procedures have been developed, there are advantages in formalising the responsibilities of the WUA officers and opening a WUA bank account. This formalisation could involve a legal framework to give the WUA rights such as the following (GDC, 1989):

- the right to make contracts;
- the right to bring legal action against defaulting suppliers;
- the ability to obtain credit;
- rights of ownership of the irrigation canals and equipment.

4.2 Design

Irrigation design is not a direct deductive process which generates a unique solution. Particularly in the design of the general concept and the canal layout, the engineer attempts to satisfy various objectives (e.g. close fit with the farming system, low capital cost, high efficiency, simple operation and maintenance), and considers various possible solutions before developing the design which seems most suitable. The chosen design is therefore not the only one nor necessarily the 'best' possible, and the experienced designer is well aware that another engineer would probably develop a different solution. It is important to remember this when designing works which directly serve farmers, such as small-scale irrigation schemes and tertiary canal systems on large schemes, because the engineer may not be able to take account of all the local factors in selecting a suitable design. For example, the unseen landholding boundaries of social groups and individual farmers are often as important as the topography.

Vermillion (1989) has described the alterations which farmers made to engineers' designs on a project in Indonesia, including destroying works after construction. These alterations arose from the better local knowledge of the farmers, and because some of their criteria differed from those of the engineers. Elsewhere, engineers observe that farmers have modified structures and canals because they misunderstood the designs, or because minorities have tried to get unfair shares of water. Many of these changes (and waste of resources) could be avoided by involving the farmers at key points in the design process, to enable the designer to take account of their objectives, and to explain important aims and constraints (e.g. water availability).

Discussion is required between project staff and the farmers on the works to be carried out, before the designs are prepared in detail and finalised for construction. Particularly sensitive issues are the alignment of canals (which will govern who loses land, and who has best access to the water), and the position of outlets. These issues include various possible sources of conflict, and a representative committee (of the WUA) can help to overcome problems. It is wise to involve as many farmers as possible; the issues can best be discussed by walking the canal line with the farmers, and trying to reach agreement on site. Some negotiation may be needed, with compromises from both sides, but it is important that the project staff retain responsibility for technical decisions, and for example do not agree to increase the size of a canal unjustifiably or to construct an unsuitable structure.

On the Indonesian tubewell project, discussions about operation and maintenance were held with WUA officers after commissioning of the first tubewells. These discussions brought up various questions and criticisms about the original designs, including the boundaries of the command area and the positions of outlets on some schemes. As a result, a more participative approach was adopted at the design stage of future schemes, to settle these issues at the right time. Design staff spent more time in the field and there was an increase in the total time required to design each scheme, but the results seemed more satisfactory.

In the participatory approach adopted in the Philippines the Community Organiser encourages the farmers to discuss the plans with technical staff. Bagadion and Korten (1985) provide a detailed description of this. They report that an important technical effect of the participatory approach was to improve the designs of the tertiary canal networks (similar costs, much less damage and greater utilisation by the farmers).

It is important to use standard designs for the irrigation canals and structures, to simplify both design and construction as far as possible, making it easier for the farmers to understand the works and build them correctly with minimum supervision, and also facilitating replication of the works on other schemes. Somewhat different design criteria may be needed for small-scale irrigation than for larger schemes, for example to take account of fluctuations of water availability or limited hours of operation per day. The standard designs need to be based on suitable materials and construction methods, so that villagers will be able to carry out the necessary maintenance later.

Usually the project design will aim for durability, but in some circumstances the farmers may be satisfied with works which have a relatively short life, provided that they work well until then and can be replaced relatively easily; motorised pumps are an example. In some situations, the easiest way to promote small-scale irrigation may be to make a suitable pump readily available for farmers to purchase, with credit if necessary. The pump may be powered by diesel, petrol, animal or human power. Lambert and Faulkner (1989) describe various simple pumps.

4.3 Construction

Small-scale irrigation projects commonly involve farmers in construction of the scheme. This has two advantages:

- they are more likely to regard the works as their own, after working on them, rather than as belonging to the agency;

- they have a direct interest in the quality of the works.

In addition they may contribute to the capital cost of the works, by providing unpaid labour (as on rehabilitation projects in Bhutan), or cash (as on tubewell projects in Bangladesh), or a mixture of cash and labour (as in the Philippines and Nepal). Farmers' contributions may be made in equal amounts per household, or according to their irrigated landholding which appears fairer.

Sometimes it may seem that the implementing agency's main interest in community participation is to reduce costs by using unpaid labour. However, farmers may only provide the labour if they approve of its purpose, in which case they get an effective veto on the works constructed. For example, on the hill irrigation project in Bhutan, there was considerable discussion with the farmers about some of the proposed works, especially at the early stages of the project, and even at later stages little progress could be made on improvements to earth channels beyond clearing weed and reshaping. This experience shows the importance of starting construction with those works which give an immediate benefit, for example the headworks or a particular problem area. Success here demonstrates the value of the project and encourages farmers to participate in other works.

If the farmers work as labourers on the project, the agency is also obliged to use unsophisticated construction techniques and materials, and train the villagers in using these, all of which make for slow construction, but strengthen the farmers capability for operation and maintenance later. Some farmers may show sufficient skill and interest to be taken on to the project payroll, to work as masons or supervisors, after training if necessary. Clearly this also raises the WUA's maintenance resources.

Because of their limited construction skills farmers can only do some parts of the works. Indeed if they could do all of it, why have they not done this previously? Therefore outside skills and materials need to be employed for complex tasks, such as concrete or masonry work.

An effective way to organise the construction seems to be for the project to provide skilled labour and materials, and for the beneficiaries to provide the unskilled labour. This approach is widely used in other small development works, e.g. community water supply. As a direct labour method of working, it obliges the project staff to carry out all the technical work, including organisation of materials, equipment and labour as well as setting line and level and quality control.

A major problem with using unpaid farmers for direct labour construction is that labour management can be very difficult in these circumstances, because farmers have many other demands on their time; farming, domestic, social and other development projects. In some situations, families may try to meet their obligations to provide labour by sending children to do the work, rather than adults. In general, unpaid labour tends to arrive late, leave early, take long holidays at times of festivals and funerals, and generally be much less productive than paid labour on contract work. For example, O'Brien (1987) reports that an effective working day of only three hours could be expected from self-help labour on a project in Tanzania. In addition, farmers may only be available for work for part of the year.

It is essential to make an elected construction committee or leader responsible for labour management, including resolving these problems. Nevertheless, delays and slow progress can be anticipated. It is in the project's interest to agree in advance with the farmers the days when work is to be carried out, and then to insist that they keep to this.

It is also advisable to use a base force of employed labour to support the skilled labourers and technicians and ensure that their time is not wasted because of the unreliability of the farmers' labour.

Another approach tried on the Bhutan project was firstly to give the WUA its own independent tasks, such as collecting a volume of stone or clearing a length of canal, and secondly to delay the work of the project's masons until the WUA's task was complete. However, it proved very difficult to persuade the farmers to work on their own, and so these ideas had to be dropped. They might be worth trying elsewhere.

On some projects a contractor is used with the aims of reducing the involvement of agency staff in construction management and increasing the rate of construction, at the cost of paying the contractor and hired labour. In practice the agency still has to provide technical supervision, and it is difficult to require a contractor to recruit labour from the local farmers. Also the quality of small-scale works built by a contractor often seems to be poor. To try to reduce such problems on the Indonesian tubewell project a preconstruction meeting is now held to introduce the contractor to the farmers. Issues discussed include construction quality and recruitment of labour.

In small-scale irrigation, as elsewhere, good engineering is still necessary for success and durability. Where permanent works are being constructed, it is important to use good quality materials, proper construction practices, and accurate setting out (e.g. levels of offtakes). Both the concept and the methods of long-life construction may be new to the farmers, so clear explanations and close supervision are needed to train them in good working practices. Examples are the compaction of earth banks, and the cleaning of sand and stone before use in concrete or masonry.

4.4 Training the Officers of the Water User Association

During the implementation stage of the scheme, the main activities of the WUA are holding meetings, liaison with project staff, and labour management. An effective leader is required for these, with the necessary motivation and personal skills, and some specific tasks may also be done by committees (e.g. assisting the survey team, or arranging rights of way for canals).

At the operation stage, an established WUA will normally have a leader, a secretary, a treasurer, a water guard, and possibly leaders of sub-sections (e.g. blocks based on the area served by a particular offtake and/or the area irrigated as a unit in the irrigation schedule), and a pump operator. These officers will all have fairly defined duties, which will probably be new to them, but which are important for the sustained operation and maintenance of the scheme. Therefore each of these officers needs to be trained in their specific responsibilities and tasks, so that they understand these and are able to carry them out. Particularly important are:

- the WUA leader to call regular open meetings of all the farmers;

- the secretary to record all WUA decisions in an official register;

- the treasurer to record all income and expenditure in an official register or cash book;

- the water guard to be responsible for maintenance of the scheme (organising others as necessary).

The ideal time for this training is probably immediately before the scheme is handed over to the WUA. An example of a particular programme for training WUA officers in Indonesia is described by Smout (1986).

4.5 Commissioning and Handover of the Scheme to the Water User Association

The commissioning and handover of a scheme is an important event, which should be formally recognised. Even if the farmers have retained control of the scheme during development, handover still represents the end of agency-assisted construction and the beginning of farmer-managed operation. This is a good time for involvement of senior local figures, to formally open the scheme, and at the same time give it their approval and stress the farmers' responsibilities for future operation and maintenance.

It is recommended that the project provides the WUA and local government with basic information about the scheme at this point, for instance a layout map and a record of the structures which have been built (and details of the tubewell and pumpset if applicable). Without a deliberate effort to do this, the information has become irretrievable after a few years on some schemes.

It may also be appropriate to provide some tools and materials to the WUA for maintenance work, if these are difficult to purchase locally.

5 OPERATION AND MAINTENANCE

5.1 Operation and maintenance by the Water User Association

As Moore (1988) has pointed out for small irrigation tanks in Sri Lanka, the operation of small-scale irrigation systems is often too complicated hydraulically to be governed efficiently by outside rules, and intervention is unlikely to bring improvements. Another example is provided by the tubewell irrigation systems in Bangladesh, where attempts to introduce systematic rotation based on day blocks have been largely ignored by farmers.

Maintenance however is not complicated. It consists of various tasks which need to be carried out in time to ensure that the irrigation scheme remains in working order. The main problem is that these tasks and their importance are not always immediately apparent to farmers, who may therefore neglect preventive maintenance on improved small-scale irrigation schemes, as tends to happen on other types of community development schemes. A strong effort is needed by project staff to overcome this, firstly by explaining the tasks, secondly by training someone to be responsible for ensuring that the tasks are carried out, and thirdly by checking from time to time that the scheme is being maintained properly.

Maintenance activities typically include the following:

- minor day-to-day reshaping and cleaning of canals and structures, to prevent blockages and leakage developing into more serious problems. These can be carried out by the water guard or farmers;

- repairs to canals and structures before each season as necessary, usually carried out by all the WUA members working together. Some materials may need to be purchased, such as cement and paint (for water control gates);

- regular servicing of pumpsets or other equipment;

- emergency repairs following breakdown or damage.

These activities require diligence from the water guard, and the mobilisation of labour by the WUA. The requirement for funds varies with the type of scheme, from simple gravity schemes which may occasionally need a bag of cement, to tubewell schemes which need funds on a daily basis for operation, with additional requirements from time-to-time for repairs.

Farmers are understandably reluctant to part with their money and suspicious about what will happen to it, so if funds are not needed regularly, it seems unnecessary for the WUA to collect fees until the need arises or the WUA has built up trust among the farmers. However, if funds are needed frequently it is important that the project introduces systematic procedures for the WUA to follow, covering for example:

- agreeing a budget and water charge;
- collecting and keeping funds (normally in a WUA bank account);
- recording receipts and expenditures (e.g. in an official cash book);
- accounting for these publicly (e.g. by reading them out in the WUA meeting).

If farmers are satisfied about security of funds and the financial procedures, the WUA can aim to collect sufficient funds on a regular basis to build up a reserve for emergency maintenance.

5.2 Groupings of WUAs

Once they are well established, the WUAs on different schemes can form a grouping to discuss common problems (e.g. obtaining materials for maintenance), and provide mutual assistance (e.g. labour or even a loan at the time of a major problem). This grouping could also act as a representative body for liaising with government.

5.3 Monitoring and Extension by Agency Staff

Even though the scheme is being operated and maintained by the WUA, some continued development agency activity may be advisable to safeguard the investment and maximise the benefits from it. The following types of activity seem to be appropriate:

- inspection of the scheme from time-to-time to check that it is being maintained properly;

- collection of monitoring data such as irrigated areas and crops, water charges, WUA funds, pump operation records (running hours, fuel etc);

- extension work on irrigated agriculture, including water management.

It may be possible for all of these to be carried out by agricultural extension staff, provided they have been involved in the project and receive some training on maintenance requirements. Much of this work would involve reminding and persuading farmers to carry out simple preventive maintenance tasks, but if difficult problems arise they should be able to call in engineering staff.

6 CONCLUSIONS

Small-scale irrigation schemes vary in size and complexity, and suitable forms of joint working between farmers and development agency will also vary. However participation is possible even on relatively large schemes (e.g. the 3000 ha Chhatis Mauja), and technically complex schemes (e.g. deep tubewells with motorised pumps). Indeed only the farmers will normally have the local knowledge and motivation needed to manage the complex social and hydrological factors which often govern the success of small-scale irrigation schemes.

Development agencies commonly hand over the operation and maintenance of small-scale irrigation schemes to the farmers, but joint work is also needed at earlier stages to ensure that the design is suitable, and that the farmers have the skills and motivation to maintain the scheme. This should usually be done through the formal framework of a water user association.

This participation needs to be integrated into the various stages of the project in a way that is acceptable to the farmers. Practical methods of doing this are summarised in Table 1. They require flexibility by the agency. Firstly, it is necessary to learn from experience on the initial schemes, and adapt the project designs and approach accordingly. Secondly, the consequence of sharing power is that the agency may have to accept that local variations and forms of participation can be agreed by bargaining and compromise between the farmers and the project staff.

The attitude of project staff to farmers is very important. The agency can assist by training project staff in the participative approach and methods, and ensuring that their supervisors and senior staff are supportive, particularly when work is delayed by disagreements and farmers' changes of mind.

A serious problem from the point of view of the development agency is that participation places high demands on the time of both technical staff and skilled labour. It is therefore a longer process than conventional design and construction. As a result project lifespans may have to be increased to optimise the benefits from the project.

Participation is difficult, but if done properly from the outset it results in a better designed and sustainable scheme. The key is for the agency to commit itself to making participation work.

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READING, WRITING AND CULTIVATING: THE ROLE OF LITERACY IN IRRIGATION

Juliet Millican

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READING, WRITING AND CULTIVATING; THE ROLE OF LITERACY IN IRRIGATION

Juliet Millican

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READING, WRITING AND CULTIVATING; THE ROLE OF LITERACY IN IRRIGATION

Juliet Millican

1 INTRODUCTION

This paper contributes to the discussion on the relevance of literacy to irrigation. It examines the role of literacy in promoting greater independence of farmers' groups, and considers literacy in relation to issues of farmer participation and 'responsibilisation'.

The arguments are based on the author's own experience as coordinator of a literacy programme within an agricultural project in Senegal, which worked particularly on post literacy and extension.

The second part of the paper outlines methods of working with farmers in the training of trainers and include examples of training materials and activities developed in the field. These will be published later this year and available from the Department of Agricultural Education, University of Wageningen, The Leewenborch, Hollanseweg 1, Postbus 8130, 6700EW Wageningen, The Netherlands.

2 THE ROLE OF LITERACY IN IRRIGATION

2.1 Projet Ile à Morphil

Projet Ile à Morphil began in 1979 as a Senegal government project which, with the aid of Dutch support, constructed small-scale irrigation schemes for rice growing. On the banks of the Senegal river, and very much a part of the Sahel, the project formed one of a series of agricultural projects aimed at increasing national rice production. Land was owned and cultivated by local farmers and organised on a village basis, but production was managed with the help of the SAED[1], the governmental organisation responsible for developments in the river valley.

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[1] *Société d'Amenagement et d'Exploitation des Terres du Delta, Senegal*

Inputs, in the form of fertiliser, diesel and pesticides were supplied on credit to the farmers though the SAED's regional offices. Debts were repaid after the harvest, sometimes in notes but often in the form of rice. Debts that remained unpaid were, on occasions waived, or carried over to the following season. Subsequently, farmers could often avoid dealing with management issues or with money, while at the same time being tied into a system that was not their own. However, during the 1980s, as a result of fluctuations in the international market price of rice, coupled with inappropriate management, the SAED met with financial difficulties. To escape from increasing debt, and as a policy fo stimulating private investment, SAED began to withdraw from management activities. This policy of 'responsibilisation' was presented as the 'removal of barriers to private investment and the development of private enterprises'. On Ile à Morphil, irrigation schemes were to fall under the management of farmers' groups organised into cooperatives. For more information on the withdrawal of SAED, see Woodhouse (1990) and Broeshart (1990).[2]

The SAED's policy of 'responsibilisation' brought with it mixed reactions. Although it was to take place in stages, the first stage was a sudden withdrawal from the provision of credit, the supply of inputs and the marketing of rice. This meant, in real terms, farmers forming themselves legally into recognised 'group d'interets economiques' or 'section villageoise', if they were to open a bank account and to trade. The project intervened by introducing a revolving fund, but rice had to be marketed in order to make repayments into the fund, and the ordering of inputs had eventually to be taken over by the group. If farmers were to do this themselves they needed to be literate.

2.2 Literacy and Cooperatives

Cooperatives were not new in Senegal. They had been introduced on a large scale in the 'peanut basin' in the centre of Senegal during the 1960s. By the end of the 1960s there were almost 2000 throughout the country,

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[2] *Woodhouse, P (1990) 'The Disengagement of the State from Irrigation in the River Senegal Valley and its Implications for Irrigation Design'. Paper presented at the International Workshop on Design for Sustainable Farmer-Managed Irrigation Schemes in Sub-Saharan Africa', Wageningen University, 5-8 February 1990.*

Broeshart, M (1990) 'Privatisation in Irrigated Agriculture; a Chance for the Deprived or the Priviledged?'. Position Paper, Department of Irrigation, Soil and Water Conservation, Wageningen Agricultural University.

with a monopoly on the marketing of peanuts. But as a means of generating credit they were new to the rice producing areas of the North. During the 1960s, Guy Belloncle, known for his work on cooperatives and on farmer participation in irrigation, worked as a technical assistant to the Senegalese cooperative movement. Belloncle saw cooperatives as having two important functions. Firstly, they enabled farmers to create collective capital, either in kind or in cash which could generate an investment budget at village level. Secondly, they could provide a framework in which eduction, particularly non-formal eduction was both necessary and feasible.

Belloncle also draws from the early cooperatives several important lessons.[3] He felt that many of them had failed due to bad record keeping and a lack of joint responsibility. Accounts sheets that were kept relied on a complicated system and were written in French, a language few farmers understood. Inadequate keeping of accounts led in many cases to embezzlement of funds and exploitation of the many by the few. If cooperatives were to succeed in replacing the SAED in the management of irrigation they needed a revised system using simple account sheets printed in the Senegalese languages, and a training programme that dealt with both literacy and responsibility.

The organisation of farmers for the management of water in an irrigation scheme lends itself easily to the formation of credit groups or cooperatives. The groups not only provide an obvious framework or focus for a non-formal education programme, but education for better management, accounting, record-keeping and literacy training becomes integral to the survival of the group. Some of the UNESCO literacy programmes (e.g. Experimental World Literacy Programme) were unsuccessful because they took a purely functional approach. Literacy was linked with limited skills, with training someone for a particular task in order to increase production. Paulo Freire, the Brazilian educator with a more radical approach to literacy campaigns, has been identified as being most relevant to a revolutionary situation. Freire saw literacy as part of a political process in which, through discussion and consciousness raising activities, individuals become aware of their ability to affect the world around them, and thus operative in the development process.

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[3] See Belloncle, G and Bergmann, H (1984) 'Farmers' Associations Making them Effective or Making them Unnecessary', *Irrigation Management Network, Paper 9c.*

Literacy for self-management within cooperatives requires a combination of these two approaches; one that is both tied in to production and has the capacity to empower. Its importance is needed and recognised by the farmers themselves, which makes it potentially a powerful programme. It not only serves the administrative needs of production, but provides a framework for increasing agricultural knowledge and improving organisational skills.

2.3 The Senegalese Literacy Programme

The syllabus used on Ile à Morphil was produced by a local training organisation and based broadly on the teaching methods of Paulo Freire. In a Freirean model, letters are introduced throughout the discussion of a picture indicating a familiar scene. From the discussions a phrase or slogan is deduced, and the trainer takes from this a word, then a syllable, before arriving at and teaching the letter of the day. As a method it puts letters and literacy into the context of words in every day language, and works from the familiar to the new. In the Senegalese syllabus the choice of pictures centred the discussions around irrigation and agricultural problems, and provided an overlap between literacy and extension.

As part of their training the literacy trainers were given some background in extension issues, but were trained more fully in communication skills. Without the higher education that many extension agents had received, they were more likely to speak the same language and use the same terminology as the people they worked among. Consequently, with the regular, weekly structure of a literacy programme, and meetings three times a week, their function as communicators was as important as their function in literacy.

Literacy and numeracy were taught alongside each other, and the numeracy syllabus provided the background for accounting. Groups had to learn to measure and to calculate surface area if they were to order supplies, to weigh and to multiply if they were to market their produce successfully, and to divide costs and record subscriptions in order to set up an effective system of repayments. If groups were to function collectively and responsibly everyone had to identify with the system and see it as something of their own.

The move towards 'responsibilisation' is not unique to Senegal. It is happening throughout the Sahel, if not throughout Africa, and comes at a time when people are debating more than ever before issues of farmer participation and questioning why projects fail. The crucial issues, both to the early Senegalese cooperatives and to our experience on Ile à Morphil, seem, as Belloncle points out, to be pedagogical in helping farmers to deal with the administrative tasks involved, and sociological in developing a personal and corporate responsibility.

The method and the syllabus inherited began to deal with both those issues, but it seemed not to go far enough. The syllabus ended with the teaching of the last letter of the alphabet, when it was felt that students could technically read. The SAED defined 'post literacy' merely as the introduction of account sheets, which they felt that farmers, having learned their 'letters' and 'numbers', should be able to use. They produced a series of these (for recording individual subscriptions, group loans, expenditures, repayments, etc) which were to be introduced by the extension agents during their visits to the field. The literacy trainers were to "assist them in this task", but it soon became apparent that if record keeping was to work, a much fuller programme was necessary. If farmers were to take over responsibility for their scheme they needed to learn about that responsibility, if they were eventually to use a system of accounting without outside help they first needed constant practice in the different steps involved. Thus the programme had to create a controlled situation in which management tasks could be broken down into manageable steps, and 'tried out' without the disastrous financial consequences of making mistakes when doing it 'for real'.

A post-literacy programme provided the obvious format for this further training. The literacy trainers, with a good rapport already established in the villages, seemed the obvious people to carry it out. But first they themselves needed to be trained. Although interested and enthusiastic and reasonably good communicators, they had learned a series of techniques which enabled them to work in a very prescriptive way. They had to become more flexible and creative in their approach if they were to develop a new programme that met the particular needs of the village concerned.

2.4 The Post-Literacy Programme

On beginning to consider a post-literacy programme the same two issues seemed to reappear. The pedagogical one of becoming sufficiently familiar with numbers, weight, area and quantity, to be able to manipulate them for higher rewards, and the sociological or personal one of taking on the responsibility for administration and management. If the aim of post-literacy was to facilitate the taking of responsibility, that process needed to be integral to a post-literacy course. Groups had to be encouraged to solve problems independently without the support of the literacy trainer, and to determine their own needs.

It also meant abandoning the prescriptive format of set activities that a literacy class entailed, and following the group's lead. The literacy trainers had to learn to set up activities relevant to the village that groups could work on alone. They needed to develop a range of teaching methods in order to build up a programme around issues the group raised. Traditional attitudes of a teacher as didactic had to be broken down and the participants encouraged to 'participate'. We experimented with role play, with simulation, with blackboard drawing, with practical work and with games.

Discussions around these issues also brought up the question of knowledge input versus self-direction. If a group was to determine its own direction and set its own syllabus (as a Freire model would encourage), how would a trainer ensure the necessary amount of controlled practice and new information?

Beyond that it called into question the role of the literacy trainer. Where, in working with an extension agent did their functions overlap; what were the dangers inherent in this; how could they ensure that they complimented and didn't contradict each other? During an initial workshop these issues became apparent and I was aware of the confusion involved. In order to communicate my own fears and to try to clarify this I invented a story, the story of Ali, which has been retold below.

The impact of the story was such that it convinced me of the importance of story telling as a medium for communication. Not only did it generate a lot of very useful discussion on the role of a post-literacy trainer, but it seemed to solve the dilemma of knowledge input versus self-direction.

2.5 Story Telling and Simulation

A post-literacy programme based around story-telling and simulation activities seemed to follow on well from a programme based around pictures for discussion and the learning of letters. Stories also have a significant advantage over the use of pictures. Pictures require that someone is visually literate, they entail quite a complex understanding of images (as well as the problems involved in the producing and storing of these images), and they generate discussion about things that are known. Stories are not only more familiar than pictures to village communities, but can introduce new issues and new information into a familiar situation.

They serve as a trigger for discussions around areas a group may not have thought of alone, while leaving the direction of the discussions open.
Within the literacy programme farmers were already familiar with the

process of using a phrase from the discussion to introduce a letter, and the different subsequent activities associated with the making of words. I felt a similar process could be adopted in post-literacy using discussions around a story leading on to different tasks. A series of tasks, divided into steps, could be set up to simulate some of the real tasks involved in the management of agriculture. A story based, for example, around a farmer who decided not to buy fertiliser might lead to a calculation of the required amount for a field of given dimensions, a comparison of figures giving yields of fertilised and unfertilised crops, and a deduction in monetary terms of the overall value of using it. Lively stories based around recognisable characters are not only memorable, but encourage the listener to identify with and to explore the different issues involved. Working in groups to solve a problem meant the group applied the information they had gained and could test for themselves whether or not it was useful.

The same format of story and simulation could easily be adapted for the training of trainers. A story covering issues of appropriate teaching methods or the need for planning could be followed by a simulation exercise that involved planning the time and activities necessary around a set theme. By listening and responding to the story, and working in groups on a set task, a trainer was at the same time experiencing the effects of story telling as a teaching method, and learning how to construct stories and exercises for their own classes. The balance of story telling and simulation seemed for trainers and for farmers to provide enough scope for creativity in raising problems and discussing significant issues, and enough direction to enable them to tackle 'a real' and clearly defined task.

In order to help the literacy trainers remember and re-use activities developed in training workshops, particularly when working on their own, we compiled them into a book. Called 'Reading, Writing and Cultivating; a Resource Book for Post-Literacy Trainers', it follows a similar format of stories and related activities. It is directed towards trainers and extension workers involved in agricultural projects and particularly in irrigation, who may have had no more than a secondary school education and may be unused to learning from books. It aims to cover teaching and learning methods in simple language, and includes information on setting up village libraries and newspapers, introducing account sheets, creating village projects and compiling games. Different pages from the book are included in the second part of this paper.

2.6 Literacy and Irrigation; Some Conclusions

The importance of literacy to irrigation seems to be greater than the sum of its defined parts. For farmers to participate in and take responsibility for the management of an irrigation scheme they need to be in charge of the results of their actions, and the recipients of the profits and losses incurred. In order to do this they need certain administrative skills. As with any trading organisation they have the option of 'buying these in'. However, in order to gain a wider knowledge of the economics of production, and to avoid exploitation, it is obviously advantageous to the group as a whole to develop them themselves.

Learning how to use figures in order to weigh up advantages, helps a group to make informed decisions about what and where to cultivate, and when and where to sell. This 'hard' information, coupled with the farming/ market/ storage/ individual problems of the area, gives a framework in which plans can be made and problems solved. The format for literacy and post-literacy training itself provides a platform for new agricultural information, to be debated within the classes or passed on through the newspaper or 'village libraries' that a post-literacy programme can contain.

Access to new information, and a broader sphere of knowledge helps put the significance of irrigation into perspective; and farmers do, in the end, need to have 'the whole picture' if they are to take responsibility for, and manage successfully, what is essentially an imported system. Taking responsibility entails making choices, and up to date information is crucial if the right choices are to be made.

Indigenous education exists in some form in every African society. According to Jakayo Peter Ocitti, professor at the Makerere University of Uganda, it generally has two functions; a socio-moral one and techno-occupational one. The socio-moral aspect, one's role and responsibilities, is passed on through stories, proverbs, songs and games. The techno-occupational content is learned through watching and doing, through trying it out for one's self. The aim of indigenous African pedagogy is that the individual should be able to do something, and to understand the reason, in community terms, for that task being theirs.

As trainers, this could be lesson to ourselves.

3 READING, WRITING AND CULTIVATING; SOME STORIES AND EXERCISES

3.1 The Story of Ali; a Warning

Last year, in a village quite near here, a literacy teacher was sent to set up a class. His name was Ali. The villagers welcomed him warmly. They liked his good humour and his enthusiasm, and felt he would make a good teacher. Both men and women came regularly to his classes which always began with a lively discussion about rice growing, budgeting or preparing food. Things seemed to be going well. Ali worked hard; he was a good teacher, he was also very proud.

One day, during a class discussion a student, Ibrahaim, asked a question about repairing a crack in an irrigation canal. There were cracks appearing in the canal next to his field. Ali wasn't really sure what the solution was but realising his students thought highly of him was reluctant to admit he didn't know. Ali, as I said, was very proud.

He thought for a while about everything he'd ever heard about the maintenance of canals and made up what seemed to be the right answer. Pretending a confidence he didn't really have, he answered Ibrahaim, and Ibrahaim agreed to carry out the repair; he trusted that Ali was right.

A couple of days later Ibrahaim was in his field trying to repair the canal in the way Ali had told him without much success. The farmers' advisor walked by and saw what he was doing. "Hey, Ibrahaim", he said when he had finished his greetings, "That won't help at all. Whatever are you trying to do?" Ibrahaim explained what had happened in class. The farmers' advisor smiled. "No" he said, "this is how you repair cracks in the canal", and he showed him a completely different way.

Now Ibrahaim was confused. Ali, the literacy trainer, his teacher whom he liked and trusted, told him one thing, and the farmers' advisor whom he'd known for a while, told him another. He didn't know what to do, so in the end he did nothing. The cracks in his canal grew worse and worse.

A week later it was so bad that Ibrahaim decided to travel into the town and see the manager of the region hoping he would be able to solve the issue. So he saddled up his donkey and set out. The journey took him half a day. When he arrived he was hot and tired, but the manager agreed to see him and Ibrahaim presented his problem. The manager gave him the answer quite simply, it was as the farmers' advisor had told him; Ali had got it wrong.

Ibrahaim then rested before returning by donkey to his village. When he arrived it was already dark so he couldn't begin to carry out his repairs before the following day. By this time the cracks had grown so large that although the repairs worked, they took a lot more time and a lot more work before the canal was strong again. And, because of the work involved the whole village soon got to hear of what had happened.

Ali continued to work as a literacy teacher in the village, and Ibrahaim continued to come to his classes. But some of the students decided they wouldn't go any more, and even those who did never knew when to believe what Ali was telling them. Ali, because of his pride, had suddenly lost their trust.

This story raises many questions, for example:

(a) what is the role of the literacy trainer?

(b) how much agricultural and technical information can be given or discussed in a literacy class?

(c) how much does a literacy trainer need to know about agriculture and irrigation?

(d) what is the best thing to do when someone asks a question you cannot answer?

Try to answer some of these issues for yourself, in view of the story and its similarity to your own situation.

3.2 The Post-Literacy Trainer

Traditionally, 'teachers' in African society are the eldest people in the village. They know the most because they have had the most experience of life. They have, therefore, earned their position and deserve respect.

Changes in agricultural development have meant the introduction of things which older people have not always experienced. In these new situations they may not have the most knowledge. From time to time elders are now in a class asking questions of a much younger trainer. They themselves are not too ashamed to say "these things are new to me; I don't know them, and therefore I am here to learn."

Ali lost the respect of his village because he pretended he knew something he was unsure of. The role of a village trainer is a new and strange one. At a young age you may be in a position of giving information to the elders. It is a position not to be misused.

In a school class room the teacher has the advantage of age, and usually knowledge over the children. In an adult class the trainer has the advantage of some knowledge, but by no means all. There are many things, for example, rice farming, the seasons, crop diseases, and life itself, about which the students will often know more. About some things no-one in the group will be informed.

As trainers what we need to be good at is working with people; helping students to share, to understand and to use whatever information is available.

It is perhaps more helpful to see ourselves not as teachers or givers of knowledge, but as communicators or sharers of knowledge; more helpful not to try to learn all the answers, but to practise encouraging students to search among themselves for their own solutions, and, where answers are missing to know where to go for help; most useful not to just listen to the problems and grumbles of farmers, but to communicate those problems to the people who may be able to do something about them, for example, the farmers' advisors, the manager of the region or the project staff.

By becoming a good communicator, a trainer can help keep information moving between the people who need it most.

A good group leader will not dominate the class by talking about what they know, but through question and encouragement will help the group to share the knowledge it has and try to apply it; will not try to impress the group with complicated explanations or language that is difficult to understand, but will use familiar terms and local examples to help make new information clear.

3.3 Problem Solving in Groups

Giving students problems to solve in pairs or in groups keeps everyone involved and gives them a chance to share their own ideas with each other. It will involve you, as a trainer, setting up the problem and being around to answer questions where necessary. The size of the group will depend on the problem set and the number of people in the class.

One way to do it is by 'pyramiding'. Pyramiding means beginning by thinking about something on you own and gradually discussing it with more and more people, for example:

(a) Present a simple problem to the class and ask students to think about it individually for 3 minutes;

(b) Ask students to get together in pairs with the person next to them and share their ideas with each other for 5 minutes;

(c) Ask each pair to get together with another pair and to find out if anyone has any ideas they have not thought of. Give them 8 minutes;

(d) Finally, bring the class together and discuss the ideas of the whole group, listing the main points on the board.

Working in this way will help give students who are shy more confidence in speaking in front of everyone. It might be useful to add more information or to make the problem more complicated at each of the four stages, for example:

(a) Think about where you would go if you needed to borrow money and jot down some ideas of your own;

(b) Discuss your ideas in pairs, and think about how you could borrow a lot of money, say 150,000 FCFA[4] in order to buy inputs for one season;

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[4] *FCFA - CFA Franc; in 1989, US$1 = 319 CFCA, £1 = 523 CFCA*

(d) Share the ideas with the whole group and go on to talk about ways of recording loans, and the problems involved in taking credit.

A short problem, like the one used above in pyramiding might take up half an hour of class time. With a longer problem involving several different tasks, a single group might need a whole session to complete it.

In setting up a problem:

1. make sure the situation you describe is similar to a real life situation that your students might have to deal with;

2. see that everyone has enough space to work in and many material they might need;

3. allow groups to spread out, both inside and outside the classroom so they are not disturbed by other groups;

4. give clear instructions on exactly what you want your students to do;

5. be available to answer questions where needed, but try not to solve a problem or make decisions for the group; allow them to find their own solutions;

6. leave sufficient time at the end of the session for students to report back to the rest of the class on what they have found, and for a discussion of the results.

A problem set in an area where students are growing vegetables might be:

Imagine you have a communal garden which everyone in your group will work on. The total area of the garden is 3 hectares. Someone suggests planting 0.5 of a hectare with cassava.

Calculate how much cassava you would need to buy to plant the area, and how much it would cost. If your harvest is good and you are able to sell 50% of your crop how much money will you make? Divide the remaining 50% between the group, how much will each of you have? Share the profit between the group, how much will each of you have? Are there any more expenses that should have been detracted from the profit?

Decide:

1. if 0.5 of a hectare is all you want to use for cassava;

2. how you will record money spent and profit made; how you will divide the work involved between you;

3. if you want to use any of your profit for communal activities?

3.4 Role Play

With some situations you might ask students to act out a part of the problem in order to make the experience of it more real. This is called role play. A role play does not involve learning parts or lines. Generally, it is spontaneous with little or no practice. In small groups students are asked to play a given character, or themselves in a given situation. As with problem solving the situation should be made clear and as close as possible to everyday life.

Using role play allows students to feel what it is like to be someone else, or to be in a different situation, before attempting to discuss the problem involved.

Role plays can form a useful part of certain themes. They can help students to develop confidence in themselves and try out roles of leadership or management.

However, in some areas it is culturally difficult for people to act in front of others; don't ask your students to do it until you know them well and have developed a feeling of trust in the group.

Try taking on a part yourself to demonstrate the technique, and always leave enough time afterwards to discuss the issues raised; a ten minute role play may generate an hour's discussion.

An example for a role play concerning irrigation might be:

A farmer constantly takes too much water into his field. His field is also badly levelled. In order to get enough water in the middle of the field the plants at the sides are suffering from too much.

He is also wasting pumping time, and keeping other people waiting for water. The president and vice-president of the group are asked to speak to him about it. The farmer tries to defend himself.

Plan for Role Play

Problem:

How to make someone understand the importance of levelling a field and complying with the rules of an irrigation system.

Actors:

Farmer 1 with badly levelled field;
Farmers 2 and 3 with neighbouring fields (they report farmer 1 to the bureau);
President and vice-president of the group (they have to sanction farmer 1).

Action:

Begin with farmers 2 and 3 in the field discussing farmer 1;
They try to explain to him themselves why he should level his field and use less water;
Farmer 1 refuses to listen so they decide to report him to the bureau;
Continue with the scene between the president and vice-president sanctioning farmer 1 and farmer 1's defence.

Time:

10-15 minutes.

Questions for discussion following the Role Play:

1. How important is it to comply with the rules of the group?
2. What rules should each system have?

3. How can you reprimand someone who doesn't respect the rules?

4. Did the people in the role play explain clearly the reason for each of the rules?

5. What is the first farmer now feeling?

6. Will he respect the rules in future or is he just angry with the people you reported him?

7. Is it fair to report on someone who is breaking the rules?

8. Could anyone have acted differently in the same situation?

9. How did the president and vice-president feel about the sanctioning of someone?

10. What have you learned from the role play?

Successful role plays which develop general awareness of social problems can often be turned into theatre and performed in front of the whole village.

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IRRIGATION MANAGEMENT NETWORK

ESTIMATING THE ECONOMIC PROFITABILITY OF IRRIGATION: THE CASE OF BRAZIL

The FAO Investment Centre

ODI/IIMI Irrigation Management Network Paper 90/2d July 1990

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90/2a Newsletter
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ESTIMATING THE ECONOMIC PROFITABILITY OF IRRIGATION: THE CASE OF BRAZIL

The FAO Investment Centre

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ESTIMATING THE ECONOMIC PROFITABILITY OF IRRIGATION: THE CASE OF BRAZIL

The FAO Investment Centre

1 INTRODUCTION

Many countries now face important questions about the future development of irrigation, especially decisions on the mixture of public and private activities in funding, implementation, management and maintenance. Options need to be reviewed, and priorities decided on from a portfolio of projects. Appropriate developments in infrastructure, advisory and support services should then follow this selection. At the moment, all these stages of irrigation policy development are poorly documented.

This paper describes an attempt to carry out a comprehensive review of the economic profitability of irrigation, in the case of Brazil. It is aimed mainly at specialists who wish either to question or improve on the Brazilian analysis, or to attempt a similar exercise for another country. Presentation concentrates on the principles behind the review and on methodology. The work concerned was carried out by a team from the FAO/World Bank Cooperative Programme.[1] Readers requiring more operational details or wishing to discuss specific Brazilian implications of the results are welcome to contact the team leader.

The authors are very pleased to acknowledge the cooperation of their Brazilian counterparts in the work described here. They would also like to thank the Brazilian Government for its support and for permission to release the review results to a wider readership.

2 BACKGROUND

Irrigated agriculture is quite sharply divided in Brazil between public schemes and private development. Public schemes, almost all located in the semi-arid northeast, comprise only some 6% of the total irrigated area,

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[1] S D Hocombe (Team Leader, Senior Adviser), M Raczynski (consultant, Irrigation Specialist) and M Mendez (Economist).

but until lately received the lion's share of Government attention and internal as well as external funds; they have often sought to respond to social as well as economic needs. Private development has only more recently been the object of special Government technical support (especially under the PROVARZEAS[2] programme), and targeted credit lines. It comprises many forms of irrigation ranging from small to large-scale, and from primitive to highly sophisticated. It is spread through most parts of the country. There has been a great diversity of performance between the two irrigation types, but with public irrigation generally tending to progress slowly and fall short of performance expectations while private irrigation, especially in recent years, has expanded fast and often given high profits. However, direct comparisons have been made difficult by regional differences in irrigation needs and opportunities, the special social needs of the impoverished northeast, as well as by the different institutional arrangements for public and private development.

It was partly for the above reasons that in 1987 the Brazilian Government decided to make a comprehensive review of the complete irrigation sub-sector before making further commitments to its development. Assisted by World Bank funding, the Review took the form of five studies:

- a study of future output and demand for basic commodities up to 2005 (rice, maize, wheat, soya beans, common beans, and cotton);

- a study of the present and possible future economic profitability of all major forms of irrigation, whether public or private;

- two separate studies of sub-sectoral legislation and institutions;

- a synthesis of all the above, leading to recommendations for future sectoral policies and development priorities.

The FAO/World Bank Cooperative Programme assisted with the second of these studies. Work took place in 1988, and although the Government's review was subsequently re-worked together with The World Bank to become a joint policy document, the FAO team's initial contribution on economic profitability was not changed.

In 1990, with hindsight, it can justifiably be claimed that the Review, and especially the estimates of economic profitability, greatly reinforced a major change in Government irrigation policy which was previously only incipient.

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[2] Varzeas are seasonally-flooded or flood-prone lowlands.

The Review advocated a shift in priorities away from an excessive focus on public schemes in the northeast, in which the Government had tended to combine the roles of instigator, financier and manager in what was often seen as a paternalistic manner, towards a much greater stress on Government as the facilitator and regulator of privately-financed irrigation. As a consequence Government plans have since moved more towards creation of satisfactory conditions for low-cost private irrigation development, through the provision of access, electricity, technical advice, credit and the like. This shift has been matched by commitments of World Bank and other external funds. It is now intended that most future Government construction of major supply works should be restricted to settings where the water source is too distant or too costly to be developed by private individuals or groups acting alone. However, in such cases a firm commitment by potential beneficiaries to repay Government costs will be a prerequisite for Government involvement, i.e. development should be demand-led. Finally, while fully public irrigation with only partial cost recovery is still not excluded *a priori* from future options, it is now recognised that special justification - usually social - is necessary. Furthermore, budgetary sources for the continuous Government funding which will be needed should be secure before new commitments are made to this type of irrigation.

3 WHY ESTIMATE ECONOMIC PROFITABILITY?

Programmes for irrigation development usually have multiple aims. Some of the most frequent are to reduce dependency on agricultural imports, to generate exports, to reduce fluctuations in output, to intensify production, to aid human survival in semi-arid areas in times of drought, to raise farmer incomes, to create employment, to keep parastatal or private contractors in work, or to raise political monuments. But all irrigation programmes have one thing in common; they use scarce resources, whether these be natural (water, irrigable land), managerial, or financial. Furthermore, in the case of existing irrigation, much of the financial contribution of Governments tends to be borrowed and hence must eventually be repaid.

Whatever the mix of economic and social aims to which a Government gives ultimate priority in its irrigation strategy, it is therefore prudent when planning sub-sectoral development to estimate the economic profitability of the use of the natural and financial resources being allocated. With such estimates, comparisons can be made between irrigation alternatives, and with rainfed options if these exist. If, at national level, it is decided for social reasons to favour one of the less economically profitable forms of irrigation, the extra public cost of doing so can be identified. From the point of view of the national finance ministry or a potential lender, the justification for, and the economic implications of, the overall programme which is eventually proposed for financing are made explicit. If changes or adjustments are considered necessary they can be negotiated on a rational and quantified basis.

In practice, few irrigation sub-sector plans are based on such estimates. Most irrigation planners have little time, or perhaps inclination, to make a systematic review of the economic profitability of all technical options when formulating national irrigation strategy. Those who belong to agencies which have irrigation as their 'raison d'etre' tend to give scant attention to rainfed alternatives or even to the comparative advantage of irrigated local production versus imports. It may be enough simply to squeeze a 12% economic return out of the technical option preferred by the agency's engineers. In addition, irrigation planners usually feel that they lack the base data and analytical methods for what is seen as a complicated exercise. However, this paper suggests that meaningful analysis is possible using skills and data which can be organised fairly straightforwardly by interested groups.

4 THE BRAZILIAN SETTING

Brazil is a huge country with a great diversity of climate and agricultural systems. There are also many types of irrigation and irrigator, on approximately 2.3 million hectares of irrigated land. For development purposes the Government has divided the country into five regions.

The south is subtropical, typically cool, with dry winters and warm, moist summers. It has a highly developed, commercially-oriented agriculture in which both large and small farmers share. The risks of winter frost are such that there are few viable opportunities for out-of-season winter irrigation. And although supplementary summer irrigation can save farmers from disaster in a dry year, on average it gives only a small increase over the rainfed yields of the staple summer crops of the south - maize, beans and soya. As a result, irrigation development in the south has instead focused mainly on summer flooding of lowlands for rice production. Most is large-scale and mechanised, and closely integrated with cattle production; largely for reasons of weed control, lowlands are typically only planted with rice once in every three years and kept under non-irrigated pasture for the other two. More recently the Government has promoted conventional lowland rice irrigation on a smaller scale, under its PROVARZEAS programme.

The southeast region, stretching approximately from the Tropic of Capricorn to 14 degrees south is, like the extreme south, dominated by technically advanced, commercial farmers. Although it too receives most of its rainfall in the summer, winters are warmer. Hence, winter irrigation can allow the farmer to crop land reliably twice instead of once, rotating winter plantings of wheat, peas or beans with rainfed summer crops, which in the southeast also include cotton. Having justified acquisition of an irrigation system on the basis of the returns obtainable from an assured winter crop, the farmer can also use it for supplementary irrigation of summer crops if necessary. Although there is less of the extensive flooded rice characteristic of the south, the PROVARZEAS programme has made progress in all regions including the southeast, where farmers are now starting to grow beans and other crops on supplementary irrigation in winter, in rotation with the main crop of summer flooded rice.

The centre west stretches from the fringes of the Amazon basin in the west to the state of Goiás in the east, and from 8 degrees to 24 degrees south. At its westerly extreme it has a relatively well-distributed rainfall of up to 2500 mm/year and there is little need for irrigation. However, most of the centre west is *cerrado* (savanna) land, potentially productive if its natural soil acidity is corrected, but limited by a marked dry season of around six months. Rainfall in the remainder of the year averages around 1000 mm. Since cerrado soil management techniques are newly developed, much of the region is only now being opened for cultivation, mainly by advanced farmers from further south. Increasing numbers are taking advantage of the region's many perennial rivers and streams to complement their rainfed cereal, soya, bean and cotton production with dry-season irrigated cropping. The large properties and level land are well suited to centre-pivot and self-propelled irrigation systems, which have expanded rapidly in the last few years. Free of winter temperature constraints, irrigation in the cerrado can greatly increase the intensity of land use of this vast, recently occupied area. However, the region is disadvantaged economically by its distance from main consumption areas and ports.

The northeast includes Brazil's semi-arid lands, which have an irregularly distributed annual rainfall averaging from 750 mm down to 250 mm. The region contains the country's poorest farmers and numerous landless people; many farmers cultivate largely for subsistence. Unlike other regions water resources in most of the northeast are severely constrained. One major river, the Sao Francisco, dominates the region, but the topography generally requires that its water be extracted by pumping. There are few other naturally perennial rivers, and although some seasonal rivers have been regulated by the Government, a number have now run dry due to uncontrolled water extraction. There are, however, some lowland areas suitable for flooded rice, mainly in the humid coastal strip. Where water constraints can be overcome, the warm northeastern climate favours maize, beans, cotton and sugarcane, as well as year-round multiple horticultural cropping and seed production. Large public-sector irrigation schemes have been constructed and allocated both to entrepreneurs and small-scale colonists, with the aim of overcoming intermittent regional food deficits while creating employment and benefitting the rural poor. Increasing use is being made of drip and sprinkler irrigation in water-scarce areas, although not always applying very modern technology.

The northern region comprises most of Brazil's humid tropics. Irrigation needs are few, and development is limited to a small area of lowland rice.

In addition to growing staple commodities such as wheat, maize, rice, beans, soya and cotton, Brazil's irrigators have also seized on opportunities to grow high-value, especially horticultural, crops whenever markets permit. Thus, centre-pivot and other advanced systems are used to grow carrots, potatoes, salads and many other vegetables on a semi-industrial scale near to the huge urban markets of the industrial southeast. The same markets are supplied off-season with fruits, onions, melons and other vegetables from the favourable climate of the northeast. Smaller scale horticulturists are found around most towns, irrigating to supply more local demand. Expansion of tomato paste and other vegetable processing factories, especially in the northeast, has given a market opportunity for large and small-scale irrigators alike. Increasingly, irrigators in the northeast are air freighting their fruit and off-season vegetables to Europe and the USA.

Over 94% of Brazil's irrigation has been developed by private individuals or companies.[3] The remainder of approximately 6%, defined as public irrigation, depends on water supplies which have been developed using Government (usually Federal Government) funds, with the major works being Government-operated. In the case of the public colonisation schemes of the northeast, the Government has constructed whole systems including on-farm works, before allocating plots of around 5 hectares to poor or landless farmers (colonos).

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[3] Although at times with official credit and/or government technical advice, e.g. the PROVARZEAS programme. Some of this area may also benefit from publicly-funded drainage schemes, especially extensive rice growing in the south.

The division of Brazil's irrigated areas and estimated irrigation potential between regions, and public and private developments, is shown below. It should be noted, however, that the estimate of potential in some regions is likely to be exaggerated. In particular, although the northern region may have water resources and soils sufficient for 20 million hectares of irrigation, to irrigate such a large area may not be economically justified.

TABLE 1: BRAZIL; ACTUAL AND POTENTIAL IRRIGATED AREA

Region	Irrigation Type	Present Irrigated	Technical Potential	Percent Developed
South	Public	24	423	6
	Private	954	4,577	21
Southeast	Public	12	578	2
	Private	580	6,979	8
Centre west	Public	16	222	7
	Private	247	10,778	2
Northeast	Public	79	718	11
	Private	321	5,352	6
North	Public	-	-	-
	Private	18	20,000	<1
Brazil	Public	131	1,941	7
	Private	2,120	47,686	4
Total		2,251	49,627	5

Source: After Ministry of Irrigation and affiliated agencies, 1987.

The approximately 2.3 million hectares so far developed represents only about 5% of estimated technical potential. Development has been piecemeal and often fragmented. For instance, the PROVARZEAS programme, for support of private irrigation, operates in all regions and is linked to the Federal Ministry of Agriculture; it is executed through the state-level units of the National Agricultural Extension Enterprise which are linked to the agricultural secretariats of state Governments. The main public irrigation agencies, on the other hand, operate only in the northeast, and were until very recently linked to a different federal ministry. They have had little interaction with state-level irrigation. Each Government body concerned with irrigation development has tended to set its own criteria and agenda. Meanwhile, much private development in all regions has taken place in a 'laissez faire' atmosphere, with minimum Government support and no systematic application of the laws on water extraction and use. At the same time public developments in the northeast have followed a conflicting set of objectives; they have been loosely justified on social grounds, whereas if all legally-specified irrigation charges were to be collected and sales taxes paid, the beneficiaries would repay more than full irrigation costs. Nevertheless, in practice far less than the legally-specified amounts have ever been recovered.

5 METHODS USED FOR ESTIMATING ECONOMIC PROFITABILITY

For a complete analysis of profitability it is necessary to consider returns to all the factors of production - irrigable land, water, labour and capital - for all major types of irrigation.[4] It is true that not all these factors are overriding constraints in a given setting, and hence some results will be redundant.[5] However, to ensure full comparability it was considered better, despite the great diversity of the Brazilian setting, to attempt an analysis which was comprehensive than to risk being too selective.

To represent the various types of irrigation, hectare crop budgets were prepared which were then assembled into static farm models. The analysis thus used techniques with which the FAO/World Bank team was already familiar. After weighing the analytical complexities of including livestock activities in the analysis against the relatively low importance of irrigated fodders and pasture, it was decided, however, not to include livestock.

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[4] Return on managerial resources was considered outside the scope of the work described here.

[5] For instance, both land and water are plentiful on the cerrado and the mechanised production system substitutes labour needs with capital. On the other hand, water and irrigable land are both scarce in the northeast and high labour use, and labour returns are desirable to meet the social aims of public irrigation.

TABLE 2: BASIC FARM MODELS FOR ANALYSIS

Basic Model Number	Description	Hectares	Regions Represented a/	Main Crops
1	Private, extensive flooded rice	120	S	Rice
2	Private, lowland (PROVARZEAS model)	12	ALL	Rice, food crops
3	Private or colonist small mobile sprinkler system	10	SE CO NE	Cereals, beans soya
4	Private, centre pivot system	100	SE CO	Cereals, grain, legumes, tomato
5	Privately developed or public supply, centre pivot system	100	NE	Cotton plus above
6	Colonist, public scheme	5	NE	Cotton, cereals, beans
7	Private, small-scale sprinkler system b/	2.5	NE	Maize, beans, onion as cash crop
8	Private, small-scale horticulture	5	ALL	Leaf and root vegetables
9	Private, large-scale scale horticulture, self-propelled irrigator	50	SE CO NE	Above plus potato, tomato
10	Colonist, horticulture, public scheme	5	NE	Tomato, water-melon, onion, food crops
11	Privately developed or public supply; intensive, mainly localised irrigation	26	NE	Grape, papaya melon

a/ S = south, SE = southeast, CO = centre west, NE = northeast.

b/ A recently introduced credit programme in the northeast is distributing small sprinkler kits to farmers.

To arrive at budgets and models all accessible local data sources were reviewed. These included project feasibility studies and recent contract awards, publications in the development literature, models prepared by consultants for a recent World Bank loan to support private irrigation in the south, southeast and centre west, and a 1983 FAO/World Bank review of irrigation in the northeast. Irrigation specialists in development agencies, extension, research, and the private sector were interviewed.

Local consultants then carried out a series of field studies in areas, or on types of system for which supplementary information appeared a priority need. On the basis of all this information, eleven basic models were defined to represent irrigation in Brazil and these are summarised in Table 2. Where a model spans several regions over which the crop mix would change (e.g. winter wheat in the south being substituted by winter beans further north), the cropping pattern used for analysis represents a weighted mean over the range. Because of the diversity of horticultural crops only a few representative species were included in the models. For instance, lettuce as a proxy for all leaf vegetables, carrot as a typical root vegetable, and tomato as a processing crop.

For each model the method of water supply (gravity flow, pumped from a surface or groundwater source), and the method of distribution and on-field application were also specified. Where there were considered to be technical alternatives with major cost or water use profitability implications -for instance, gravity versus pumped supply, or sprinkler versus furrow application - variants of the model were specified. Because of the markedly greater irrigation needs in the semi-arid northeast than elsewhere in Brazil, and the lower potential evapotranspiration in the south, northeastern variants with a higher irrigation volume were also specified for models 2, 3, 8 and 9, and southern variants with lower volumes were specific for models 2 and 8. In addition, because of the greater distance of the centre west from major consumption centres and ports, variants were made for some of these models assuming transport costs equivalent to 1000 km, instead of the 250 km assumed for all base models. Taking account of these variants, the eleven basic models, as defined by cropping pattern, were expanded to 34 for eventual analysis. For analysis, the following were defined for each model:

- size of the irrigated farm;
- annual crop areas, yields, cropping intensity and total agricultural output;
- an indication of which are winter and which are summer crops;
- estimated total water requirements for each crop (Hargreaves' method);

- an estimate of the proportion of this total which would, depending on region and season, need to be met by irrigation;
- off-farm water supply works, with an estimate of the total area served by these works if, as on a public scheme, they would supply more than one property;
- on-farm works and irrigation equipment;
- on the basis of the above definitions, the estimated overall profitability of irrigation;
- hectare budgets for each crop divided between purchased inputs, services[6], other materials and hired or family labour.

For the purposes of calculation all irrigation infrastructure costs were updated to the present before analysis. This allowed old and new systems to be directly compared, although at the same time it also eliminated any advantages which would otherwise have accrued to old systems because of their sunk costs. The analysis effectively examined the question, therefore, of what would be the economic profitability of a given system if built today, as well as used at today's levels of performance.

Using the above data the total cost of meeting water requirements was calculated. This was done by combining amortisation of the capital costs of the system over an appropriate period[7] at the prevailing opportunity cost of capital with its estimated annual operation and maintenance costs (usually a fixed annual percentage of capital cost of the infrastructure specified). Total water cost was expressed per farm per annum, as well as per thousand cubic metres taken from the source. Crop production costs were calculated per hectare, and then per annum for the whole farm. Together, these calculations gave the annual fixed and variable costs of irrigation, plus all other variable crop production costs. The team abandoned attempts to include the remaining fixed elements of the annual production cost - amortisation of productive farm infrastructure other than the irrigation system, and farm management overheads. Firstly, there were virtually no sources of information, and secondly it was felt that for most models these costs would be insignificant in relation to the total of other costs.

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[6] For simplicity, contract hire rates were used for all machine operations.

[7] Useful life was assumed to vary from 3 years for sprinkler heads, up to 20 years for pumps, and 50 years for dams and main canals.

Examples of the forms used to tabulate the data before processing are given as tables 3, 4 and 5.

To produce figures comparable with the output projections generated by the output/demand study for the rainfed sub-sector and existing irrigated land, it was then necessary to estimate the improvements in profitability which would be obtained on new irrigated areas by 2005. To make these calculations it was assumed that:

- models which are, at present, relatively far from their maximum technical potential (assumed to be models 1, 3, 6 and 7) would increase their crop yields at a compound rate of 2% per year and cropping intensities at 1% per year;

- for the remaining models, all of which could be considered as already closer to their maxima, increases would be limited to 1% per year and 0.5% per year respectively;

- the resultant gains in gross production value would be obtained on relatively favourable terms. Costs would rise by one dollar for every two dollars of gain in gross value.

The work was done at a time when Brazilian inflation was about 20% per month. All local costs and prices were therefore converted to US dollars at the exchange rate of the day for which they were quoted. Although dollars were traded in the black market at a premium of about 55%, at the time the official conversion rate was preferred to avoid making judgements on the views of speculators about the future course of Brazil's crawling peg system of exchange rate adjustment.

Capital, operation and maintenance costs of irrigation works were converted to economic values by applying a conversion factor of roughly 0.9, to represent the removal of taxes, duties and subsidies. Most agricultural inputs (seeds, fertilizers and pesticides) were valued at import parity prices using multi-year averages from other importing markets - mainly the USA - and recent price quotations from Brazilian importers. Unit machinery operating costs for construction of irrigation works were derived from recent Government equipment rental costs, applying separate conversion factors to capital costs, fuel and labour to bring them to economic values. The opportunity cost of capital was assumed to be 11%. Since there were no reliable data on regional labour markets, shadow wage rates for farm labour were calculated from real daily wages for each region, adjusted for assumed regional unemployment. Unemployment rates were assumed to be 5% with 10% underemployment outside the northeast, and twice these figures within the northeast. On the basis of available data, wages in the northeast were assumed to be 60% of those elsewhere.

Tradeable agricultural products were valued at border prices, based on import or export parity using six-year average world prices for the commodity concerned. Non-tradeable items - beans and horticultural crops - were valued at average local market prices.

The analysis was run on a standard desk-top computer using Lotus 123. The following were quantified for each model, for the present situation and 2005:

- total economic benefit generated by the model;
- total economic costs of the model;
- net economic benefit generated per hectare of land cropped;
- net economic benefit generated per thousand m^3 of water abstracted from the source;
- net economic benefit generated per man/day of labour used.

By taking account of water use for each crop within the model, it was also possible to derive an economic cost of production in US$ per ton for that commodity at present, and in 2005 under the system represented by the model.

6 SUMMARY OF RESULTS

Table 6 shows the estimates of present and future economic profitability of irrigation, ranked from models with the highest ratio of net benefit to total costs to those with the lowest ratio. The following are the key findings:

Basic Commodities (rice, maize, wheat, soya, beans, cotton): Present gross economic benefits from models growing basic commodities (rice, maize, soya, beans and cotton) are seldom greater than 1.5 times total costs (a value of 0.5 or more for BN/CT in the tables), while the less efficient forms of irrigation at present fail to cover their costs when these are calculated in economic terms. Under the future scenarios the most efficient models based on these crops generate a gross benefit equivalent to about 1.75 times total costs (BN/CT = 0.75), but the three least profitable models (all representing colonos on public irrigation perimeters in the northeast) remain heavily in deficit.

High Value Crops: Present economic benefits from models producing fruits and vegetables are always more than 1.5 times total costs and sometimes by over 2.5 times. These figures rise to a minimum of 1.7 times and a maximum of three times economic costs under the future scenarios.

Public Water Supply: Because of generally high capital, and operation and maintenance costs, variants on a given model which depend on a publicly-financed primary supply are generally less economically efficient than variants assuming private development of the water source.

Colonisation Schemes in the Northeast: These public schemes are doubly penalised by (a) depending on public water supplies, and (b) by growing mainly low-value crops at low yields and cropping intensities. They are the least profitable of all forms of irrigation in purely economic terms. However, model 10 shows the better prospects from higher-value crops.

Economic Costs of Water Supply: Supply costs range from about US$ 30 to US$ 47 per 1000 m^3 for models depending on public supplies and between US$ 13 and US$ 50 per 1000 m^3 for private supplies. Net economic benefit generated per 1000 m^3 of water averages around US$ 20 for low-value crops at present (range US$ 38 to US$ -31) and is estimated to average around US$ 30 (range US$ 57 to US$ -4) for these crops in future. For high-value crops estimated net returns on water range from at least US$ 50 per 1000 m^3 up to US$ 400 per 1000 m^3.

Net Economic Returns per Year on Irrigable Land: Economic returns average around US$ 250 hectares (range US$ 670 to US$ -530) for low-value crops at present, rising to about US$ 350 hectares (range US$ 1000 to US$ -250) in the future. Corresponding figures for high-value crops are US$ 2000 hectares (range US$ 1200 to over US$ 4500) at present, with the average reaching about US$ 3000 hectares in the future.

Table 7 summarises estimated irrigated production costs per ton for wheat, maize, beans and rice for a selection of models. It shows that the estimated present economic cost of irrigated production per ton of these basic commodities often exceeds their economic value. Only for the relatively low cost model 2, or highly efficient (centre pivot) private models are present estimated costs less than the value of output. Future scenarios show some improvements, but gains are limited.

For comparison, Table 7 also includes estimated rainfed production cost for the same commodities based on re-working of the output/demand study data by a subsequent World Bank mission (January 1989). The irrigated farm models with low cost or high technical efficiency are also able to produce beans and rice at economic costs per ton which are lower than for rainfed. For wheat and maize, however, rainfed costs are below those of any irrigation model. This implies that irrigation would not be the preferred strategy to fill any future supply gaps for these two commodities. It would not, however, preclude the use of efficient irrigation for out-of-season production, or for growing seed crops of wheat or maize, in both of which situations irrigation would bring clear technical advantages over rainfed production.

The sort of guidance which such results can give to those responsible for sectoral policy is readily appreciated. For instance they highlight:

- the need, if irrigation is to be an economically viable means of producing basic commoditites such as wheat, maize or cotton, to encourage only those forms of irrigation which are either cheap or technically efficient;

- the low probability that further investment in public irrigation in the northeast for colonos will yield acceptable economic returns, for so long as these farmers grow only such basic commodities;

- the need, therefore, for there to be important parallel social benefits from public irrigation of low-value crops by colonos in the northeast, in order to justify the economic losses which further investments of this type are likely to incur;

- the economic desirability of encouraging a shift in irrigated cropping patterns from basic commoditites to high-value crops;

- the particular importance of such a shift for existing public irrigation by colonos in the northeast, if the present drain on the economy by public schemes is to be reversed;

- the close implied connection between expansion of the more profitable forms of irrigation and the size, location and organisation of markets for high-value processing or horticultural crops - which must therefore receive close attention in future sectoral plans.

The results also provide planners with some general figures on economic value added from irrigation, which could be used in deciding the allocation of water resources between competing demands of agricultural and non-agricultural uses.

7 CONCLUSIONS: ADVANTAGES AND LIMITATIONS

The main advantage of the analysis was that it attempted to compare the economic profitability of all major forms of irrigation in Brazil on a common base. Due to the past fragmentation of institutional responsibilities and programmes this had never previously been done. As a result arguments on the relative merits of alternative development options - e.g. public irrigation in the northeast versus private irrigation in the south - had previously tended to be settled on a subjective rather than an objective basis. More rational decisions were possible subsequently, and at the time of writing seem likely to be followed up by appropriate programmes of technical and financial assistance.

The major limitation, as in all such modelling exercises, is that the outcome depends on the quality of the estimates on which the calculations are based. This is already important in determining the credibility of the normally simple models used in ordinary project analysis. Fallibility is, unavoidably, magnified in a more complex exercise of the type described here. Furthermore, to formulate such an exercise, if dependent on field surveys to generate all the base data, would be extremely time-consuming. The team responsible was fortunate in having had wide previous exposure to irrigation in Brazil over a number of years. It worked with high-calibre local counterparts and benefitted from the accumulated experience of a range of outside experts who were also assisting the Government. Local data sources happened to cover some of the types of irrigation on which the team's personal experience was the most limited. A team starting a similar exercise in another country might not have all these advantages.

Nevertheless, two positive final points can be made. Firstly, both the setting and the range of irrigation types are likely to be less complex in most other developing countries. Secondly, the Brazilian analysis presented here, which is a first run and not the culmination of a series of approximations or the product of any 'massaging' of the numbers, is remarkably clear cut in its indications. This leads the team to believe that the method of analysis used in the case of Brazil is both replicable and valid. Indeed, similar analytical approaches have since been used by the FAO Investment Centre for irrigation reviews in Chad, Malawi and Venezuela, and have also made useful contributions to clarifying future development options and priorities.

TABLE 3: BRAZIL - NATIONAL IRRIGATION SECTOR REVIEW

STUDY 2: IRRIGATION PROFITABILITY
A Description of Model Farm

Model: .... Number: ....

Situation Present

Type: .... Operator: ....

Farm physical area (hectares): ....

Farm irrigable area (hectares): - Total ....

- Developed ....

Crop/Product	Area planted (ha/year)	Average Yield (t/year)	Total Output (t/year)	Gross economic value (US$ '000/year)
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
	Total		Total	....

Water Source: ....

Method of supply to farm: ....

Method of supply to field: ....

Method of distribution in field: ....

TABLE 4: WATER USE AND COSTS

Model: .... Number: ....

Annual Water Use

Crop, No ha	Evapotranspiration	Overall Efficiency	Total Water Use
....	....	....	....
....	....	....	....
....	....	....	....

Farm total (m³/year) ....

Annual Economic Cost of Water Supply

Off-farm works	Area Served (hectares)	Total Cost, Year Built (US$ '000)	Allocated Cost to Model (US$ '000/year) Amortisation	O & M	Total
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....

Sub-total ....

On-farm works	Units	No	Unit Cost (US$)	Total Cost (US$ '000)	Annual Cost to Model (US$ '000/yr) Amortisation	O & M	Total
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....

Sub-total ....

Total annual economic cost of water (US$ '000/yr) ....

Economic cost of water per m³ (US$) ....

TABLE 5: CROP HECTARE BUDGETS (US$) continued

Labour (man day equivalents)

	Quantity F	M	Total	Economic Cost Per Unit	Total
- land prep					
- plant					
- maintain					
- harvest					
- post-harvest					
Sub-totals					
- total family					
- total hired					
Sub-total inputs					....
Total Variable Costs (excluding water)					
Water Costs (from Section B)					
Fixed Cost Allowances (footnotes)					
- amortisation, non-irrigation farm infrastructure					
- farm management					
Total Economic Production Cost					....

TABLE 5: CROP HECTARE BUDGETS (US$)

Model: ....

Crop: ....

Inputs	Quantity Units	No	Economic Cost Per Unit	Total
- seeds	kg			
- pl material	no			
- fert 1	kg			
- fert 2	kg			
- fert 3	kg			
- fest 1				
- pest 2				
- pest 3				
- pest 4				
Sub-total inputs				....
Machinery (includes driver)				
- animal	hr			
- tractor, heavy	hr			
- tractor, light	hr			
- harvestor	hr			
- threshing	hr			
-				
-				
Sub-total machinery				....
Materials and others				
e.g.				
-				
-				
- transport				
- drying				
Sub-total materials and others				....

TABLE 6: RESULTS OF IRRIGATION MODELS, RANKED IN ORDER OF THE RATIO OF NET BENEFITS TO TOTAL COSTS

BASIC MODEL	AREA	WATER SOURCE	SYSTEM	NET BENEFIT			
(INT or interior = transport costs equivalent to 1000 km)				(1987 DATA)			FUTURE
				000's US$ per ha	US$ per 000 m^3	BN/CT ratio to total costs	BN/CT ratio to total costs
9							
Private producer; 50 ha;	NE	pump lift	centre pivot or	3.27	229.3	1.69	2.04
potatoes, carrot, onion	SE, CO	pump lift	self-propelled	3.09	250.5	1.47	1.78
tomato, lettuce, beans	NE	public perimeter	traveller	3.01	141.9	1.38	1.69
11							
Private producer; 26 ha; grape, mango, melon, etc	NE	pump lift	drip or conventional sprinkler	4.77	406.1	1.36	1.36
8							
Private producer; 5 ha; lettuce, carrot, tomato, onion, etc	NE	pump lift	furrows	2.58	150.2	1.01	1.21
10							
Settler; 5 ha; tomato, beans, watermelon, corn	NE	public perimeter	furrows	1.21	60.9	0.88	1.19
8							
Private producer; 5 ha; lettuce, carrot, tomato, onion, etc	NE	pump lift	conventional sprinkler	2.39	186.6	0.87	1.08
7 (KIT)							
Private producer; 2.5 ha; lettuce, carrot, onion, etc	NE	well, creak or river	conventional sprinkler	0.56	54.4	0.73	1.28

(TABLE 6: continued)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
8							
Private producer; 5 ha; lettuce, carrot, tomato, onion, etc	SE, CO	pump lift	furrow	1.97	131.6	0.62	0.78
	S	pump lift	furrow	1.98	149.9	0.62	0.78
5							
Private producer; 100 ha; cotton, soybeans, wheat, beans, tomato	NE	pump lift	centre pivot	0.67	38.8	0.55	0.79
8							
Private producer; 5 ha; lettuce, carrot, tomato, onion, etc	S	pump lift	conventional sprinkler	1.8	183.2	0.54	0.7
	SE, CO	pump lift		1.8	160.8	0.54	0.7
2 - Interior							
Private producer; 12 ha; rice, corn, beans	INT SE, CO	river diversion	furrow by gravity	0.29	24.4	0.54	0.75
5 - Interior							
Private producer;100 ha; cotton, soybeans, wheat, beans, tomato	NE	pump lift	centre pivot	0.64	37.2	0.53	0.77
2							
Private producer; 100 ha; rice, corn, beans	S	river diversion by gravity;	flood furrow	0.27	25.1	0.5	0.71
	NE, INT	pump lift		0.23	17.4	0.39	0.61
	SE, CO	river diversion by gravity		0.21	17.3	0.38	0.57
	SE, CO, INT			0.21	17.6	0.34	0.39
	S	pump lift		0.2	18.6	0.33	0.53

(TABLE 6: continued)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(2 continued)	NE	pump lift	flood furrow	0.15	11.1	0.25	0.44
4 Private producer; 100 ha; cotton, soybean, corn, beans tomato, wheat	SE, CO, INT	pump lift	centre pivot	0.28	20.9	0.25	0.45
	SE, CO			0.24	17.4	0.21	0.4
5 Private producer; 100 ha; cotton, soybeans, wheat, tomato, beans	NE	public perimeter	centre pivot	0.33	14.5	0.21	0.43
1 Private producer; 120 ha; rice, soybeans	S	river diversion by gravity;	flood furrow	0.05	5.83	0.09	0.37
	S	pump lift		-0.01	-0.62	-0.01	0.28
3 Private producer; 10 ha; soybeans, beans, wheat	NE, INT	pump lift	conventional sprinkler	-0.11	-8.9	-0.13	0.2
	SE, CO, INT			-0.13	-12.4	-0.15	0.16
	NE			-0.16	-12.5	-0.18	0.13
	SE, CO			-0.18	-16.78	-0.2	0.09
6 Settler; 5 ha; corn, beans, cotton	NE	public perimeter	furrows	-0.31	-14.79	-0.33	-0.02
	NE		conventional sprinkler	-0.35	-23.45	-0.35	-0.06
3 Settler; 10 ha; soybeans, wheat, beans	NE	public perimeter	conventional sprinkler	-0.53	-30.76	-0.43	-0.17

TABLE 7: COMPARISONS OF IRRIGATED AND RAINFED PRODUCTION COSTS FOR WHEAT, MAIZE, BEANS AND RICE, 1989

Wheat	**Price per ton US$ 182**
a.	Rainfed, fully mechanised, winter crop, yield 1.7+/ha, in regions S, SE, Southern CO, production costs US$ 169 per ton.
b.	Irrigated Production, in models:
(3)	NE, pump lift, conventional sprinkler, private, 10 ha, (with soybean and beans), yield 2 t/h, production costs US$ 426 per ton;
(4)	SE, CO, pump lift, centre pivot, private, 100 ha, (with cotton, soybeans, maize, beans, tomatoes), yield 3 t/h, production costs US$ 207 per ton;
(5)	NE, pumping from water source, centre pivot, private, 100 ha, (with cotton, soybeans, beans, tomatoes), yield 3 t/h, production costs US$ 203 per ton;
Maize	**Price per ton US$ 140**
a.	Rainfed, fully mechanised, in regions S, SE, CO, yield 3.1 t/ha, production costs US$ 85 per ton.
b.	Irrigated production, in models:
(2)	SE, CO, river diversion by gravity, flood furrow irrigation, private, 12 ha (with rice, beans), yield 3.5 t/ha, production costs US$ 117 per ton.
(6)	NE, public perimeter, conventional sprinkler, private, 6 ha, (with beans and cotton), yield 4.0 t/ha, production costs US$ 183 per ton.
Beans	**Price per ton US$ 485**
	Rainfed:
(i)	S, SE, CO, part-mechanised, yield 0.85 t/h, production costs US$ 427 per ton.
(ii)	NE, animal traction, fertiliser, yield 0.65 t/h, production costs US$ 419 per ton.

(TABLE 7: continued)

	Irrigated production, in models:
(2)	SE, CO, river diversion by gravity, flood furrow, private, 12 ha (with rice corn), yield 1.6 t/h, production costs US$ 306 per ton.
(4)	SE, CO, pump lift, centre pivot, private, 100 ha, (with cotton, soybeans corn, tomatoes, wheat), yield 1.6 t/h, production costs US$ 430 per ton.
(3)	NE, pump lift, conventional sprinkler, public perimeter, settler, 10 ha, (with soybeans, wheat), yield 1.2 t/h, production costs US$ 654 per ton.
(5)	NE, pump lift, centre pivot, private, 100 ha, (with cotton, soyabeans wheat, tomatoes), yield 1.6 t/h, production costs US$ 389 per ton.
(6)	NE, public perimeter, conventional sprinkler, settler, 5 ha, (with corn cotton), yield 1.0 t/h, production costs US$ 750 per ton.
Rice	**Price per ton US$ 127**
	Rainfed upland rice, Amazon fringes, favourable rainfall, yield 1.65 t/ha production costs US$ 101 per ton.
	Irrigated production, in models:
(2)	SE, CO, river diversion by gravity, flood furrow, private, 12 ha, (with corn, beans), yield 5 t/ha, production costs US$ 92 per ton.
(1)	S, river diversion by gravity, flood furrow, private, 120 ha, (with soybean), yield 5 t/ha, production costs US$ 125 per ton.

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IRRIGATION MANAGEMENT NETWORK

TANK IRRIGATION IN SOUTH INDIA: WHAT NEXT?

K Palanisami

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TANK IRRIGATION IN SOUTH INDIA: WHAT NEXT?

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TANK IRRIGATION IN SOUTH INDIA: WHAT NEXT?

K Palanisami

1 INTRODUCTION

Tanks are a common feature of the south Indian cultural landscape, irrigating about one third of the total rice area in the states of Andhra Pradesh, Karnataka and Tamil Nadu. The concentration of tanks is high in these states because of topographical features such as undulating terrain, hardrock geology, red soils (alfisols), and the bi-modal rainfall distribution. (In Tamil Nadu, there are about 39,000 tanks accounting for about 32% of the irrigated area.) This paper examines reasons for the poor performance of tank irrigation in recent years, and reports on a simulation study developed in Tamil Nadu to examine potential modernisation strategies. This paper examines the results of financial criteria used to evaluate these strategies, but also summarises findings when production and equity criteria were applied.

Tanks are classified as system and non-system tanks, based on the source of water supply. Tanks depending purely on rainfall are called non-system tanks, while those depending on perennial surface water sources such as reservoirs, rivers, etc, in addition to rainfall, are called system tanks. Typically, more than 90% of the tanks are non-system tanks; these tanks are the focus of this paper. Though a majority of the tanks are small, with a command area of not exceeding 50 hectares, some tanks are very large, irrigating more than 2000 hectares. Tanks are also classified on the basis of the size of the command area; minor tanks are those with a command area of less than 80 hectares, and major tanks serve more than 80 hectares. Minor tanks account for more than 70% of the total tanks. The area irrigated is based on the assumption that 1 million m^3 irrigates 85 hectares of rice. Normally one rice crop is grown between September and December, and, depending upon the water storage, a second non-rice crop may be possible. Besides the irrigation tanks, there are about 5,300 percolation ponds (tanks) in the State which are used only for recharging the wells in and around 1 kilometre radius.

The average rainfall of the State is about 950 mm per year and it is mainly the rains during the Northeast monsoon (October-December) which fills the tanks. Variation in the rainfall in the Northeast monsoon period heavily influences the tank filling and the tank irrigation. On average, over a 10 year period, the tanks overflow in 1 year and get adequate (70% to 100%) supply in 2 years; in 2 years there is complete failure, and in the remaining 5 years the tanks are partially filled (Palanisami & Flinn, 1988).

2 CURRENT STATUS

Since India's independence, the development of tank irrigation has stagnated. Several factors have contributed to this. Firstly, the developments of major and medium surface irrigation projects, and of groundwater, have received priority. Exploitation of favourable sites for surface projects has helped surface irrigation development expand on a large scale, and groundwater development has been favoured by the introduction of diesel and electric pumpset technology and availability of institutional finance. Tank irrigation has been somewhat neglected both by the government and the local community. For example, from 1960 to 1983 alone, the exploitation of the groundwater has been so fast that it rose from 30% to 42% of irrigation nationally, and the proportion of the tank irrigation declined from 19% to 12% nationally, and from 38% to 31% in Tamil Nadu.

In addition, other factors, such as heavy siltation of the tank and feeder channels, encroachment on the tank foreshore area, deforestation in the catchment area, poor functioning of the tank (upper) sluices, defective tank structures (lower sluices and canals), and weak farmers' organisation, have contributed to the decline in tank performance. Tank siltation has reduced the water storage capacity by about 15% on average, and in some of the tanks heavy siltation has almost eliminated the storage capacity (Palanisami & Easter, 1983). In conjunction with this siltation, farmers during the last 2 decades have slowly encroached on the tank storage area. It was observed that 10% to 25% of the water-spread area of the tank has been encroached by the villagers for unauthorised cultivation. In total both siltation and encroachment has reduced the tank storage capacity by about 30%. The other important factor which affects the water storage and irrigated acreage is the rainfall. As the command area under each tank is based on the capacity of the tank multiplied by the number of fillings, variation in rainfall pattern influences the quantity stored and area irrigated. It was observed that the variability in rainfall pattern has increased by about 8% over the last 10 years. Thus the performance of the tank irrigation has declined over years, and tank irrigation, formerly a source of stability, has become a source of instability.

However, recently it has become apparent that major irrigation projects are not yielding the expected benefits because of the inordinate delays in completing projects, as well as cost escalation. In addition, under-utilisation of the created potential, coupled with water-logging in several locations, made it clear that future investment should be made carefully. In the case of groundwater, poor availability of power, increasing power costs, and over-exploitation leading to declining watertables in several locations, have constrained development. In view of these problems, the government now feels that tanks could be made a viable source to meet the future demand for irrigated acreage, and tank modernisation is the only possible way to achieve this demand in both the short and long-term, in the areas we discuss.

3 TANK MODERNISATION

The Tamil Nadu government, realising the seriousness of the tank management problems, has already started work to rehabilitate the tanks through several initiatives. The Agricultural Engineering Department of the State government has started lining the canals of small tanks. Further, the assistance of the European Economic Community (EEC) has been utilised to modernise about 150 non-system tanks. Following evaluations, the EEC is proposing to modernise more tanks in the second phase of their assistance. The World Bank is also considering major investment in tank modernisation.

The various modernisation strategies being adopted by different departments and agencies fall into 2 groups:

(a) improving the tank structures

this includes strengthening the tank bunds, and restructuring the existing sluices and surplus weirs. Since the functional specifications of the existing control structures have been lost due to tank siltation and poor management, restructuring the sluice gates and surplus weirs will help correct this problem;

(b) on-farm water management

since water losses in the unlined canals and field channels range from 20 to 30%, lining has been done in several tanks, which reduced the water losses by about 20%. Further, lining the field channels and reorganising the water distribution around blocks is also done for efficient water distribution.

4 WHAT IS NEXT?

The above modernisation strategies in restoration and improved efficiency are not making the expected impacts on overall tank performance. The strategies of structural improvements are inadequate as they confine the nature and scope of the tank modernisation to existing conditions. It is important to consider all the following strategies for tank modernisation. Depending upon the scope and nature of the government intervention needed for tank modernisation, the strategies are grouped as 'above' and 'below' outlet strategies.

5 ISSUES ABOVE THE OUTLET

(a) Desilting the Tanks

Siltation over years has reduced tank storage capacity by about 15%. In the earlier days farmers used to desilt the tanks using their bullock carts and manual labour with the aim of maintaining the tank storage, as well as obtaining manure for their lands. Today it is becoming increasingly difficult to desilt by themselves due to the lack of bullock carts and the reduced spirit of kudimaramathu (community repair work). The government cannot perform the desilting, since it is too expensive to desilt the entire tank capacity, and also it is difficult to dispose of silt outside the tanks. Further, the tanks surplus in only 1 out of the 10 years, or are 70% to 100% full in 2 out of the 10 years, and the desilting will not have much impact in the remaining drier years. Hence, what is needed is for the farmers in each tank to organise and start the desilting in a phased manner, so that the disposal of the silt is easier.

(b) Desilting the Supply (Feeder) Channel

In many tanks the supply channels feeding the tanks are heavily silted, and in several cases they are missing due to the combined effect of both siltation and encroachment. Restoration of the supply channels with original capacities will help capture the run-off water to the tanks. The estimated run-off from catchments is 10% to 15% depending upon the soil type; for alfisols (red soils) run-off is deemed to occur when the rainfall exceeds 17 mm/day (Agricultural Engineering Department, 1987).

(c) Curtailing Encroachment

The use of illegal 'pattas' (rights from the government) to encroach the tank foreshore should be discouraged via the intervention of the Revenue

Department. The removal of the encroachment will further help increase the tank water storage by proper filling.

(d) Afforestation Programmes

Tank siltation is one of the major causes for the reduction in the tank storage capacity. This is further aggravated by deforestation in the tank catchment area, both by the encroachers and tank irrigators for firewood, and causing extensive soil erosion during heavy rains. Hence, the afforestation programme has to be strengthened in the tank catchment area. The social forestry programme now introduced in other areas has to be introduced in the tanks also. As per the social forestry programme, the Forestry Department is planting trees in the tank catchment and foreshore areas. In some cases the water spread area of the tanks are also used for planting the trees and after 10 years, the trees will be auctioned off. About 50% of the revenue from the auctioned trees will be given to the local Panchayat (village level administrative body) which will be spent on tank and village improvement works.

(e) Tank Water Management

The simple procedure of closing the sluices during the rainy days, when there is no apparent demand for water has been shown to increase storage, which in turn increases the irrigated area by more than 20%, with a 17% lower risk of crop failure. According to the ICRISAT study (Venkatram, 1980), supervisors, at the rate of 1 person for every 100 tanks, could be used to enforce minimal water regulation rules and provide technical guidance. Such a guideline still has to be tested in Tamil Nadu.

6 ISSUES BELOW THE OUTLET

(a) Redefining the Water Requirements/Command Area

The command area of the tanks has been fixed in relation to the rainfall pattern, number of tank fillings and the capacity of the tanks. After the introduction of high yielding varieties of rice, the water requirement of the rice crop has steadily increased. Hence, to satisfy the same command area, water supplies have to be increased from the given level, or for the given water supply. The size of the command area has to be respecified.

(b) Conjunctive Use of Tank and Well Water

Due to inadequate tank water supplies from the tank for the rice crop, particularly at the end of the crop period, there is a growing need for supplemental irrigation from wells. Currently, about 15% only of the tank farmers own wells, and there is a powerful monopoly market for groundwater. It was estimated that about 38% of the crop income of the non-well owners is paid as water charges to the monopoly well owners (Palanisami, 1987). Hence, provision of additional groundwater wells in the command area either by private, community or government investment will help increase crop income via conjunctive use and discourage the monopoly pricing of well water. The hydraulic interaction between tank storage and well water recharge will further encourage the investment in groundwater development, depending on the suitability of geology and tank bund construction.

(c) Farmer Involvement in Tank Modernisation

In view of the huge investment proposed in tank modernisation, it is important that farmers should be encouraged to participate both in the pre- and post-modernisation activities. Participation by the farmers, as well as incentives to farmers' associations, will help define appropriate proposals and their implementation. The incentives may be in the form of additional funds from the government to meet emergency repairs, or additional authority to raise fish in the tank and market them without outside intervention.

(d) Crop Management

Changes in crops during years of low rainfall are another possibility for increasing income from tank irrigation. Tank irrigation choices, based on tank storage adequacy, can be grouped as 'a good year' (surplus), 'a satisfactory year' (normal), 'a deficit year' (below normal), and 'a very bad year' (failure). For example, in a 10 year period, the surplus year occurs once, a normal year occurs twice, a deficit year occurs five times, and for 2 years there is failure. Hence, particularly during deficit years, (i.e. on average, every alternate year) non-rice crops can be grown to minimise the risk due to inadequate tank irrigation.

(e) Tank Administration

Under the present 2-tier system, ownership and maintenance of most of the tanks lies with the state Public Works Department (PWD), and the irrigation fee collection lies with the Revenue Department. There is practically no coordination between the 2 departments. The funds allotted by the Revenue Department to tank repairs and maintenance are highly inadequate. It costs about Rs 40 hectares[1] for the operation and maintenance of the tanks, and the fund allotted for this purpose is only about Rs 15 hectares.

7 EVALUATION OF IMPROVEMENT STRATEGIES

A simulation study was performed to evaluate the tank modernisation options (Palanisami & Flinn, 1988). The model constructed permits the simulation of decision-making at several levels, such as water release from the tank, water allocation to rice crops in different sectors of the command area, crop yield reduction due to water stress at different stages of growth, and at different positions in the irrigation system. The Srivilliputhur Big Tank in Ramanathapuram district was selected as a representative tank to test the model. The catchment area of this tank is over 1,500 hectares, storage capacity is 14,160 hectares cm, with a water spread of 53 hectares. The irrigated rice area is 402 hectares.

Several modernisation options were simulated in the model, such as sluice modification, canal lining, provision of additional wells for supplementing the tank water, sluice management (closing the sluices for 2 days when the daily rainfall exceeds 60 mm), and rotation management (closing the alternative sluices for 1 week). These are listed in Table 2.

Alternative management and improvement in irrigation structure leads to farmer gains. Thus strategies can be evaluated both by production criteria and for their contribution to improved equity. However, it is also necessary to evaluate whether these investments are beneficial from the point of view of society. In principle, strategies should be cost effective to justify their adoption.

The direct benefits of tank improvement are increased rice production. But production increase is not always constant year-to-year due to seasonal failures of the tank system. Alternatively, there will be minimal benefits from system improvement in water surplus years, as in these years water is not a constraint even with the existing situation. The 10 years of data available on levels of tank replenishment, and associated benefits from tank improvement are given in Table 1 below, and arranged in the order

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[1] In 1990 US$ 1 = 17.28 rupees.

they occur. Over this 10 year period, full benefits of modernisation were expected to be realised in the 5 years when the tank storage reached 50 to 70% of storage capacity. Partial benefits, assumed to be half the benefits, were assumed to be realised in the 2 years the tank was 70% to 100% filled. In turn, no benefits are realised in the year the tank overflows (because tank supply was not a constraint), or in the 2 drought years when no rice was planted.

TABLE 1: PATTERN OF OCCURANCE OF TANK IMPROVEMENT BENEFITS IN A 10 YEAR CYCLE, RAMANATHAPURAM, TAMIL NADU, INDIA

Year	Tank storage level (%)	Groundwater supplementation[1] (%)	Benefits of tank modernisation
1	50-70	30-40	Full
2	50-70	30-40	Full
3	<50	No cultivation	No
4	>100	0	No
5	70-100	5-10	Half
6	50-70	30-40	Full
7	<50	No cultivation	No
8	70-100	5-10	Half
9	50-70	30-40	Full
10	50-70	30-40	Full

[1] Based on survey data on groundwater supplies for 4 years (1981-84).

(Source: Palanisami, K and Flinn, J C, 1988.)

The sequence of water supply events was used to calculate the expected values of benefits of the eight improvement strategies defined in Table 2. These, in turn were used to calculate the benefit cost Ratios (B/C), and the Internal Rates of Return (IRR) for the various improvements in tank management (Table 2).

TABLE 2: BENEFIT-COST RATIOS & INTERNAL RATES OF RETURN FOR DIFFERENT TANK IMPROVEMENT STRATEGIES, TAMIL NADU, INDIA

Strategies	Life period (years)[1]	B/C ratio[2]	IRR
Sluice modification	6	0.5	0
	11	0.6	0
Sluice management	10	10.0	2204
	15	10.6	2204
Canal lining	6	1.8	54
	11	2.9	63
Additional wells	8	1.7	35
	16	2.1	38
Rotation management	10	10.8	1974
	15	10.9	1974
Canal lining + additional wells	8	1.5	30
	16	1.9	33
Sluice management + additional wells + canal lining	18	1.7	37
	16	2.1	39
Rotation management + additional wells + canal lining	8	1.4	27
	16	1.8	31

1 Upper figure represents life period without maintenance, the lower figure represents lif period with maintenance

2 Discount rate = 12.5%

(Source: Palanisami, K and Flinn, J C, 1988)

Two periods for investments were assumed; one with no maintenance and another with proper maintenance of structures. Thus, in Table 2, each strategy is shown with two life periods. For example, sluices and canal linings have a life period of about 6 years without proper maintenance. After that time sluices silt up and the cement slabs used as canal lining break, and sometimes are lost. With proper maintenance the useful period before major reconstruction is up to 11 years. The life period of wells is assumed to be 8 years initially, and up to 16 years with further deepening. The management strategies of sluice management and sluice rotation have no time limit; for the purpose of the analysis, 10 to 15 year benefit periods were assumed. However, when management is combined with the physical investments, the benefits of improved management are assumed to be of the same duration as the life periods of the other investments for purposes of this analysis.

The results of the financial evaluation indicated that both sluice and rotation management has the highest returns, followed by the canal lining and provision of additional wells. This is because the management strategies have low cost components compared to their benefits. Further, combinations of strategies have lower benefit-cost ratios compared to strategies considered individually. This is because the maximum possible modernisation benefit expected can be reached with one or two of the strategies, and each additional strategy generates comparatively fewer benefits. Since the cost of each strategy is almost fixed compared to their benefits, the benefit-cost ratio is lower for the combination of the strategies. This is a very interesting conclusion since most of the modernisation strategy considered by the EEC, or any other funding agency may be to go for 'total package' rather than 'selective items'. Given the vast numbers of tanks, limited budget and other constraints, it is important to select the most appropriate strategies for modernising tanks. However, the success and scope in implementing the strategies depend heavily upon how the farmers are involved in various stages of the tank modernisation. The management strategies also depend heavily on competence and commitment to the operation of these strategies. Physical improvements alone, or in combination with management improvements, also generated substantial IRRs, although the B/C ratios, at less than 2.0, were modest.

The simulation model also looked at modernisation strategies in terms of production and equity criteria. Aggregate rice production was used as a measure of production performance. However, it was also recognised that access to food and increased income for poorer households is an important development issue, so the equity impact of modernisation strategies was as important. An equity ratio was developed which compared per hectare net returns of head-end farms, to per hectare net returns of tail-end farms. While management strategies gave the best returns under financial criteria, this was not the case with production and equity criteria. The most substantial reduction in production losses occurred when management and physical investment strategies were used in combination. These were not the strategies with the best equity ratios, but nevertheless had the second best (and very reasonable) 'equity' scores, and are likely to be preferred by all sets of farmers because of their contributions to farm income. The strategy with the most favourable equity ratio is canal lining and well development. However, this equity is achieved by reduced head-end net returns, as opposed to higher tail-end yield gains and so higher net returns, and so does not give the best results in productivity. As discussed earlier, well provision needs to be spread across all groups, and provide water at reasonable prices for well development strategies to contribute to equity in a broader sense.

8 CONCLUSIONS

The study demonstrated interesting results in the behaviour of financial criteria when applied to modernisation strategies. It also showed the differential effect that selection criteria can have on selection of modernisation strategies for tanks. The existence of trade-offs between financial and equity criteria are useful in defining the system performance in a consistent way to permit comparisons between different improvement strategies. The existence of trade-offs between financial and equity gains also highlights the importance of the political process in determining actual choices, and the importance of incorporating farmers in the identification of improvement strategies which best meet their needs, and is operationally realistic within the social system in which they live (Palanisami and Flinn, 1988). This study has illustrated the advantages in all areas of mixed strategies providing management skills are available, but also help target physical improvements if these wider improvements are unfeasible.

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IRRIGATION MANAGEMENT NETWORK

NEWSLETTER

ODI/IIMI Irrigation Management Network Paper 90/3a December 1990

Agricultural Administration Unit, Overseas Development Institute, London

The Overseas Development Institute (ODI) is an independent, non-profit making research institute. Within it, the Agricultural Administration Unit (AAU) was established in 1975. Its mandate is to widen the state of knowledge and flow of information concerning the administration of agriculture in developing countries. It does this through a programme of policy-orientated research and dissemination. Research findings and the results of practical experience are exchanged through four Networks on Agricultural Administration (Research and Extension), Irrigation Management, Pastoral Development, and Social Forestry. Membership is currently free of charge to professional people active in the appropriate area, but members are asked to provide their own publications in exchange, if possible. This creates the library which is central to information exchange.

The International Irrigation Management Institute, Colombo

The International Irrigation Management Institute (IIMI) is an autonomous, non-profit making international organisation chartered in Sri Lanka in 1984 to conduct research, provide opportunities for professional development, and communicate information about irrigation management. Through collaboration, IIMI seeks ways to strengthen independent national capacity to improve the management and performance of irrigation systems in developing countries. Its multidisciplinary research programme is conducted on systems operated both by farmers and by government agencies in many co-operating countries. As an aspect of its dissemination programme, it has joined ODI in the publication of the Irrigation Management Network papers, to enable these to appear more frequently to an enlarged membership.

The ODI/IIMI Irrigation Management Network is sponsored by:

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IRRIGATION MANAGEMENT NETWORK NEWSLETTER

Linden Vincent

1 NEWS FROM THE IRRIGATION MANAGEMENT NETWORK

Editor's Note

This is a special edition of the IMN Newsletter in many respects. We have collected a group of papers focusing on problems of resource management in water-scarce regions, which cover policy issues and management interventions, as well as studies concerning cooperation and conflict among farmers. They deal with both scarcity as a result of supply problems, as well as environments of actual physical scarcity. We are also carrying a more general paper on technology issues which nevertheless contributes to the debate on efficient water management in situations of water scarcity. Five papers make it a bumper issue, as befits the last edition under the ODI-IIMI agreement.

Changes will be taking place in the collaboration between IMN and IIMI, when sharing of the joint Network ends at the end of 1990. Older members of the Network will recall that it began in 1975 as one of the Networks operated by the Agricultural Administration Unit of the ODI, with support from the British Overseas Development Administration. The aim of ODI's Networks has always been to pursue research and to facilitate the exchange of information leading to the better management of agricultural services for small farmers in developing countries. Six years ago, ODI invited IIMI to join it in managing the Network, as a co-sponsor, as joint provider of inputs, and to assist in the quantitative and qualitative development of the Network.

IIMI was founded in 1984. Its mission is to strengthen national efforts to improve and sustain the performance of irrigation systems in developing countries through the development and dissemination of management innovations. It conducts this through programmes of research, extension and information. It was therefore natural that IIMI should turn to the Network, both for providing support to it as well as receiving support in the form of an appropriate information vehicle, in its early formative years.

Since January 1986, IIMI provided additional financial support for what became the ODI-IIMI Irrigation Management Network. This has led to an expanded membership, which increased from 760 to 1800, an improved publication format, and an improved computerised system of library information exchange. Each Newsletter has carried information on IIMI's programmes and publications, and each set of papers has frequently included one by an IIMI staff member. It was at one time envisaged that IIMI might eventually wish to take over the IMN.

The collaboration in its present form ceased at the end of 1990. IIMI, now a little older and with a growing record of research achievements, will focus on the generation and distribution of IIMI research results. ODI intends to maintain the original objectives of the Network, namely as a primary vehicle to produce and convey the results of its own research and interests in irrigation management, and that of its Network members.

Both partners will continue to collaborate and assist each other on informal and individual staff bases, and both institutes will continue to take an interest in each others' work, and exchange information and publications. The recently-launched African edition of the Irrigation Management Newsletter and papers, published simultaneously in English and French, will continue with the support of CTA (Technical Centre for Agricultural and Rural Cooperation, Netherlands). ODI is seeking supplementary funds to cover the on-going costs of the translation, production and dissemination of the Newsletter.

The IMN wishes to thank IIMI for its help with a valuable period of research information exchange on irrigation management.

Network Papers for Discussion

In Lucas Horst's paper, *Interventions Between Technical Infrastructure and Management*, 90/3b, the trend towards automisation of modern irrigation schemes to improve efficiency is questioned. The gap that exists between water diversion technology and management capabilities might be better addressed by adapting the technology if skills shortages persist.

In *Irrigation Allocation Problems at Tertiary Level in Pakistan*, 90/3c, Bhatti and Kijne consider efficiency and equity problems associated with warabandi allocation systems in Pakistan. Warabandi encourages wastage and conflict, and would be better replaced by a more flexible system based on allocation by volume, united with research into social and political rigidities.

In *Sustainable Development of Groundwater Resources: Lessons from [two] Indian Villages*, 90/3d, Tushaar Shah discusses means of improving groundwater management to mitigate overpumping and saline intrusion problems. He recommends a strategy of village level management, combined with legal and policy interventions.

In *The Politics of Water Scarcity: Irrigation and Water Supply in the Mountains of the Yemen Republic*, 90/3e, Linden Vincent examines the practical challenges likely to develop in water allocation decisions, and the difficulties of dealing with disputes and conflict at the local level. Relevant institutional changes to assist the transition to new patterns of use vary in relation to the culture and the type of water management problem.

In *Perspectives on the Middle East Water Crisis: Analysing Water Scarcity Problems in Jordan and Israel*, 90/3f, Richard Sexton examines different perceptions on the cause of water scarcity, and the prospects for different types of institutional change to manage water effectively. He considers that the main cause of water scarcity in Jordan and Israel is the structural overcapacity of irrigation schemes. The existing water administrations evolved as water supply agencies oriented to agriculture, and new powers to steer relevant changes in agricultural water use.

Lunchtime Meetings

Dr Douglas Vermillion (IIMI, Sri Lanka) presented his paper on *The Programme for Privatising Small-scale Irrigation Schemes in Indonesia by Turnover to Farmer Management*, to UK members at a Lunchtime Meeting held at Regent's College on Thursday 22 November.

The Programme aims to turnover small irrigation schemes (which farmers can manage), including headworks and distributaries, and to reallocate operation and maintenance funds to larger, more technically complex projects. Dr Vermillion argued that; (a) government bureaucracies were less effective than water-user associations and non-governmental organisations to manage small-scale irrigation schemes, and are also more of a strain on national budgets, and (b) poor management can cause a negative environmental impact (e.g. soil erosion, waterlogging, salinisation, pollution, etc).

IIMI's proposed three year programme aims to investigate the effects of turnover and privatisation using case studies at implementation and policy levels. This will involve establishing an information exchange system of database, library, networking, conferences and workshops. Network members interested in this project should either contact Dr Vermillion at IIMI, Sri Lanka.

2 NEWS FROM NETWORKERS

Special Initiatives in Water Scarcity and Allocation

Winrock International has established a *Water Resource and Irrigation Policy Program* which will focus particularly on issues linked to judicious water management of scarce water resources. Topics of interest range across water allocation, water conflict and improving productivity and sustainability of water resources. The Program hopes to (a) raise issues, (b) conduct and support studies, (c) strengthen analysis, and (d) advise in policy formation and implementation. The Program is under the overall direction of David Seckler, backed up by Stan Peabody, but will link in Jack Keller (Utah State University) and Peter Rogers (Harvard University), and actively use membership of Winrock's African and Asian Networks. For more information, write to David Seckler or Stan Peabody at Winrock International, Washington D C Office, 1611 N Kent Street, Arlington, VA 22209, USA.

The East-West Centre, Hawaii, has a long-standing research record in water management and allocation, and on watershed management. For more details of research programmes, and a list of publications, please write to Dr Maynard Hufschmidt, East-West Centre, Environment and Policy Unit, 177 East-West Road, Honolulu, Hawaii 96848, USA.

General

IIMI have launched *IMCD News*, a new newsletter concerning Crop Diversification in Rice-Based Systems. The context for the newsletter is the glut of rice on the world market, and its resulting impact on prices and producers. The concern is not to displace rice, but to find better ways to grow other crops in association with rice, and to encourage exchange of ideas. To obtain the newsletter, write to Dr Senen Miranda, Secretariat Coordinator for the IMCD Research Network, IIMI, PO Box 2075, Colombo, Sri Lanka.

The *Irrigation Management News* has been launched to cover information on irrigation management and training programmes in India. To obtain a copy, write to IMTP, 213 Ansal Chambers II, 6 Bhikaji Cama Place, R K Puram, New Delhi 110066, India.

The *United Kingdom Register of Research on Irrigation, Drainage and Flood Control 1990*, is now available at a cost of £19.50 in the UK and £24.50 elsewhere. It is obtainable from Richard Wooldridge, Overseas Development Unit, Hydraulics Research, Wallingford, Oxon OX10 8BA, UK.

The 4th annual *Compendium of International Short Courses* is now being compiled. Last year's compendium had details of short courses, conferences and workshops from 33 countries worldwide. If you have courses you wish to register, or would like a copy, please write as soon as possible to: Tom Kajer (Winrock International), Louis Berger International Inc, 213 Ansal Chamber II, 6 Bhikaji Cama Place, R K Puram, New Delhi 110066, India.

The 3 year *International Programme for Technology Research in Irrigation and Drainage* (IPTRID), discussed in the previous Newsletter, was launched on 2 January, with a programme budget of US$ 1.5 million. For further details, contact the Agriculture and Rural Development Department, The World Bank, 1818 H Street, Washington DC 20433, USA.

The Agency for Relief and Development are compiling a "living memory" of lessons learned in the field in relief and development efforts in conflict regions. Thus, any researchers, consultants, NGOs, local or international organisations who have field reports, planning surveys, or evaluations of projects are asked to send a copy of their work to the resource centre. In turn, they will have access to the Agency's findings, which will be organised by subject and by region. Not only will this help to assure the same mistakes are not repeated, it can help to assure that successes are duplicated, and provide a link between people working on similar problems in diverse regions. Send your contributions to Kerry Abbott, Agency for Relief and Development, PO Box 20546, East Jerusalem, via Israel.

Bill Moffatt will become the new leader of the Water, Engineering and Development Centre (WEDC) at Loughborough University of Technology, UK. Bill Moffatt has been a faculty member of Loughborough since 1960, and has extensive experience in groundwater development. John Pickford will continue to provide an input to WEDC activities, but is looking forward to spending more time on research and consultancy.

Peter Dempsey, Research Associate with ODI, is preparing a Network paper on the conjunctive use of surface and groundwater for irrigation. He would be pleased to hear from anyone who has been working with, or researching conjunctive use irrigation. Case study material is particularly welcome. He can be contacted c/o The Editor, Irrigation Management Network, ODI.

Kate Morse, an MSc student at Silsoe College has undertaken a project to assess research priorities in small-scale irrigation in sub-Saharan Africa. Kate would like to receive any opinions from workers involved in farmer-managed systems on any future research from which their schemes would benefit. Please send any letters to K Morse at Silsoe College, Silsoe, Bedford MK45 4DT.

Global Consultation on Safe Water and Sanitation, September 1990

The world community has been reviewing the impact of the 'Water Decade' in a series of meetings throughout 1990, culminating in a major international meeting in New Delhi last September. No major new financial plans have been declared for the next decade, with the focus switching to support for programmes specific to individual country needs. The meeting did, however, declare the *New Delhi Statement* summarising the key issues likely to assist improved water services, and shows a new focus on developing water in a wider environmental context. Rural water services would need around US$ 73 billion to achieve universal coverage even by low cost technologies, but it seems there is little likelihood of finding international aid to assist these loans, nor was there very clear evidence that governments and donors will find or develop the administration and technology required for rapid expansion of rural services.

The New Delhi Statement

1. Protection of the environment and safeguarding of health through the integrated management of water resources, and liquid and solid wastes;

2. Institutional reforms promoting an integrated approach and including changes in procedures, attitudes and behaviour, and the full participation of women at all levels in sector institutions;

3. Community management of services, backed by measures to strengthen local institutions in implementing and sustaining water and sanitation programmes;

4. Sound financial practices, achieved through better management of existing assets and widespread use of appropriate technologies.

15th Congress of ICID, Water Management in the Next Century, The Hague, Netherlands, 6 - 11 September 1993

Papers are now invited for the ICID Congress which will study the topics given below. Case studies should be less than 2000 words, and technical/scientific papers less than 4000 words. ICID members should submit their papers through their National ICID Committees or international organisations involved in irrigation and drainage. For further details about topics and procedures, contact your National Committee or the International Committee on Irrigation and Drainage, 48 Nyaya Marg, Chanakyapuri, New Delhi 110 021, India. Potential British contributors should send an abstract by 1 September 1991 to B S Piper, Chairman, ICID Papers Sub-Committee, Institute of Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB, UK.

Question 44: Planning and Design of Irrigation Schemes

1. Relating drainage, irrigation needs and technologies to different crops and climatic requirements;
2. Planning and design for flexibility;
3. Research aspects on irrigation and drainage;
4. Design aspects of sediment control in irrigation, or drainage systems;
5. Possibility and limit in the use of agricultural drainage water.

Question 45: Irrigation and Drainage Systems Management - Institutional and Financial Interrelationships

1. Role of farmers and governmental organisations in managing and financing irrigation and drainage systems;
2. Irrigation and drainage service fee and recovery of dues;
3. Policies and mechanisms for funding operation and maintenance;
4. Irrigation and drainage in the socio-economic and legal environment;
5. Influence of on-farm activities on the management of irrigation and drainage systems;
6. Research and training programmes and their influence on institutional management performance.

Special Session: Irrigation and Drainage in Competition for Water

1. Regional water management strategies;
2. The effects that competition for water is having on irrigation operations and the manner in which the users are coping with it;

3. Case histories illustrating the growth of competition for water, its effects and resolution.

Symposium: The Impact of Real Time Information on System Management

1. Application of management techniques to irrigation and drainage project management;
2. Economics of different approaches;
3. Decision support and expert systems;
4. Obtaining user input and user acceptance/
5. Network design: type, frequency and density of measurement.

3 IIMI NEWS

Colombo-based IIMI has been admitted to the internationally renowned Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of over 40 governments, international organisations and private foundations that was established in 1971 to support a system of agricultural research and development around the world. The World Bank, FAO, and the UNDP are its co-sponsors. The CGIAR now funds 15 international research centres providing more than US$ 250 million annually for food crop and livestock research to benefit developing countries.

IIMI was admitted after scrutiny by an external review panel that found IIMI's work contributed greatly to improving food security throughout the developing world.

IIMI's entry into the CGIAR system will help the US$ 8 million organisation consolidate its funding, increase its international stature and form additional links with other international agricultural research centres working to improve food self-reliance in developing countries. Dr Roberto Lenton, Director General of IIMI, commented "The decision to admit IIMI unconditionally into the CGIAR system is one that we have eagerly been awaiting for some time; it is of great significance both to IIMI and to Sri Lanka". He also added that: "Sri Lanka can be very proud of this decision because it is now one of only four countries in Asia to host a CGIAR centre". The other countries are the Philippines, India and Syria. IIMI's admission to the system "gives us a new sense of identity", stated Lenton. "No longer are we each simply staff members of IIMI; now we are a part of a global system involving over a thousand distinguished scientists who are working together with a common goal of improving sustainable agricultural production in developing countries".

The Institute Appoints a Director for Research

Mr Khalid Mohtadullah has been appointed to the newly-created position of Director for Research. Mr Mohtadullah will commence his assignment at the Colombo headquarters of the Institute in April 1991. The Director for Research is a new position at IIMI. It has been created to provide overall leadership to the Institute's worldwide research programmes, in particular by directing thematic and global research programmes and by advising on country-specific projects. The Director for Research will also provide strategic and programme planning leadership for the Institute. This new post replaces that of Director of Programmes.

A national of Pakistan, Mr Mohtadullah brings to the Institute considerable experience and skill in water resource management. He is currently General Manager (Planning) of the Pakistan Water and Power Development Authority (WAPDA). Previously, he has occupied, over a period spanning 30 years, a variety of positions in the public water and irrigation sector of Pakistan, rising to high positions of leadership in his profession. For a 5 year period in the late 70s and early 80s, he was principal of the WAPDA training academy at Tarbela. Mohtadulla is an alumni of the Massachusetts Institute of Technology with a Master's Degree in Civil Engineering, which he received after completing his Bachelor's Degree at the University of Peshawar. He is also an alumni of the Harvard Business School, where he attended their Advance Management Program.

Talking in Colombo recently, Mohtadullah said that the challenges lie in helping IIMI plan future directions for its research that aim at the heart of issues faced in managing irrigation systems. In particular, research work should be linked with real problems as they are felt, and studies should strive to improve performance without major physical interventions, through institutional change and improved management. "It is the management and the direction which need to be tackled," Mr Mohtadullah states, "the facilities and the infrastructure are there. Within the Institute, I see my role as providing greater coordination between global and country programs, and establishing linkages with scientific research around the world wherever the required strengths lie."

IIMI

Irrigation Management in Latin America (1990), xii + 96p. Price US$ 13.50 (US$ 8.50 for developing countries). Also available in French and Spanish.

In Latin America, some 11 million hectares or 8.1% of the total arable area is classified as irrigated. Although the total extent of irrigated agriculture in Latin America is small compared to that of Asia and represents less than 5% of the total worldwide irrigated land, the potential for increasing the area under irrigation is great. Over the next few years IIMI will initiate collaborative programmes in Latin American institutions to complement similar activities in Asia and Africa. The publication presents papers from seven Latin American experts describing the present situation of irrigation management in their own countries in the wider context of overall irrigation management issues in the region and identifying problem areas and areas where the potential for improvement seems great.

Yoder, Robert., and Thurston, Juanita., (eds), (1990)
Design Issues in Farmer-Managed Irrigation Systems: Proceedings of an International Workshop of the Farmer-Managed Irrigation Systems Network held in Chiang Mai, Thailand, 12 - 15 December 1989

In many countries irrigation systems have been built and managed by government agencies, but due to poor performance and high recurring costs, governments are seeking ways to turn over the operation and maintenance of the systems to the water-users. However, the procedures and designs used for improving existing systems and building new farmer-managed systems are often not appropriate when the end product is to be managed by the farmers. This publication represents an effort to focus on design and the design process for farmer management, to give attention to the technical expertise of the farmers, and to highlight the necessity of incorporating farmer input into all phases of the design process.

Manor, Shaul., Patamatamkul, Sanguan., and Olin, Manuel. (eds), (1990)
Role of Social Organizers in Assisting Farmer-Managed Irrigation Systems: Proceedings of a Regional Workshop of the Farmer-Managed Irrigation Systems Network held in Khon Kaen, Thailand, 15 - 20 May 1990

The successful and often impressive experiences in farmer-managed irrigation systems in many countries of Asia have promoted the development of a number of programmes in various countries with the purpose of accelerating this process. Implementing these types of systems is generally accomplished through the fielding of 'social organisers'. Social organisers serve as intermediaries between the farmers and the agencies. These regional workshop proceedings document the experiences of practitioners and researchers from nine countries in South and Southeast Asia, emphasising the problems they encountered and their suggested solutions.

Resource Mobilisation for Sustainable Management: Proceedings of a Workshop on Irrigation Schemes in Sri Lanka held in Kandy, Sri Lanka, 22 - 24 February 1990 (1990)
The papers focus on institutional reforms that are seen as a prerequisite to effective mobilisation of sufficient resources for sustainable management of irrigation schemes. They analyse the impediments to high-performance system management within the irrigation management agencies and the direction in which reforms must move to bring improvements and identify broader policy issues and recommendations that are very important to the whole change process underway.

Robert Yoder (ed), (1990)
Assistance to Farmer-Managed Irrigation Systems: Results, Lessons, and Recommendations from an Action-Research Project, Nepal Country Paper No 3

This report highlights the results and lessons learned in an action/research project that developed and tested strategies for assisting 19 farmer-managed irrigation systems in a remote area of Nepal. The results and lessons drawn are based on continuous observation and documentation of field activities, project accounts, and reports from project staff, consultants, and farmers. Using the experience and lessons of the action/research project, recommendations have been prepared in the form of procedures to be followed for providing assistance to existing irrigation systems in a similar environment.

Inge Jungeling, (1989)
Improving Management of Small-Scale Irrigation Systems, Sri Lanka Country Paper No 5

This paper analyses the contributions of a NGO in improving management of small-scale irrigation systems in Sri Lanka. It documents the decision-making processes of the NGO and the context in which this decision making takes place; government policies and policies of NGOs in improving the performance of small-scale irrigation systems and in assisting the rural population in general. The site selected for research was the Tank Settlement Project in Hambantota District, southern Sri Lanka.

Shyamala Abeyratne, (1990)
Rehabilitation of Small-Scale Irrigation Systems in Sri Lanka; State Policy and Practice in Two Systems, Sri Lanka Country Paper No 6

Based on a study of two small irrigation systems in Sri Lanka, this report analyses the impact of a government programme for system rehabilitation and improvement of water management. The study reveals that during the improvement process, there had been insufficient coordination between the implementing agencies, and consultation with farmers was also below the expectations of the managers of the national programme. As a result, the existing system of water allocation was disrupted, threatening the long-term impact of the programme. The study draws lessons for improving future programmes of this nature in Sri Lanka and elsewhere.

David Groenfeldt, (1989)
Guidelines for Rapid Assessment of Minor Irrigation Systems in Sri Lanka
Working Paper No 4

This paper presents a set of guidelines for rapid evaluation of an irrigation system developed by IIMI staff in cooperation with the staff of the Regional Development Division and the Badulla District office of the Integrated Rural Development Projects in Sri Lanka. It was compiled following a workshop on rapid-assessment methodologies suitable for small-scale irrigation systems held in August 1988.

Ijsbrand H de Jong, (1989)
Fair and Unfair: A Study into the Bethma System in Two Sri Lankan Village Irrigation Systems, Working Paper No 15

Bethma is a traditional custom in small, communal tanks of Sri Lanka, where water supplies which are not adequate for the full command area are allocated to a part of the area, and all farmers are given proportional land shares in the irrigated part. This paper deals with the rules that govern bethma, how farmers make use of them and the role of the government in bethma. It also addresses the questions; why do conflicts happen less frequently during bethma? why do farmers practice bethma? What are the farmers' perceptions?

Ekanayake, Rathnasiri., Navaratne, W M U., and Groenfeldt, D., (1990)
A Rapid-Assessment Survey of the Irrigation Component of the Anuradhapura Dry-Zone Agricultural Project (ADZAP), Working Paper No 16

The focus of the ADZAP in Sri Lanka has been to provide a viable farming system through careful development of local resources. The pre-project context of semi-shifting chena (swidden) agriculture was to give way to permanent, intensive cultivation of both irrigated command areas and upland plots. The report deals with the irrigation component of ADZAP which constitutes the greatest component cost and the dominant focus of the project. It is suggested that supplementary lift irrigation, that is, tapping groundwater supplied by the tank itself, could become an important feature of the farming system in the project area.

Ekanayake, Rathnasiri., and Groenfeldt, D., (1990)
Organizational Aspects of Improved Irrigation Management: An Experiment in Dewahuwa Tank, Sri Lanka, Working Paper 17

One of the incentives in improving irrigation management is to find ways of stretching water further during the dry season in water-deficient systems, when rice is relatively more expensive to grown than during the wet season, and when other crops which can be grown only during the dry season offer the farmer and the country a comparative advantage. This report addresses the issue of irrigation management to promote diversified crops during the dry season.

Dayaratne, M H S., and Wickramesinghe, Gamini., (eds), (1990)
Role of Nongovernment Organisations in the Improvement of Minor Irrigation Systems in Sri Lanka: Proceedings of a Workshop held at Digana Village, Kandy, Sri Lanka, 17 - 18 March 1989, Working Paper No 18

An inherent feature of non-government intervention in minor irrigation schemes is the continuous involvement of beneficiary farmers to create a sense of ownership of the system by farmers which ultimately reduces their dependency on outside assistance. The Government of Sri Lanka has encouraged these assistance programmes as operation and maintenance of minor irrigation systems have become a heavy burden on the government. These proceedings present experiences of importance to government organisations that are directly involved in minor irrigation work.

Moragoda, Ranjanie., and Groenfeldt, D., (1990)
Organizational Aspects of Improved Irrigation Management: Kalankuttiya Block, Mahaweli System H, Sri Lanka, Working Paper No 19

IIMI's research interest in Sri Lanka's Mahaweli System H, in general, and the Kalankuttiya Block in particular, was prompted by the existing widespread adoption on non-rice crops during the dry season. By studying a case of diversified cropping 'success' IIMI hoped to better understand the irrigation management factors underlying that success, and if possible, to improve on them. This report addresses the issue of irrigation management to promote diversified cropping during the dry season.

de Silva, Ramya., (ed), (1990)
IMIN Bibliography: A Selected Bibliography on Irrigation Management, Vol 3, No 1, viii + 126p. Free selectivity on request.

A bibliography of selected documents entered in the Irrigation Management Information Network (IMIN) database. Publications and information from over 100 countries are indexed; monographs, conference proceedings, government publications, technical and research reports, dissertations, and journal articles. Chapters in books are included. The present issue covers acquisitions in 1989.

Vimaladharama, Kapila P., (Compiler), (1990)
A Selected Bibliography on Small-Scale Irrigation Systems in Sri Lanka
A bibliography of available writings, whether published or unpublished, on minor irrigation in Sri Lanka covering such areas as assistance programmes, water management, farmer participation, and system performance and management.

For further information on IIMI publications, contact the Distribution Section, Information Office, IIMI, PO Box 2075, Colombo, Sri Lanka. Tel: 94(1)-565601, Fx: 94(1)-562919, Tx: 22318 or 22907 IIMIHQ CE

Other Publications

Beaumont, P., Levine, M., and McLachlan, K., (eds), (1989)
Qanat Kariz and Khattara, Menas Press Ltd, (available through the Middle East Centre, School of Oriental and African Studies, University of London, Thornhaugh Street, London WC1E 7HP).

This book examines the origins and diffusion of the qanat (horizontal well) in its various forms, and also its influence as a supplier of water on patterns of human ecology and settlement. The survival of the qanat and trends in their modern utilisation are also discussed. About three quarters of the articles focus on qanats in Iran. However, there are also chapters on the **foggara** (oases in Algeria), **khattara** (also called **rhettara**) irrigation in Morocco, qanats in Israel, aflaj in Oman, kariz in Afghanistan, and mambos (qanats) and gamas (spring tunnels) in Japan.

Underhill, H., (1990)
Small-scale Irrigation in Africa in the Context of Rural Development
Cranfield Press, CIT, Bedford MK43 0AL, UK. Price US$ 12.50.

This study updates the author's previous study for FAO. Part A includes a brief but comprehensive summary of issues and experience with small-scale irrigation in sub-Saharan Africa, aimed at African agricultural development workers. The issues of large versus small-scale schemes, outgrower schemes, and the role of international, national and local donors, especially NGOs, are critically discussed. Part B looks at practical aspects of implementation at each stage of development and is aimed at irrigation field workers. There are also appendices on planning and health aspects. The author expects the book to be useful to those promoting small-scale irrigation, and seeking financial and other support from development agencies.

Tiffen, Mary., Harland, C., (1990)
Socio-Economic Parameters in Designing Small Irrigation Schemes for Small-Scale Farmers, Nyanyadsi Case Study, (3 reports, and a summary report), Hydraulics Research, Wallingford, UK. £15.00 per report.

This four volume collaborative study by Hydraulics Research, ODI and Agritex, Zimbabwe, is a detailed socio-economic analysis of a 400 hectare irrigation scheme in Zimbabwe. It investigates the minimum farm income level necessary to sustain irrigated cultivation, the minimum economic plot size, and the effects of drought on farm incomes. It looks at relative scarcities in labour, land, capital and water, and the interrelations between irrigated cultivation, livestock rearing, dryland farming and non-farming activities. Finally, it examines cultivator's attitudes towards authority, land inheritance, tenancy forms, irrigation system management and payments for water. It was found that the reliability and adequacy of the water supply is the main determinant of cropping patterns and yields, hence incomes. This is a comprehensive and detailed study that will be of interest to researchers and practitioners interested in small-scale smallholder development in sub-Saharan Africa, of which Nyanyadsi is representative. It demonstrates useful appraisal techniques, includes a critical discussion of the methods used, and the questionnaires are appended. It also demonstrates the merits of collaboration between research institutions with different but closely associated interests.

Gooneratne, W., and Hirashima, S., (eds), (1990)
Irrigation and Water Management in Asia, Sterling Publishers, New Delhi, India.

This book provides an overview of Asian irrigation through both general policy analysis and case studies. Case studies look at small-scale irrigation in the northern Philippines, in Bali, and in the dry zone of Sri Lanka. Large-scale irrigation is discussed through case studies for Sri Lanka, and comparing India and South Korea. Both scales of irrigation are reviewed in terms of management, maximisation of agricultural production and employment, and the promotion of equitable distribution of gains. The book is targeted at Asian development planners and policy makers, as well as students in agricultural and rural development.

Sampath, R K., and Young, Robert A., (eds), (1990)
Social, Economic, and Institutional Issues in Third World Irrigation Management, Westview Studies in Water Policy and Management, No 15, US$ 40.00.

Experts now recognise that poor returns on irrigation investment are often due to project or programme mismanagement and inadequate attention to social, economic, and institutional factors. The contributors to this volume examine problems of irrigation management, and propose strategies for improving irrigation efficiency and equity in the developing world. A series of detailed case studies of project successes and failures provide an interdisciplinary analysis of irrigation management in a variety of Third World settings. Its twenty chapters form a comprehensive read for those involved in irrigation management theory. Early chapters outline recent concepts and theories from the social and management sciences, while sections 3 and 4 provide applied economic analysis with useful case studies.

Dhawan, B D., (ed), (1990)
(a) ***Big Dams; Claims, Counterclaims***
(b) ***Minor Irrigation, with Special Reference to Groundwater*** Commonwealth Publishers, New Delhi, India.

(a)This book, which reprints a series of articles first published in India's Political and Economic Weekly, debates the issues related to big dams from an India perspective. Dhawan argues that environmental, geological and sociological criticisms of big dams are outweighed by their benefits. There follows a series of convincing counter arguments by a number of contributors. Dhawan concedes a middle way, in which dam heights are reduced with a cut in total irrigative capacity, may be most appropriate.
(b) This collection of papers, all by Dhawan, critically reviews the shift

in India from large-scale surface water irrigation to small-scale groundwater irrigation from tubewells. Dhawan warns that estimates of groundwater potential are over estimated, especially in hardrock regions, and his discussion of tubewells questions how well they address problems of under utilisation, or allocative efficiency and equity.

Both books are polemical in style to promote lively debate. The issue of 'openness' recurs with both sides calling for more cooperation between the public, planners and engineers.

Howell, P P., and Allan, J A., (eds), (1990)
The Nile: Resource Evaluation, Resource Management and Legal Issues
Proceedings of the joint RGS-SOAS conference, May 1990, from the Centre of Near and Middle Eastern Studies, Thornhaugh Street, London WC1H 0XG.

In recent years, reduced flows, increased climatic fluctuations and intensified drought in the Nile basin, have highlighted the need for improved water management and planning to meet the water supply, irrigation and power needs of dependent states. This small and highly readable book brings together hydrological, historical, geopolitical and legal analyses and presents priorities for future water development.

A detailed hydrological analysis is presented, using historical and current data, by senior engineers and hydrologists. There is an absorbing account of the history of water development in the region, especially the influence of the British colonial authorities and the impact of independence, not least, Nasser's unilateral commissioning of the Aswan Dam. There follows reviews of legal treaties affecting water sharing between states, especially the 1959 agreement between Egypt and Sudan.

It is concluded that more efficient management of the Nile is vital to meet the region's food requirements and maintain political stability. 'Clean slate' negotiations between all nine affected states, not least Ethiopia, will be necessary to create a more robust political and legal environment for effective river basin planning.

Biswas, A K., et al., (eds), (1990)
Environmental Modelling for Developing Countries
Tycooly Publishing, London, UK.

Biswas opens with a critical review of environmental modelling in which he acknowledges the progress made in computing and mathematics, but argues that too often modelling is the preserve of theoreticians and has limited application to real environmental problems in developing countries. Frequently, hardware and software are transferred unmodified from developing countries to under-qualified staff in developing countries who may not be aware of simplifying assumptions within the model, and where data may be scarce or unreliable. Further, models are too often static, i.e. they are not updated according to changing parameters, and are separated from project decision-making. There follows a series of examples from modelling experience in ecology, air and water quality and water resource development. Of particular interest are papers on the use of QUAL I and QUAL II in evaluating waste loads in streams and rivers, modelling groundwater overdraft and related environmental consequences, and the integration of environmental concerns into water resources project planning. In the concluding chapter, the judicious use of modelling is advocated as a powerful tool in environmental management.

Cernea, Michael., (1990)
Social Science Knowledge for Development Interventions, World Bank Development Discussion Paper No 334

Failures have plagued many development programmes because they were sociologically ill-informed or ill-conceived. However, the conventional 'entrance points' for sociological/anthropological knowledge in planning for induced development are few and of little influence, and we need some new frameworks for social enquiry. The growing role of planning and state interventions are prime examples of circumstances that require a new design of structures for research and analysis.

Bromley, Daniel., and Cernea, Michael., (1989)
The Management of Common Property Natural Resources, World Bank Discussion Paper No 57

This paper reviews interpretations of common property regimes and of resource degradation. It points out that many common property regimes have become 'open access' regimes, and it is exploitation under open access principles which is a greater cause of resource degradation. Development assistance will only succeed if programmes and projects address social interactions between resource uses, and help build up social organisation conducive to sustainable productive use of natural resources.

IRRI

Masicat, P., De Vera, V., and Pingali, P L., (1990)
Philippine Irrigation Infrastructure: Degradation Trends for Luzon, 1966-89, Social Science Division, Paper 90.03.

Pingali, P L., Moya, P F., and Velasco, L E., (1990)
The Post-Green Revolution Blues in Asian Rice Production, Science Division, Paper 90-01.

Pingali, P L., and Xnan, V T., (1990)
Vietnam: De-Collectivisation and Rice Productivity in the Philippines, Social Science Division, Paper 90-04.

Dorji, N., Flinn, J C., Maranan, C., (1990)
Rice Production in the Wangdiphodrang-Punakha Valley of Bhutan, IRRI Research Paper Series No 140.

These papers collectively gave an overview of rice yield trends in Southeast Asia and factors influencing their improvements or decline. These papers are likely to be useful for Network members interested in irrigation system performance and environmental impact of irrigation, as well as research and extension needs in rice production.

All available from The International Rice Research Institute (IRRI), PO Box 933, 1099 Manila, Philippines.

Journal Articles

Appropriate Technology
17(1), June 1990

Barrett, Alison., 'Floods in Bangladesh', pp 8 - 10.

Water Resources Development
Vol 6(4), 1990

Goodland, R., 'The World Bank's New Environmental Policy for Dams and Reservoirs', pp 226 - 239.

Biswas, A., 'Watershed Management', pp 240 - 249.

Vincent, L., 'Sustainable Small-Scale Irrigation Development: Issues for Farmers, Governments and Donors', pp 250 - 259.

Oyeband, L., 'Drought Policy and Drought Planning in Africa', pp 260 - 269.

Lema, A J., 'East African Climate: 1880-1980', pp 270 - 277.

Margeta, J., and Fontane, D G., 'Designing Communal Rain-Harvesting Systems by Spreadsheet Methods', pp 278 - 286.

Vol 6(3), 1990

Govindasamy, R., and Balasubramanian., 'Tank Irrigation in India: Problems and Prospects', pp 211 - 217.
Water Resources Management
4(3), 1990

Jermar, Milan K., 'On the Rationalisation of Water Management for Food Production', pp 211 - 217.

World Development
18:10, 1990

Adams, W M., 'How Small is Beautiful? Scale, Control and Success in Kenyan Irrigation', pp 1309 - 1323.

Waterlines
9(2), October 1990

Several articles on the public and environmental health impact of water development projects.

Kandiah, A., (1990), 'The Role and Responsibilities of Engineers and Agriculturalists', pp 7 - 11.

Abu-Zeid, M., (1990), 'Environmental Upgrading of Irrigation Systems to Control Schistosomiasis', pp 31 - 35.

ODU Bulletin
No 20, October 1990

Contains a selection of papers on 'Irrigation Management and Microcomputers'. Available from Hydraulics Research Ltd, Wallingford, Oxfordshire OX10 8BA, UK.

No 19, July 1990

Articles on 'Irrigation and Drainage Research'.

No 18, April 1990

Articles on 'Irrigation System Performance'.

The Courier
No 124, November-December 1990

This edition of The Courier features a special dossier on irrigation in Africa, including contributions on small-scale irrigation, environmental inputs, improving efficiency, diversification, and groundwater irrigation. Case studies are taken from several Sudano-Sahelian countries and there are summaries of programmes by FAO, IIMI, EEC, CTA and ILRI, Wageningen, and Leiden.

***International Institute for Land Reclamation and Improvement (IIED), Annual Report*, 1989**

Immerzel, Wivan., and Oosterbaan, R J., 'Irrigation and Flood/Erosion Control at High Altitudes in the Andes', pp 8-24.

Wolters, W., and Bos, M G., 'Irrigation Performance Assessment and Irrigation Efficiency', pp 25-37.

Jurriens, M., and Landstra, W., 'Water Distribution: Conflicting Objectives of Scheme Management and Farmers', pp 38-46.

Steekelenburg, P N G van., 'Towards Situation-Specific Management in Irrigation', pp 47-62.

Oosterbaan, R J., and Abu Senna, M., 'Using Saltmod to Predict Drainage and Salinity in the Nile Delta', pp 63-75.

5 TRAINING COURSES

United Kingdom

During 1991 Silsoe College is offering short courses in **Field Management for Effective Drainage** (7-10 January), **Irrigation Principles and Practices - UK** (February), **Irrigation for Developing Countries** (15-19 April), **Soil Conservation** (3-28 June). For details, contact the Short Courses Administrator, Silsoe College, Silsoe, Bedford MK45 4DT. Tel: 44(0525)-60428, Fx: 61527.

January 8-1 April 1991, Diploma Course in Irrigation and Water Resources, WEDC, (Water, Engineering and Development Centre), Loughborough University of Technology, Leicestershire LE11 3TU, UK.

Aimed primarily at professional staff who work in irrigation and water resources in LDCs, but who have not received a specialist training in these subjects. For further details, write to the Course Tutor.

January 8-1 April 1991, Diploma Course in Wastewater and Irrigation WEDC, (address as above).

A 12 week diploma course for people working in irrigation who consider wastewater as a possible source if water is in short supply, and for people involved in wastewater who consider irrigation as a means of disposal of sewage effluent. It covers the basic principles of wastewater collection and treatment, and design of irrigation systems, with specific attention to the reuse of wastewater for irrigation. Contact the Course Tutor, as above, for more details.

May 20-27 July 1991, Rehabilitation and Management of Irrigation Projects

An intensive 10 week course for engineers and other professionals involved in the rehabilitation, upgrading and management of irrigated agriculture. Institute of Irrigation Studies, The University, Southampton SO9 5NH. Tel: 44(0703)-593728, Fax: 593017, Tx: 47661 (a/b sotonu g). Applications should be made as soon as possible.

September 30-18 October 1991, Effective Irrigation Management: Setting Targets, Monitoring Performance and Achieving Objectives

A 3 week intensive course organised in association with Hydraulics Research, Wallingford, which draws on extensive experience of irrigation management methods and performance assessment techniques. For more details, write to the Effective Irrigation Management Short Course, at the Institute of Irrigation Studies, Southampton, at the address above.

October 1991, Irrigation Engineering

This 12 month course covers subjects areas such as assessment and development of water resources, project planning and implementation, irrigation theory and practice, irrigation and drainage design, irrigated agriculture (soils, crops and farming systems), groundwater engineering, and management, operation and maintenance of projects. For further details, contact Mrs T Clinton-Carter, Institute of Irrigation Studies, The University, Southampton SO9 5NH, UK. Tel: 44(0703)-593728.

Worldwide

The CEFIGRE (International Training Centre for Water Resources Management) is running several courses mainly designed for managers and engineers from developing countries. They are organised either at CEFIGRE headquarters in Sophia Antipolis, France, or in the countries themselves in cooperation with local or regional partner institutions.

4-15 March, Egypt, Waste Water Reuse (code 1.1)
1-26 April, Sophia Antipolis, France, Base de données et gestion des ressources en eau souterraine (code 1.2)
July 15-2 August, Bangkok, Environmentally-Sound Watershed Management (code 1.3)
4-29 March, Montpellier et Nimes, Management des périmètres irrigués (I) Management stratégique et gestion des ressources humaines et financières (code 3.1)
1-26 April, Monpellier et Nimes, Management des périmètres irrigués (II) Exploitation et maintenance des infrastructures (code 3.2)
3-28 June, Bangkok, Integrated Rural Development (code 3.3)
September 30-18 October, Niamey, Aménagement du terroir villageois et place de la CES/DRS (code 3.5)
8-26 April, Bangkok, Environmental Impact Assessment (code 4.1)
3-21 June, Sophia Antipolis, France, Etudes d'impact des projets d'hydraulique sur l'environment (code 4.2)

11-23 November, Douala, Environmentally Sound Management of Water Resources (code 4.3)

CIFIGRE, Sophia Antipolis, BP 113, 06561 Valbonne, France. Tel: 331(93)-654900, Fx: 654402, Tx: 461 311 F.

6 FORTHCOMING CONFERENCES AND WORKSHOPS

Worldwide

17-19 February 1991, Alexandria, Egypt
African Regional Symposium on *Techniques for Environmentally Sound Water Resources Development.* For details, write to either The Overseas Development Unit, Hydraulics Research, Wallingford, OX10 8BA, UK, Tel: 44(0491)-35381, Fx: 32233, or the Water Research Centre, 22 El Galla Street, Bulak, Cairo, Egypt.

20-22 February 1991, Marrakesh, Morocco
CMWR 1991 2nd International Conference on *Computer Methods and Water Resources,* organised by the IAHR. Contact Liz Newman, Computational Mechanics Institute, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO4 2AA, UK. Tel: 44(0703)-293223, Fx: 292853.

March 1991, Taipei, Taiwan
Computer Applications in Water Resources International Conference. Details from IWRA, University of Illinois, 205 N Matthews Avenue, Urbana, IL 61801, USA. Tel: 1(217)-333 0536, Fx: 333 8046.

15-20 April 1991, Malta
Conference and exhibition on *Desalination and Water Reuse.* Details from Institution of Chemical Engineers, 165 - 171 Railway Terrace, Rugby CV21 3HQ, UK.

22-26 April 1991, Wiesbaden, Germany
Hydrological Modelling for Irrigation & Drainage in XVIth General Assembly of the European Geographical Society.

13-18 May 1991, Rabat, Morocco
Water for Sustainable Development in the 21st Century. *The 7th World Congress on Water Resources.* Secretariat, Administration de l'Hydraulique, Direction de la Recherche et de la Planification de l'Eau, Rue Hassan

Benchekroun, Agdal-Rabat, Morocco. Tel: 212(7)-78690, Fx: 76658, Tx: PLANEAU 310-82.

June 1991, Vienna, Austria
The 17th International Congress on *Large Dams*. Information from the International Commission on Large Dams, Secretariat, 151 Boulevard Haussman, 75008, Paris, France.

4-9 June 1991, Saskatoon, Saskatchewan, Canada
Waterscapes 91 international conference and exposition devoted to ensuring that all aspects of water management contribute positively to the development of a sustainable environment. For more information, write to Waterscapes 91, 3 - 3002 Louise Street, Saskatoon, Saskatchewan, Canada S7J 3L8, Canada. Tel: 1(306)-373 9089, Fx: 373 3778.

19-23 August 1991, Nairobi, Kenya
The 7th WEDC Conference on *Infrastructure, Environment, Water and People*. Short papers and discussion notes will be welcomed from people actively working on these topics, including environmental and social aspects of irrigation. For information, contact, WEDC, Loughborough University of Technology, Leicestershire, LE11 3TU, UK. Tel: 44(0509)-222885, Fx: 211079, Tx: 34319 UNITEC G.

21-25 October 1991, Mexico City, Mexico
International Seminar on *Efficient Water Use*. Details from IWRA, University of Illinois, 205 N Matthews Avenue, Urbana, IL 61801, USA. Tel: 1(217)-333 0536, Fx: 333 8046.

18-23 November 1991, Bangkok, Thailand
The 8th ICID Afro-Asian Regional Conference on *Land and Water Management in Afro-Asian Countries*. Contact International Commission on Irrigation and Drainage, 48 Nyaya Marg, Chanakyapuri, New Delhi 110021, India. Tel: 3016837, Tx: 031 65920 ICID IN.

3-6 December 1991, New Delhi, India
1st International Conference on *Research Needs in Dam Safety*. Information from C V J Varma, Organising Secretary, 1st International Conference on Research Needs in Dam Safety, Central Board of Irrigation and Power, Malcha Marg, Chanakyapur, New Delhi 110021, India. Tel: 3015984, Tx: 31-66415 CBIP IN. Closing date for abstracts 30 November 1990.

5-11 July 1992, Budapest, Hungary
The 16th ICID European Regional Conference. Contact Secretary-General, ICID, 48 Nyaya Marg, Chanakyapuri. New Delhi 110021, India.

6-12 September 1993, The Hague, Netherlands
15th International Congress on Irrigation and Drainage *Water Management in the Next Century.* Contact Secretary-General, ICID, 48 Nyaya Marg, Chanakyapuri, New Delhi 110021, India. Tel: 91(11)-301 6837, Fx: 91(11)-301 5962, Tx: 031-65920 ICID IN.

7 CONFERENCE AND WORKSHOP REPORTS RECEIVED

United Kingdom

Organisation and Management of Irrigation Projects
International Commission for Irrigation and Drainage (ICID) meeting at the Institute of Civil Engineers, 3 October 1990

Mr J Hennessy, new President of ICID, introduced the speakers and publicised the activities of ICID in research and development worldwide. There followed presentations by I W Makin (Overseas Development Unit, Hydraulics Research), D R Stacey (Binnie & Partners), and T Franks (University of Bradford). Mr Stacey focused on the need for a project management structure tailored to suit specific projects which can be adapted to suit each particular phase with detailed consideration given to staffing levels, structural change, communications, and the relationship between project organisation, agricultural extension services, farmer organisations, credit banks and revenue authorities. Mr Franks explored the potential for applying management theories taken from other sectors, e.g. organisation environment and management systems, to irrigation schemes. It was noted that the application of managerial performance indicators, privatisation methods, and improved government agencies were already under evaluation in the irrigation sector. Mr Makin concentrated on improved control technology, i.e. a computerised scheduling system at Kraseio in Thailand as a relatively low-cost alternative to rehabilitation and increased staffing. Improved monitoring, feedback and control can improve rainfall and irrigation water utilisation and give scheme managers a clearer picture of the success or failure of the system to meet target objectives.

Economics, the Environment and Water Development
Joint meeting of ICID and the Agricultural Economics Society at ICE, 13 December 1990

Ian Carruthers (Wye College) began by polarising the views of economists, engineers and environmentalists. Nicholas Hildyard (the Ecologist) then criticised the negative effects of big dam and irrigation projects, especially resettlement, land shortage, waterborne diseases, and salinisation. John Gardiner (Thames National River Authority) and Peter Bolton (Hydraulics Research) discussed the issue of sustainability in development projects and suggested a River Catchment Planning model for managing land drainage, flood defences and the environment. Attention was given to adaptive planning and closer liaison with local authorities and environmental groups.

Richard Palmer-Jones (University of East Anglia) considered potential adverse effects of dry season tubewell development in Bangladesh, including lowering of water tables and reduced flows to river courses and ponds encouraging salinisation and reduced fish stocks. He argued that government regulation of the resource had slowed irrigation adoption, whereas privatisation (especially in deep tubewells) is responsible for the recent recovery in boro rice production. He added that poor or inadequate data makes environmental impacts difficult to assess.

Eng Joas Ribeiro da Costa (Portugal) illustrated the importance of political support and institutional cohesion for successful water resource management, together with judicious use of models. Julian Bertlin (Wye College) introduced Dr Abdelhafid Debbarh who described salinisation problems at a scheme on the Tadla Plain, Morocco, where they are developing an environmental monitoring system and database.

Appropriate Development for Survival - The Contribution of Technology
Joint ICE/IME Conference, Institute of Civil Engineers, 9-11 October 1990

The conference covered a range of topics related to development under the sector headings of Food, Energy, Water and Sanitation, and Infrastructure. Presentations included appropriate and economic development, practical implementation, environmental impact, social issues, the engineer's contribution, education and training, management and planning, and technology choice and maintenance. In addition to the formal presentations, there were a large number of papers from delegates on a wide cross section of issues and research programmes related to technology development.

Sector workshops allowed delegates to discuss specific topics in more detail and prepare 'action plans' for the future.

Worldwide

Resource Mobilization for Sustainable Management
Proceedings of a Workshop on Major Irrigation Schemes in Sri Lanka held in Kandy, Sri Lanka, 22-24 February 1990, IIMI

These papers focus on institutional reform that is seen as a prerequisite to effective mobilisation of sufficient resources for sustainable management of major irrigation schemes. They analyse the impediments to high performance system management within the irrigation management agencies and the direction in which reforms must go to bring improvements and identify broader policy issues and recommendations that are very important to the whole change process underway.

International Conference on Groundwater Resources Management
5-7 November 1990, Asian Institute of Technology, Bangkok, Thailand

Fifty papers were presented at this conference, which provided an overview of current research and development issues. Sections of the conference covered groundwater investigation, groundwater modelling, groundwater quality, environmental impact, conjunctive use, and groundwater management. One key issue in the discussion was the limited number of examples of realistic and practical development, and management strategies. The problem of developing realistic and appropriate groundwater investigation methods and models, that could and would be used by field representatives, was also raised.

ERRATA

In our last Newsletter of July 1990, we carried comments from David Potten of Hunting Technical Services, on the divergence between theoretical and actual water demand on groundwater irrigation projects. At two points in this section, volumes of water were printed with an 'm' instead of 'm^3'. The information should read:

- theoretically calculated demand averaged 47,600 m^3 per well, per month;

- the actual average monthly demand has not exceeded 17,500 m^3;

We apologise for any misunderstandings caused by these typographical errors.

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IRRIGATION MANAGEMENT NETWORK

INTERACTIONS BETWEEN TECHNICAL INFRASTRUCTURE AND MANAGEMENT

L Horst

ODI/IIMI Irrigation Management Network Paper 90/3b December 1990

Papers in this set:

- 90/3b Interactions Between Technical Infrastructure and Management by L Horst
- 90/3c Irrigation Allocation Problems at Tertiary Level in Pakistan by M Akhtar Bhatti and Jacob W Kijne
- 90/3d Sustainable Development of Groundwater Resources: Lessons from Amrapur and Husseinabad Villages, India by Tushaar Shah
- 90/3e The Politics of Water Scarcity: Irrigation and Water Supply in the Mountains of the Yemen Republic by Linden Vincent
- 90/3f Perspectives on the Middle East Water Crisis: Analysing Water Scarcity Problems in Jordan and Israel by R Sexton

Please send comments on this paper to the author or to:

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Comments received by the Editor may be used in future Newsletters or Papers

INTERACTIONS BETWEEN TECHNICAL INFRASTRUCTURE AND MANAGEMENT

L Horst

Contents **Page**

This paper was first presented at the 9th International Irrigation Symposium, Berlin, April 1989. It is a further development of the thinking Professor Horst outlined in ODI Network Paper 7c "Irrigation Systems - Alternative Design Concepts", 1983, copies of which are still available on request.

L Horst is Professor of Irrigation, Department of Irrigation and Soil and Water Conservation, Wageningen Agricultural University, De Nieuwlanden, Nieuwe Kanaal 11, Wageningen, The Netherlands.

INTERACTIONS BETWEEN TECHNICAL INFRASTRUCTURES AND MANAGEMENT

L Horst

1 INTRODUCTION

This paper discusses the management issue from the angle of the technical irrigation infrastructure, focusing specifically on smallholder irrigation projects in developing countries.

The technical infrastructure in medium- to large-scale irrigation projects comprises a large number of works, ranging from the actual irrigation and drainage systems, to roads, bridges, buildings, etc. I would like to focus on the irrigation system; a system of canals and structures to convey, regulate and divide the water and to deliver it to the users (Fig 1).

The conveyance components - the canals - are of less importance in the context of this discussion; if they are well designed, constructed and maintained, they will convey the water as designed and as expected. They do not need to be *operated.*

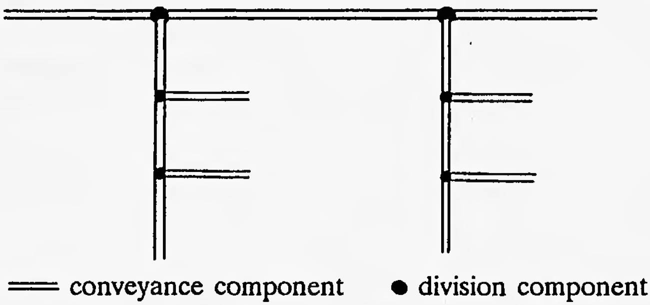

Figure 1

The crucial component of the irrigation system - the operational parts - are the structures for regulating, dividing and measuring the flows of water to the various parts of the project. Their type and characteristics largely determine the operability and subsequently the manageability of the system. These structures may be simple or complicated to handle, they may be more or less sophisticated, they may be fragile or sturdy, they may be flexible or rigid, they may be user-friendly or user-incompatible. Furthermore, their type and characteristics largely determine whether centralised management is necessary or whether decentralised management and farmers' participation[1] are possible. The operation and maintenance of these structures accounts for a very large part of the total management input of a project and therefore requires adequate numbers and sufficiently skilled management staff.

Consequently, the question "how can a system best be managed?" is directly related to the physical/technical irrigation system. It is the planners and designers who determine this irrigation system. Hence, their choice of technology and design largely determines the management options.

A management specialist once said to me, "The water, the irrigation system, the technical infrastructure are of no importance; once the management of irrigation is functioning properly, the water will flow where it has to flow". In my opinion, this is putting the cart before the horse.

2 DEVELOPMENT OF IRRIGATION TECHNOLOGY

If we now consider the development of irrigation technology, focusing particularly on structures, we might, in very broad lines, see the following picture:

Probably the oldest method of irrigation is *flooding.* Floodwaters are guided and spread over the cultivable fields in a more or less controlled way.

The next step is when the water is captured and conveyed by means of canals and divided by simple overflow structures, proportional to the areas to be irrigated; this is called *proportional division.* Since the water is divided in a fixed way, no operation or adjustments are needed and no measurements are taken. Examples can be found in North Africa, Spain, Nepal and in Bali (the famous Subak system). These systems are mostly farmer-managed and they are based on supply criteria, irrespective of its fluctuations the captured water is equally divided according to areas.

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[1] *Farmers' participation is used here to mean farmers directly being involved in the decision-making process of management. (Contrary to when farmers hire technical and managerial skills to run the project for them.)*

The next step in development is the *on/off system,* in which the structure is either open or closed. This implies that flows cannot be regulated, measurements do not need to be taken and operation is easy.

In colonial times, a drastic change in technology was introduced in many of the developing countries of today. On the one hand this resulted in the development of large irrigation projects, made possible by improved technology which allowed large dams, canals and structures to be built. But another important result was that the basis of water delivery changed from being supply-oriented (where the water is divided according to the areas to be irrigated, following fixed rules) to demand-oriented. In demand-oriented delivery the division of water is according to crop water requirements. These are translated, via irrigation schedules, into operational procedures for the various irrigation structures.

Traditional fixed structures of the types described above cannot accommodate variations in flow based on water requirements. The need for *adjustable structures* was born.

An earlier paper (Horst, 1983) described how each colonial power developed its own irrigation technology. During the colonial period, many large areas were developed by irrigation systems with adjustable (manually or mechanically) weirs or gated orifices, which provided a means for accurately controlling, regulating, and dividing flows of water. However, these systems required a large competent staff to operate and measure these flows of water. Such schemes were centrally controlled and at that time the phrase "farmers' participation" was rarely heard. It is important to note that though they were oriented to supplying cropwater requirements, it was management at the centre which decided what these demands were, and not the farmers at the base.

During the latter part of the colonial period, the French began to develop *automatically controlled systems* in the Mediterranean area. In recent decades further advances have been made in automatic systems, and today systems based on automatic and remote control, computer models, advanced communication systems, micro processors, etc, are in use, mainly in the United States and France. This development of automatic systems has drastically reduced the numbers of staff required and at the same time has drastically increased the skill the staff require to able to operate and maintain these systems. These systems could either be demand-orientated systems where the demand is calculated centrally, or demand systems where demand is determined by farmers' perception of their crop water requirement. Both types leave little room for participation of farmers in general scheme management. For the second type of system it might be argued that the need for farmers' participation is small as long as the supply of water is assured. That this is often not the case has been reported, e.g. by Wallach for Morocco: "An intricate network of semi-circular elevated concrete flumes gives a misleading picture of successful management. Broken modules and unauthorised crops point to uncertain relations with the farmers" (Wallach, 1985).

From a management point of view it is interesting to review the manpower requirements of these various technologies in terms of numbers and skills, as well as in terms of their scope for farmers' participation (Fig 2). It goes without saying that this picture is no more than indicative.

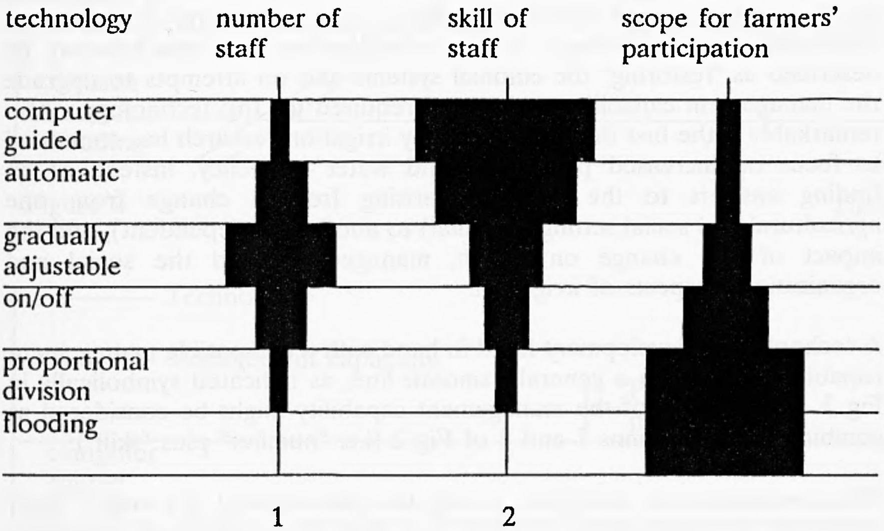

Figure 2

3 POST-COLONIAL PERIOD

After independence, many new nations found themselves facing problems relating to irrigation management. These problems, which resulted from the second world war and wars of independence, were aggravated when less funds became available for operation and maintenance. Training facilities were scarce and, furthermore, trained technical personnel were underpaid and often attracted by emerging private posts, better salaries and prospects of jobs in towns instead of in the country. A number of countries embarked on the large-scale expansion of their irrigable areas. This led to a demand for more and better qualified staff. This demand was often augmented by increasing interventions in the lowest levels of the irrigation systems; the development of the tertiary unit or chak (e.g. Command Area Development Programmes). All these factors contributed, and are *still contributing*, to a situation in which it is extremely difficult to establish a management infrastructure manned by staff sufficient in terms of technical skill as well as in numbers. In this context, "sufficient" relates to the inherited technology of adjustable structures.

When considering the activities of national, international and bilateral agencies in the field of irrigation development in the Third World during the last three decades, it is remarkable that colonial technology has seldom been questioned. Activities have been concentrated on new projects employing that technology, or on rehabilitation that could better be described as "restoring" the colonial systems and on attempts to upgrade the management capability to the level required for this technology. Also remarkable is the fact that up until today irrigation research has continued to focus on increased production and water efficiency, instead of on finding answers to the questions arising from a change from one agricultural and social setting (colonial) to another (independent), and the impact of this change on design, management, and the social and organisational aspects of irrigation.

A technological development hand in hand with a compatible management capability will follow a generally smooth line, as indicated symbolically in Fig 3. The "value" of the management capability might be considered as combination of columns 1 and 2 of Fig 2 (i.e. "number" plus "skill").

The combination of disruption during the post-colonial era and a rapid expansion in requirements resulted in a kink in management capability curve, but during the last 30 years the level of technology has been rigidly maintained (Fig 4).

In spite of all efforts, the level of management capability has seldom approached the level of technology over the expanded area, leaving a permanent gap between level of technology and level of management capability. This resulted in general in understaffed (in terms of number as well as skills), projects, leading to low water efficiencies, low production and inequitable division of water.

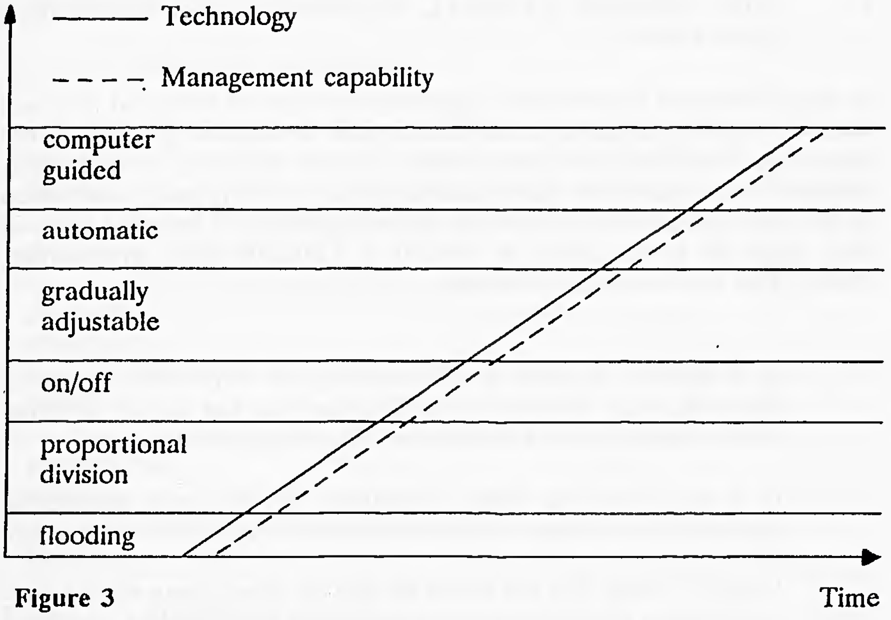

Figure 3

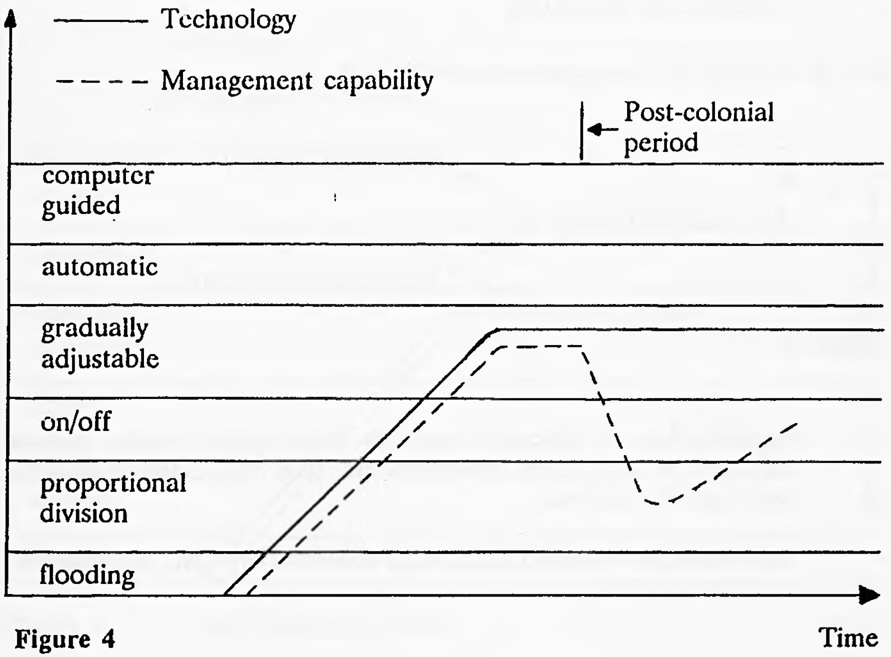

Figure 4

4 THE PRESENT GENERAL PICTURE - THE EMERGING QUESTIONS

In many countries the situation regarding the level of technical skill and required number of management staff is still unsatisfactory. This is not surprising, considering the total number of staff required. For example, although exact figures are sparse and inconsistent, a very rough estimation of the total manpower required for the management of irrigated areas in Asia might be in the order of 500,000 to 1,000,000 (Bos, Storsbergen, 1978). This raises certain questions:

- Is it realistic to stick to a technology of adjustable structures requiring huge numbers of staff, when one can clearly see that these numbers cannot be reached for many years to come?

- Is it not better to adapt technology to the local managerial potential and training facilities, instead of the other way around?

- In other words, it is not better to look at other, more appropriate technologies when starting new projects or rehabilitating old ones?

5 AVAILABLE OPTIONS

Let us consider the two options available (Fig 5).

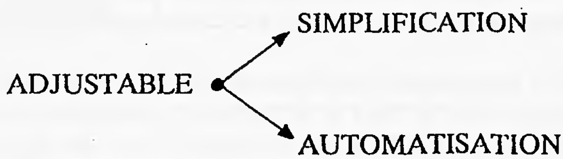

Figure 5

- *simplification* of structures, so that they require fewer manual adjustments and fewer measurements, (e.g. proportional division and on/off structures.

- *modernisation* in terms of automatic controlled systems, by whatever modern means.

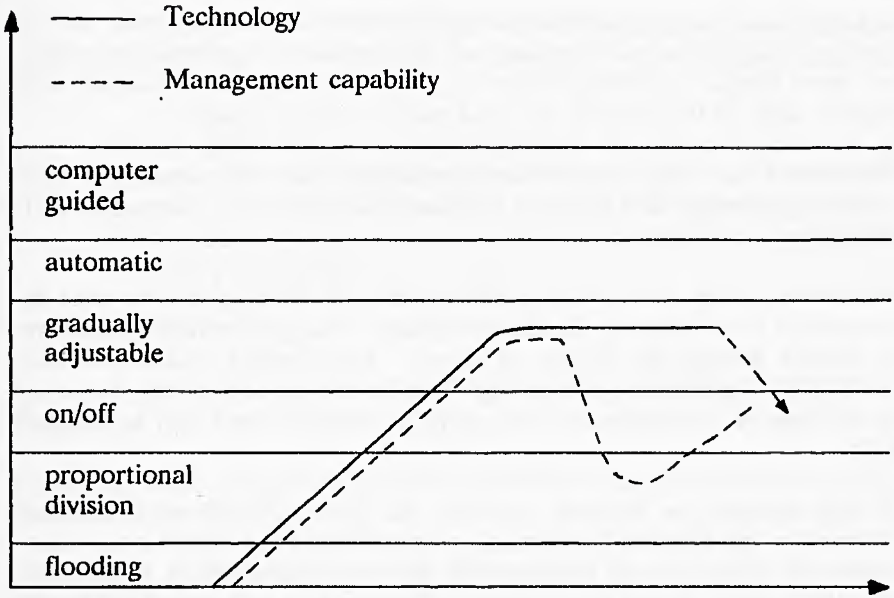

Figure 6 SIMPLIFICATION

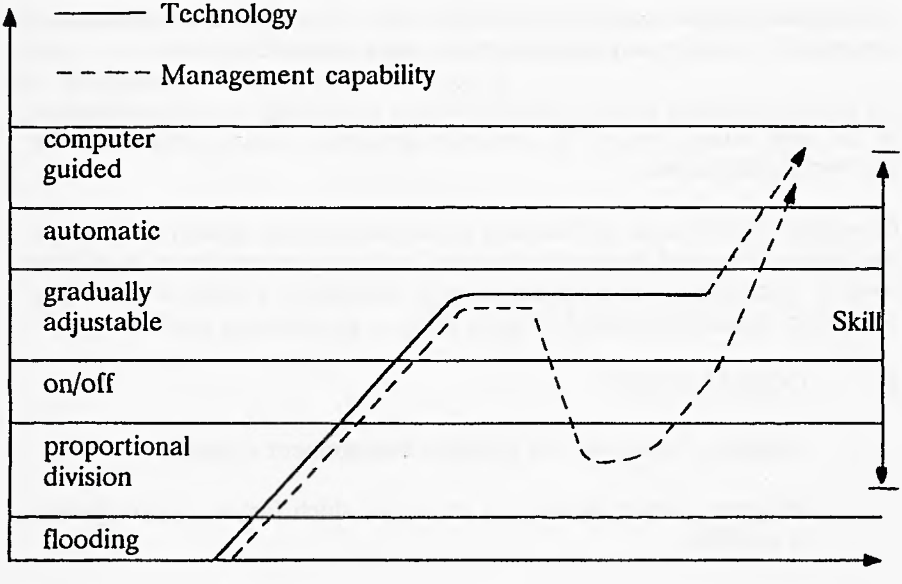

Figure 7 MODERNISATION

In both cases less manpower in terms of number will be required. In the first case (Fig 6), the skill required will also be less, because the structures are more simple; operation will be easy, and maintenance and repair will require skills at the level of the local mason and blacksmith.

The second case (Fig 7) implies an operational and maintenance staff with a very high level of skill and with knowledge of computers, electronics and mechanics.

Whichever system is adopted to deliver water to users, problems arise in the case of water-scarcity. In the *simplification* case, the burden of scarcity is divided among the groups of users. The farmers understand the structures. Attempts to tamper with the structures can readily be seen. In the case of *modernisation*, the system is vulnerable and easy to tamper with.

If both systems are working correctly, the *automatisation* case is more efficient by far, because it accurately accommodates the actual crop water needs. If it works well, yields should increase. However, it is believed that the "simple" system may increase efficiencies by well above the levels presently attained by most projects, because these cannot be managed well by the available staff.

Clearly, the *modernisation* option will be more costly than the *simplification* option. Its benefits may be higher, but more difficult to attain.

As regards possible farmer participation, a technology of automatisation, by its very nature, has to be centrally operated, leaving little room for farmers' participation.

Obviously, the decision to choose a certain technology should be made in the light of the local situation. Farmers' preferences may lie in individual control, joint control at a certain level in the system, reliable service by a competent manager, elected or paid, or by a government service.

6 CONCLUSIONS

- designers largely dictate possible management options;
- designers largely dictate the extent to which farmers' participation is possible;

- attempts to improve the management of schemes that disregard the engineering and especially the design of structures, will remain cosmetic corrections;

- the "a priori" choice of modernisation by automatisation as a panacea for all irrigation problems should be considered questionable. It could even aggravate the managerial problem. Furthermore, this solution is seldom compatible with the aim of farmers' participation.

7 REFERENCES

Bos, M G, and Storsbergen, (1978), "Irrigation Project Staffing", ICID 10th Congress.

Horst, L, (1983), "Irrigation Systems - Alternative Design Concepts", ODI Network Paper 7c.

Wallach, B, (1985), "Grabbing the Bull by the Horns", IIMI Research Paper No 2.

Professor Horst is interested to hear from any Network members who have comments or data relevant to this issue. Please write to him directly at the Wageningen address given on page 3.

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IRRIGATION MANAGEMENT NETWORK

IRRIGATION ALLOCATION PROBLEMS AT TERTIARY LEVEL IN PAKISTAN

M Akhtar Bhatti and Jacob W Kijne

ODI/IIMI Irrigation Management Network Paper 90/3c December 1990

Papers in this set:

Please send comments on this paper to the author or to:

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IRRIGATION ALLOCATION PROBLEMS AT TERTIARY LEVEL IN PAKISTAN

M Akhtar Bhatti and Jacob W Kijne

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Dr M Akhtar Bhatti and Dr Jacob W Kijne are Principal Irrigation Engineer and Senior Irrigation Specialist, respectively, at the International Irrigation Management Institute (IIMI), Pakistan.

IRRIGATION ALLOCATION PROBLEMS AT TERTIARY LEVEL IN PAKISTAN

M Akhtar Bhatti and Jacob W Kijne

1 SUMMARY

Limitations are described in the current system of allocation and distribution of canal water at watercourse level in Punjab irrigation systems. It is argued that the rigidity implicit in the warabandi system prevents farmers from managing irrigation water in an optimal way. Alternative water allocation systems should be developed because of larger water supplies, resulting from the use of pumped groundwater, and persistent inequity in water distribution going from head to tail reaches in distributary and watercourse command areas. It is proposed that a new set of rules for allocation and distribution should be flexible and take account of the water quality of pumped groundwater used for irrigation.

2 INTRODUCTION

Because of climatic conditions characterised by low rainfall and high evaporative demand, irrigation is required for most agricultural production in Pakistan. Irrigation is practiced on about 75% of the cropped area, which contributes about 90% of the nation's total agricultural production. The river Indus and its tributaries serve as source of irrigation water for around 86% of the irrigated area in Pakistan.

2.1 Irrigation System of Pakistan

The irrigation system in Pakistan (14.6 M Ha.) is the largest contiguous irrigation system in the world. It comprises the Indus and its major tributaries, 3 major storage reservoirs, 19 barrages/headworks, 43 canal commands and some 89,000 chaks (watercourse command area). The total length of canals is about 56,000 km, with watercourses, farm channels and ditches running another 1.6 million km in length. The first controlled all-year irrigation began in 1859 with completion of the Upper Bari Doab Canal from Madhopur Headworks on the Ravi River. The main objective of the early canal systems was drought protection and since then irrigation systems have been designed to fit the availability of water supplies in the river and to meet the objective of bringing to maturity the largest area of crops with the minimum consumption of water.

Land holdings in the Punjab canal colonies were laid out on a grid system of 25 acres (10 ha.) squares, whereas in the other provinces existing land holdings were of highly irregular shape, which complicated the laying out of the distribution system for irrigation water. The area served by a particular watercourse may range from 40 to 400 ha but the average is around 180 ha. Flow in the chak is governed by an open outlet or 'mogha' designed to pass a discharge that self-adjusts in proportion to flow in the parent canal. Design discharges from moghas vary from less than 30 to 120 l/s (1 to 4 cusecs) to enable efficient handling by individual farmers.

Extensive developments in the Indus basin over the last century and lack of appropriate drainage facilities have caused severe waterlogging and salinity problems in large areas of Punjab and Sindh provinces. Public tubewells were first introduced in the 1940s to address these problems, and the first large scale Salinity Control and Reclamation Project (SCARP) with 30 to 150 litres per second capacity tubewells was completed in 1963. The large-scale development of groundwater by the private tubewells started soon after the initiation of the SCARP program. The most recent estimate (1984-85) of groundwater contribution is about 40.66 million acre feet annually.

2.2 Existing System of Irrigation Water Allocation

The rules that serve the irrigation water allocation were developed by the British over a century ago. Under these rules the Irrigation Department delivers a specific amount of water based on a predetermined 'water allowance' and on the size of the cultureable command area of the watercourse. The outlets ('moghas') are constructed such that each watercourse draws its allotted share of water from the distributary simultaneously, when the discharge in the distributary is at design level and the hydraulic design of the channel is maintained.

The present water allocation system within chaks is known as 'warabandi' (wara means turn and bandi fixation). The warabandi is basically a continuous rotation system in which one complete cycle of rotation usually lasts seven days, i.e. each farm receives its water once a week. The duration of the turn is in proportion to the size of the farmer's holdings. During his turn, he is entitled to all the water flowing in the watercourse. Each year the warabandi schedule is rotated by twelve hours to give relief to the farmers who had to irrigate at night under the previous schedule. The water from the public tubewells is also shared according to the warabandi.

There are two types of warabandi system being practiced currently. Under the 'pacca' (official) warabandi system, a weekly rotation is fixed by the canal officer for each farmer at the joint request and by agreement of the cultivators. This becomes binding on all shareholders and cannot thereafter be altered. Under the 'kacha' (temporary) warabandi system, the turns for each farmer are agreed upon by all shareholders and the Irrigation Department does not interfere unless a complaint is lodged. The two systems have been explained in detail by Nasir (1981) and Malhotra (1982).

2.3 Merits and De-Merits of Warabandi System

The main operational objective of the warabandi system is to achieve both high efficiency of water use by imposing water scarcity on every user and social equity through ensured irrigation for many rather than intensive irrigation for a few. According to Malhotra et al (1984), the first and most important single thing to appreciate about the warabandi system is that it is a system of imposed water scarcity. For anyone at all familiar with the social tension and conflict created by scarce irrigation water in these areas, the fact that warabandi has been able to impose such extreme scarcity, over such large areas, for such a long time is little short of miraculous.

The pacca warabandi system has been successful in reducing the opportunities for disputes and conflicts among the farmers as water turns are fixed officially keeping in view the benefits for the community as a whole. The system tends to be self-policing, because the next in turn is waiting and ready to take his turn (Chaudhry, 1986). On the contrary, the kacha warabandi system is considered unsatisfactory because it often leads to disputes among farmers, particularly during periods of peak demands and shortages. Changes from kacha to pacca warabandi in the Punjab are said to have occurred mainly because of concerns for ensuring equitable water supplies to all farmers.

A major disadvantage of the pacca warabandi system, however, is that the volume of water available to a farmer is independent of the stage of a crop growth and he is forced to either take his turn (whether needed or not), or to forego it. This means that the system not only leads to wastage of water but sometimes even results in low crop yields due to over-irrigation. Compensation cannot be obtained from the Irrigation Department nor from other water users for turns one has not received because of lack of water in the distributary (e.g. due to frequent breaches, cuts, etc, necessitating closure of the distributary for repairs). Renfro

(1982) also observed that rigidity of the supply schedule under this system causes periodic shortages and at other times an excess of water supply.

Contrary to this, the kacha warabandi system is more flexible in accommodating the common interests of all farmers. It also ensures that no one suffers from the unplanned and undesired closures as the warabandi turn restarts from the user where it terminated when the lack of water occurred. The warabandi system is too rigid for supplying water according to the current understanding of crop water requirements and for the present levels of water supply. The reliability in supply, both with respect to the timing and its amount, is insufficient (Reidinger, 1971). Gustafson and Reidinger (1971) have proposed that water trading (selling and lending) should be legalised as they observed that farmers who trade water were on average more productive than those who did not.

In addition, Renfro (1982) has pointed out that the pacca warabandi system allows farmers to supplement canal water with tubewell water only if either they have an uninterrupted right to the total flow in the watercourse or when the stretch of watercourse between the outlet to their fields and the tubewell is unused and empty of another farmer's water. Thus rigidity of the system affects the economics of private tubewell installation because of fewer potential users and purchasers of tubewell water. Maass and Anderson (1978) have mentioned that in some parts of the world, e.g. USA and Spain, water rights are actively traded or sold. Their simulation analysis showed substantially higher returns from a distribution system with active cash transactions in water rights than from more rigid systems, including rotational ones similar to the warabandi system.

It is suggested that the rigidity implicit in the warabandi system prevents farmers from maximising private and social net benefits from scarce water. Inflexible allocation of water has serious consequences, especially when new water supplies show high marginal development costs. Moreover, it has been found that equity of distribution cannot be attained along a watercourse by applying water for an equal length of time per unit of land for all farms regardless of their location along the watercourse. Conveyance losses from the watercourse result in smaller supplies per unit of time in tail than in head reaches of the watercourse command area. However, farmers pay an equal amount per acre cultivated with a specific crop, although downstream farmers may receive 20% to 30% less water than those in the head reach, with lower yields for similar cropped areas.

3 FIELD INVESTIGATIONS

Since 1987, IIMI Pakistan has carried out research activities focused on the secondary level (distributary) of canal irrigation systems in Punjab. Several distributaries representing head (Lagar & Manawala) and tail (Pir Mahal & Khikhi) portions of the Gugera Branch of the Lower Chenab Canal were selected for detailed field investigations in collaboration with the Irrigation Department. Early results indicated low reliability of water supply from canals and public tubewells. Therefore, during 1989, a random sample of 89 farms was selected in the command areas of the selected distributaries in Farooqabad sub-division (head) and Bhagat sub-division (tail) to assess the effects of current distribution practices (warabandi system) on water availability at tertiary level during Kharif (summer cropping season). A second sample of 96 farms was studied during Rabi (winter cropping season) 1989-90.

Data collection included the duration of canal turns (sanctioned time and discharge) and the number of turns actually received during the season. Observations on trading of water turns among the sample farmers were also recorded.

4 RESULTS AND DISCUSSION

4.1 Duration of Canal Turns

Figures 1 present histograms of actual durations of canal turns for 89 sample farms during the Kharif season 1989. About 31% of the sample farms received canal supplies during a period equal to or less than 2.25 hours per week. Irrigation water available for such a short duration simply cannot be managed efficiently considering the distribution network at the tertiary level and surface irrigation practices employed at the farm.

An almost similar pattern was observed in case of the 96 sample farms where detailed investigations were carried out during Rabi 1989-90 (Figure 2). For about 36% of the sample farms, the weekly turn of the canal supply lasted 2.25 hours or less.

Because of the socio-economic environment, major changes have occurred in farm size. A comparison of 1972 and 1980 Agricultural Census data revealed that the number of small farms of less than 2 ha increased from 28% of the total in 1972 to 34% in 1980. Expressed as a fraction of the total cultivated land, the area cropped at small farms also increased. The share of medium and large farms in the total number of farms decreased concurrently. The decrease in farm size affects directly the water rights

FIGURE 1 : DURATION OF CANAL TURNS
89 SAMPLE FARMS (GUGERA CANAL)

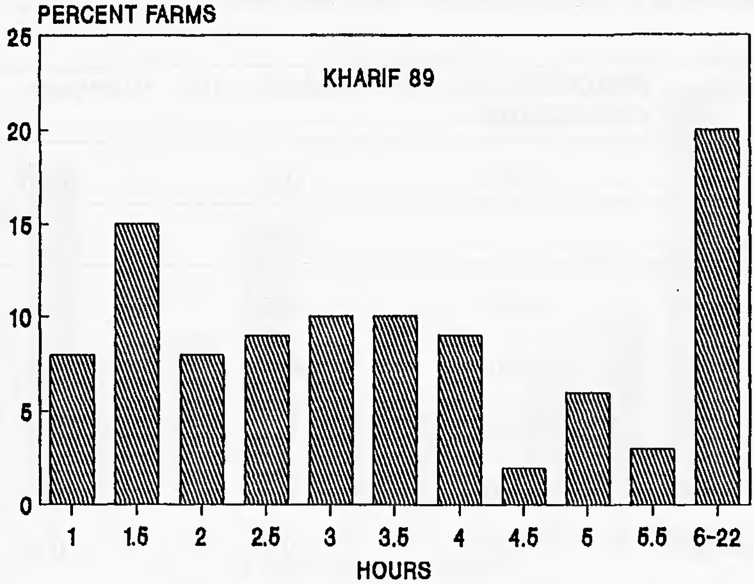
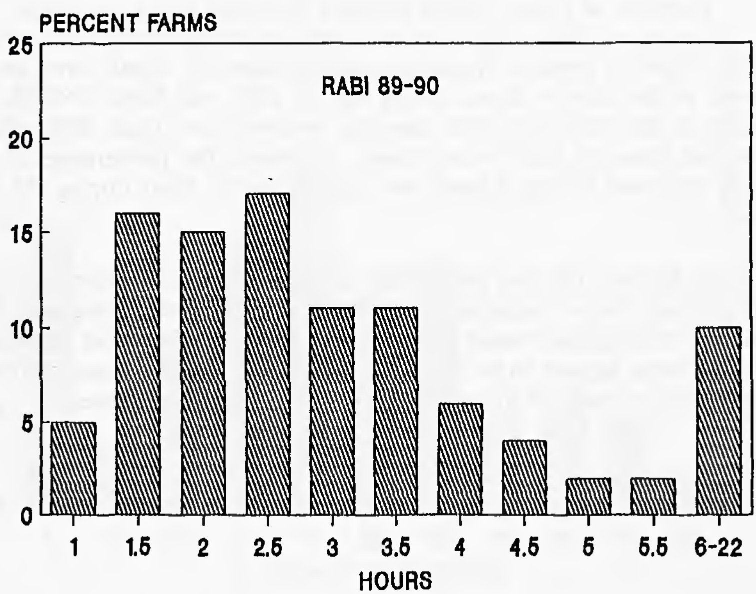


FIGURE 2 : DURATION OF CANAL TURNS
96 SAMPLE FARMS (GUGERA CANAL)



and therefore the duration of the turn in the same proportion. Table 1 presents the comparison between percentages of farms in the various categories as it changed between 1960 and 1980.

Table 1: PERCENTAGE OF FARMS IN VARIOUS SIZE CATEGORIES

Year	1960	1972	1980
Farm Size			
< 3 ha	34.1	43.6	50.9
3 - 10 ha	52.6	45.6	39.9
10 - 20 ha	9.4	7.7	6.5
20 - 50 ha	3.4	2.7	2.4
> 50 ha	0.5	0.4	0.3

The comparison reveals that during one generation (20 years) a large number of farms have been split up between sons to form smaller farms. Since 1980, this process has undoubtedly continued.

4.2 Number of Canal Turns Actually Received

Figures 3 and 4 present frequency distributions of canal turns actually received at the sample farms during Kharif 1989 and Rabi 1989-90. The majority of the farms in both samples received less than 50% of their theoretical share of canal water turns. However, the percentage of turns actually received during Kharif was slightly better than during the Rabi season.

For many farmers the low probability of receiving canal water is certainly an important factor impacting negatively on efficient management and utilisation of irrigation water at the farm. This and the short duration of the water turns appear to be key factors impeding the attainment of higher productivity per unit of irrigation water from the public system.

FIGURE 3 : CANAL TURNS RECEIVED
89 SAMPLE FARMS (GUGERA CANAL)

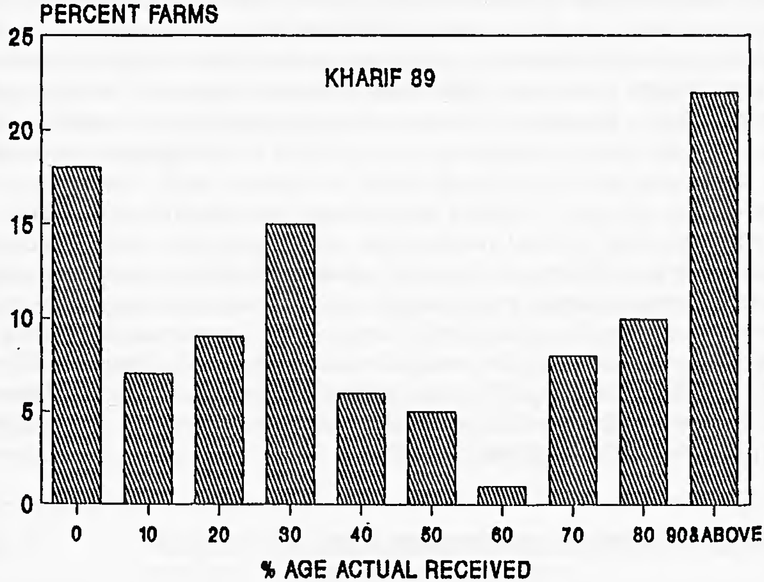
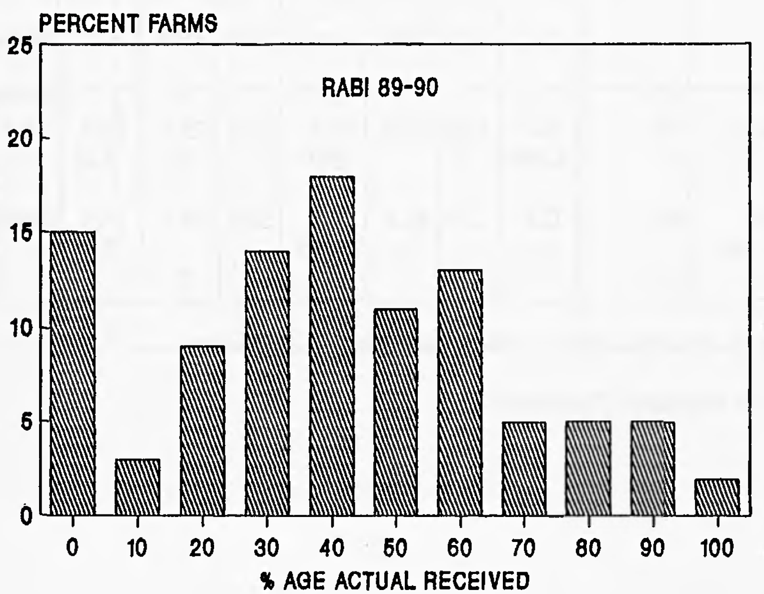


FIGURE 4 : CANAL TURNS RECEIVED
96 SAMPLE FARMS (GUGERA CANAL)



The chance of receiving canal water has a spatial distribution which cannot be discerned from Figures 3 and 4. Field data collected by IIMI field staff have revealed that due to various reasons, equity of distribution is no longer attained in the sample distributaries. Distribution was never equitable when the water supply in the parent canal dropped below 70% of the design level, and this occurs quite frequently in the sample distributaries. Because of increased cropping intensities and, in recent years, a shift toward cultivation of crops with a higher water requirement (i.e. sugarcane and rice), much more is expected from the systems now than ever in the past. Lack of maintenance and the increased occurrence of water stealing in head reaches has complicated the issue of supplying canal water to tail farmers. Inequity of water distribution repeats itself for much the same reasons within watercourse command areas, again the tail farmers receiving less than their share. In as far as many of the public tubewells are located at the head of watercourses, with the pumped water to be distributed through the same network of watercourses and branches, access to water from public tubewells is also restricted for farmers in the tail portions of the command areas.

Table 2: RANGE OF STREAM SIZES

Cropping Season	Sample Size (n)	Stream Size in litres per second								
		Canal			Public Tubewell			Private Tubewell		
		Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Kharif 89	89	35.4 12.9*	11.6	68.0	52.8 13.9*	25.5	73.1	27.4 8.4*	14.7	58.3
Rabi 89 - 90	96	32.9 7.5*	22.9	46.2	54.3 13.3*	38.5	79.3	26.9 7.4*	14.7	58.3

Avg = Average, Min = Minimum, Max = Maximum

* = Standard Deviation

4.3 Stream Sizes

Stream sizes made available for irrigation applications are presented in Table 2. The data show a large diversity in stream sizes used by farmers at the tertiary level. This large variation has been identified as a key obstacle in the application of appropriate water amounts in individual irrigations (Bhatti, 1991). This is particularly true in case of combined canal and public groundwater supply.

4.4 Trading of Turns

To improve water management some farmers trade their turns by selling and lending among themselves. Table 3 presents a summary of the available information on trading of water turns for the sample farmers. Turns were traded depending upon farmers' needs and/or convenience. The data provide reasonable evidence of farmers' lack of satisfaction with the allocation system and proof of their efforts to make the system more flexible in order to improve the management of the available water supplies.

Table 3: PERCENTAGE OF ACTUAL WATER TURNS RECEIVED BY ALL THE SAMPLE FARMERS

Description	Kharif 89		Rabi 89-90	
	Canal	Public Tubewell	Canal	Public Tubewell
Borrowed	11	8	14	28
Lent	20	18	37	51
Purchased	1	1	1	0
Sold	2	1	7	7

4.5 Alternative Water Allocation Systems

The problems associated with the present water allocation system as discussed here require remedial measures. Chaudhry (1986) has presented a brief summary of some of the methods which could be employed to improve the present system.

Relative scarcity of water is said to be the main factor which influences the selection of a specific water allocation mechanism. The complex and elaborate characteristics of Pakistan's warabandi system reflect the initial severe scarcity of water, a shortage which continues to be a critical bottleneck in the desired growth of agricultural productivity. The development of groundwater, first through public tubewells and more recently through a large number of private tubewells has added large amounts of water for irrigation purposes. In some of the sample areas, contributions from groundwater amount to around two thirds of the annual water supply for irrigation. Water distribution from public tubewells, however, takes place according to its own warabandi. As public tubewells are powered by electric motors and electricity is rationed in rural areas especially during periods of peak water demands (e.g. early in the rice growing season), the reliability of water supplies from public tubewells also leaves much to be desired. The desired flexibility in water allocation, therefore, cannot be provided by the public tubewells. However, farmers can use pumped water from their own tubewells whenever they wish, provided electricity is available if the pump is driven by an electric motor.

Recent analysis of water quality from public and private tubewell waters has revealed that the water quality of pumped groundwater shows a spatial variability with deterioration occurring generally towards tail ends of distributary command areas (Kijne and Vander Velde, 1991). This means that farmers in tail reaches of command areas face a double handicap; they receive a far smaller proportion of their share of canal water than do farmers upstream along the same distributary, and the groundwater in these locations which must be used to obtain any crop is of poorer quality than elsewhere.

The provision of either more water, better quality water or better controlled water constitutes a necessary condition for economic growth in the presence of such constraints (Howe, 1976).

Reidinger (1971), and Burnes and Quirk (1979) are among those who have argued the need for added flexibility in the system and suggested that the key factor is the institution of organised water markets. In Pakistan, under the existing set of institutional rules, it will be politically difficult to switch from the warabandi system to a much different set of water allocation rules.

However, certain institutional arrangements can be made within the framework of the existing warabandi system which will add flexibility to the system and, in turn, will make the system economically more efficient and socially more equitable (Chaudhry, 1986).

The present water allocation rule distributes water in accordance with the time specified per cultivated unit of land. An improvement would be to take into consideration the volume of water delivered to make sure that a certain minimum volume is supplied during each season and water charges are collected only if the minimum volume was delivered to the farm. Although it does not ensure delivery of water at critical growth stages of the crops grown on the farm, at least it will make the Irrigation Department more responsible for delivering certain limited quantities during the growing season. It would ensure some reliability and adequacy, which is presently not there. In view of the increased exclusive use of marginal and poor quality groundwater, especially in tail reaches of command areas, it is desirable to consider quality aspects also in the set of allocation rules. This would oblige the Irrigation Department to deliver water of a specified average seasonal quality. Of course, it is realised that this has far reaching consequences in terms of the conjunctive management of surface water and groundwater, which are presently not perceived at all, both in terms of 'hardware' (redesign of distributary canals and gates), and 'software' (operational rules).

5 CONCLUSIONS

Apparently, since the design and introduction of the warabandi system, no effort has been made to see what has happened to the historical water rights granted on the basis of land holdings, despite major physical, political and socio-economical changes which have occurred during the last century. Much has been said about the shortage of water resources in relation to crop water requirements, but little has been done to evaluate its allocation or to find ways and means to improve distribution procedures. Sample data suggest that management procedures to utilise the available irrigation supplies in an optimal way are inadequate.

Optimal water management at farm level requires a flexibility of water allocation that the present warabandi system does not provide. In drawing up a new set of rules for distribution and allocation of irrigation water, consideration should be given to the vastly increased amounts of water available at the farm gate through the development of groundwater. This occurs not only in areas with good quality groundwater; private tubewells have been installed also in areas which are known to be underlain by saline groundwater where farmers tap fresh (or marginal) groundwater from the top of the aquifer by means of skimming wells.

New rotational rules should aim at flexibility in providing each farmer with an ensured seasonal supply as a first step towards more equitable distribution of irrigation water. In addition, rules should not be the same everywhere but they should be appropriate for each environment. For instance, assured supplies should be given to saline groundwater areas (since farmers in those areas cannot respond to uncertainty by pumping: Berkoff, 1987). Similarly, farmers who are using poor quality groundwater which is known to have an adverse effect on soil conditions, should also have priority in the allocation of an ensured amount of good quality canal water.

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SUSTAINABLE DEVELOPMENT OF GROUNDWATER RESOURCES: LESSONS FROM AMRAPUR AND HUSSEINABAD VILLAGES, INDIA

Tushaar Shah

ODI/IIMI Irrigation Management Network Paper 90/3d December 1990

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SUSTAINABLE DEVELOPMENT OF GROUNDWATER RESOURCES: LESSONS FROM AMRAPUR AND HUSSEINABAD VILLAGES, INDIA[1]

Tushaar Shah

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[1] *The report is based on fieldwork conducted by Dr Daniel Bromley and the author during 2-9 June 1989. It also draws upon discussions with farmers, local leaders, Anil Shah and other members of the AKRSP staff, and builds upon and uses the results reported by William Barber's recent enquiry into the geological and other physical characteristics of the aquifers underlying the area.*

SUSTAINABLE DEVELOPMENT OF GROUNDWATER RESOURCES: LESSONS FROM AMRAPUR AND HUSSEINABAD VILLAGES, INDIA[2]

Tushaar Shah

1 INTRODUCTION

In a workshop on groundwater management at the Institute of Rural Management (IRMA) held in March 1989, Rolf Mueller, one of the workshop participants, called groundwater a "free, but scarce" resource: Because it is free, it is used freely where there are no rules which define who can take how much of this precious resource, and because it is scarce it tends to get exhausted with rising pressures of demand. As a result, in many areas, conditions of over-exploitation of groundwater aquifers have resulted in serious ecological consequences.

In such areas, groundwater management regimes can go in either of two ways. Firstly, the groundwater balance may be disrupted and (the farming system) may fall to a new equilibrium at lower levels of output and incomes. Alternatively, some system of rules may be accepted by groundwater users that so regulates each user's behaviour as to begin a new, sustainable, community-based management of the resource.

A good part of coastal Saurashtra, Gujarat, as indeed many other regions in the country, has in the last 15 years gone the first of these two ways. In thinking about resource management issues in these areas, the recurrent question is: "Are there ways village communities can be helped consciously to move towards the second way and develop *self-correcting mechanisms* (SCMS)."

The Aga Khan Rural Support Programme (AKRSP), India, has been exploring this question in several villages of Junagadh and Surendranagar districts of Saurashtra, Gujarat state. This report describes the results of work done by Daniel Bromley and the author in two of these villages,

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Amrapur and Husseinabad, to examine local level planning and resource management options available for NGOs like the AKRSP to experiment with in such areas. .

Amrapur and Husseinabad represent the conditions that obtain in much of coastal Saurashtra which, until a decade ago, was so green and agriculturally prosperous as to be popularly called 'Lili Nagher' (Green Creeper). The intensive groundwater irrigation which developed with the onset of the modern pumping technologies in the mid-1950s was central to this rural prosperity. Under supportive government policies which made subsidies and credit freely available for intensive private groundwater development, motorised wells expanded rapidly, especially after 1960: In many areas, water-loving crops such as sugar cane, banana, fruit orchards, etc, began to replace traditional crops. Three crops a year became quite common with the help of motorised wells. The amount of water lifted from the coastal aquifers between any two monsoons increased over 10-15 times. As a result, by the late 1960s, the fragile coastal groundwater balance was disrupted. In inland areas, such as Amrapur, separated from the sea by a natural ridge, wells began to dry up in late rabi (January-March) and summer seasons, as happens in the hardrock areas of the south-Indian peninsula. More seriously, in low-lying areas closer to the sea, such as Husseinabad, large and increasing areas experienced intrusion of sea water into their wells.

The socio-economic backlash that salinity ingress created in the area and the misery it caused, especially among the poor, have been documented by several authors (Shukla 1985, Menon 1985, Shah 1988). The government responded to the challenge by mounting a programme to construct physical structures, check dams, bandharas, and tidal regulators with the aim of increasing fresh water recharge and reducing intrusion. It was soon found that farmers quickly used up the 'slack' so created by a free 'open access' resource. This response, and the need for a strategy to cope with intrusion, emphasises the need for a more effective and sustainable common property management of the aquifer at village or sub-regional level.

The main purpose of our fieldwork was to explore the possibilities of this happening, and to understand the conditions under which the present open access groundwater use regime could be replaced by a better regulated management regime. Section 2 of this report describes our experience in raising some of these issues with the people of Amrapur where conditions are somewhat better than in Husseinabad, and the scope for cooperative management strategies are good. Section 3 presents a somewhat speculative analysis for Husseinabad; this analysis offers some guidelines and ideas for action but falls quite short of an action plan. Section 4 is essentially an apology for this inadequacy and argues strongly for experimentation and adaptation through a flexible plan of action that involves the two village communities in planning and managing the use of their groundwater resources.

2 AMRAPUR

2.1 Village Profile and Social Structure

Amrapur is a largish multi-caste village in the Malya taluka of Junagadh district. Ismailies, Karadias, Sagars, Lohanas, and lower-caste communities, including Harijans, Rabaris, Bharwads, Mumnas, and Khat Darbars account for over 95% of the village's 2000 strong population.

Farming, dairying and trade in agricultural outputs and inputs are major sources of incomes. Amrapur is the hub of a major trading outfit serving 17 neighbouring villages, controlled by the Lohanas of Amrapur. In agriculture, the bulk of the surpluses are generated on irrigated lands; over half of the irrigated land in the village is owned by Ismailies who account for 25% of the households; Karadias and Sagars claim the bulk of the remaining irrigated land. About 60-70% of the land has some irrigation facilities; almost all Sathani land and the land belonging to marginal farmers has no irrigation and can be used only for the kharif crop. Some Harijans and Rabaris got Sathani land from the government of Gujarat in 1969, however, this land used to be government wasteland of poor quality, and almost all of it is un-irrigated and therefore useful only for a kharif crop[3]. The land holdings of those who own wells are quite large ranging from 6-32 acres with a modal value of around 8 acres. For non-well owners (whom we did not get to know so well), the modal value of land holding would most likely be around 2 acres.

2.2 The Origin of the Problem

Open, dug wells are the primary source of irrigation in the village; some farmers also lift water from river Madherdi and river Vrajmi when they have water. There are about 320 wells: over half of these use electrically powered pump sets, the remaining use diesel engine driven pumps. Almost

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3 *The seasons used in Gujarati cropping are:*
Kharif - during the southwest monsoon, July-September;
Rabi - withdrawal of southwest monsoon, October-January;
Summer - February-May. (editor)

all the farmers we talked to used 5 hp motors or engines; 7.5 hp motors were exceptional. Well water has caused particular shifts in rabi cropping activities.

The monsoonal rainfall in the area ranges between 750-1000 mm. Groundnut continues to be the most kharif important crop despite extensive access to well irrigation. In more recent times, a rabi wheat crop has become common for most farmers with well irrigation. In summer, a small area is normally planted with sorghum fodder or lucerne. Some farmers have also converted a part of their farm into a mango-cum-coconut orchard; these are quite intensive in water consumption.

At the end of the 1988 monsoon, which was one of the best the area received in decades, all wells in Amrapur were full and many continued to yield long after the last rain. Even at the beginning of February, there was water in the Magherdi river. Encouraged by this, there was extensive sowing of rabi wheat by the farmers. In addition, given high prices available, many farmers still with water in their wells at the end of rabi season decided to plant sizeable areas with summer groundnut.

Most of these farmers ended up losing heavily and regretting their decision to plant an additional crop. Many wells ran dry in the middle of rabi; as a result, rabi wheat took heavy losses for the want of last two or three waterings. Of the remainder, most well owners ran out of water in the mid-Summer and had to either write off the crop fully or do with very low yields of 150-200 kg per acre, despite buying water at Rs 200[4] or more per bigha watered from those lucky few with wells still yeilding water.

Farmers saw the problem as insufficient harvesting of water; their preferred solution was to build more check dams to improve rainwater storage. Barber, however, came to a somewhat different conclusion and saw the problem essentially as the inability of the farmers to foresee the possibility of the wells drying up and incorporating such fore-knowledge into their planning and decision making.

2.3 Aquifer Characteristics

Amrapur village is in a valley and is surrounded on all the sides by elevated plain land and hillocks. The Magherdi, a seasonal river, cuts

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[4] ***In December 1990, US$ 1 = 17.8 rupees***

2.5 bighas = 1 acre.

across the village and is met by three small rivulets called Vrujmi, Rakhodio and Jarado. All these then flow into Dadhichi reservoir where water is stored to provide piped drinking water to several villages of Mangarol taluka.

The entire valley constitutes the catchment area for the aquifer, and the rivers bring water which recharges the aquifer. The AKRSP has built two check dams which further increase the recharge and storage (see Figure 1). Check dam 1 was ready by the 1988 monsoon and brought considerable benefit to the wells.

Our initial hypothesis was that the village is underlain by a 'trap'[5] aquifer whose boundaries coincide with the village boundaries. The aquifer is like a bowl so that the wells located at the center will always have more water and for longer periods than those at the rim. However, with the river, the bowl has a hole in the bottom, as it were, so there is no incentive to conserve water since water not used is lost. Thus, the aquifer and the wells provide no inter-year storage. The key needs are: (a) to capture as much of the rainfall and river recharge as possible; (b) to schedule its utilisation so that water loss via the river from the village catchment is minimised; (c) to ensure that all water is used up before the next monsoon; and (d) to organise the most efficient and equitable use of the available water through a suitable community groundwater management system.

2.4 Interviews with Farmers

We visited about 30 wells and had discussions with some other well-owners. We visited wells in all major topographical zones across the village catchment; for instance, we met well owners in the valley and along the rim, within the river bed, near the river and away from it; near the check dams and away from them; near the Dadhichi reservoir and away from it, etc. Contrary to our starting thesis many wells on the rim had good recharge even at the end of Summer, with some being able to pump almost continuously. On the contrary most wells in the center, including many near the river and the dams and one or two within the river bed had no water at all. Indeed no pattern seemed to emerge which would explain why some wells had water and others did not. We visited wells less than 50 feet apart with one having plentiful of water and the other completely dry suggesting independent sources of recharge for such wells.

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5 *'Trap' rocks derive from extrusive volcanic activity.*

In contrast, in some areas, there was a major element of well-interference among neighbouring wells.

We inquired if the farmers had a theory of their own to explain how the aquifer of the village behaved. Farmers operate under conditions of uncertainty right from the point of decision about digging a well. Striking water at the first attempt was uncommon; we met a farmer who had spent over 100,000 Rs digging five unsuccessful wells. Even if one struck water, there was no way of being sure of yeild across the year. If over years of differing rainfalls, one developed some working knowledge of the well's behaviour, that too could be invalidated as more new wells come up in the neighbourhood, or check dams are built, and more deep bores for water supply are sunk behind the Dadhichi tank which would 'steal' water from underneath the village wells.

Farmers are found to respond to this uncertainty in a variety of ways. Most make sure that they make several vertical and horizontal bores[6] at the bottom of their dug well so as to capture all possible sources of recharge. Those who have resources dig two or three productive wells at different locations in their farms; in a few such cases, we found that if one well did not have water, the other did.

Each farmer seemed to have identified, from experience, some kind of 'leading indicators' which help them to predict the behaviour of their wells. For instance, a series of well owners we met along the river suggested that as soon as the river begins to dry up and water level drops below a certain level, they know that it will not be long before yields decline. Farmers, therefore, begin to pump simultaneously to claim as much of the remaining water as possible, presumably wasting a good deal of it. This 'competitive pumping' must, to a great extent, hasten the pace of depletion of the aquifer. A power tariff linked to horse power accompanied by a reasonably good electricity supply has further encouraged this behaviour.

Though our interviews were unstructured, we collected for each well information on (a) diameter of the well in feet, (b) depth to the bottom and the number of vertical and horizontal bores inside the well, (c) current depth to the water level in the well, (d) hours of pumping needed to empty the well, (e) hours taken for the well to refill. These unstructured interviews also provided us some clues about the pumping behaviour of well owners, especially towards the end of rabi and through the summer.

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6 *2-4 being common, but several having more than 5.*

Normally, during and after a good monsoon, most wells can be pumped continuously since the rate of recharge to the wells far exceeds the rate of withdrawal. In some wells, the water table would not fall at all, while in most it would fall but only by a few feet even after a fully day's pumping and would be restored in a few hours. From mid-Rabi onwards this situation would begin to change. The water table would fall by several feet after a day's pumping. In summer, continuous pumping becomes impossible in most wells; our interviews suggested that the well would be emptied after pumping of between 10 minutes to six hours depending on the well; and it would take between 6 and 48 hours before the well can be pumped again for the same duration.

2.5 Individual and Group Strategies

From our discussions with farmers, there seemed four distinct conditions of recharge in the wells, with two which 'continuous pumping' is possible. In the first of these, the rate of recharge clearly exceeds the rate of discharge so that the water level in the well is not affected at all by pumping; in the second, the rate of recharge is marginally less than the rate of discharge so that it takes several days and nights of continuous pumping before the well begins to empty and pumping has need to be discontinued to allow recharge.

The remaining conditions are 'wait and pump' phases ('uteri uteri' in local language) in which the rate of recharge is much less than the rate at which water is extracted. In the third phase, the well can be pumped throughout the day and will get recharged during the night; in the fourth phase, recharge becomes so small that the well can be pumped only for a few hours, often for a few minutes, before the well gets emptied and needs a day or several days to recharge. In these later two phases of 'wait and pump', water use programming becomes important. It is also largely during these phases that farmers become aware about the well-interference externally and practice 'strategic behaviour'. All the wells in the village can be classified according to their conditions of recharge at any time point. A model for pumping regimes in these four recharge phases is given in Box 1.

Box 1:

Given the location of a well with a recharge source, the static storage in the well S can be written, in a simplified form, as

$$S = \pi . (d/2)^2 . h$$

where d = diameter of the well below the highest recharge point and h = H* - HO, with H* = depth to the basalt layer (i.e. weathered thickness), and HO = depth to the water level in the well.

If x defines the rate of discharge of the pump and r is the rate of recharge both in cubic feet per second, then the hours for which the well can be pumped continuously can be written as [S/(x-r)]/3600 and the time the empty well will take to recharge to the pre-pumping water level will be (S/r*3600).

We can also define the define the pumping regimes in relation to these four recharge conditions:

Phase 1	r>>>x : continuous pumping
Phase 2	x>r ; but [S/(x-r)]/[3600x24] = several days
Phase 3	x = (1.5 to 2.5)r and/or S is large; so that [S/(x-r)]/3600 = 8 to 12 hours
Phase 4	x = (10 to 30)r and S is small; so that [S/(x-r)]/3600 = 0.5 to 3 hours

The options available to individual well owners, especially in phases 3 and 4, and to the community as a whole are:

(a) increase the the rate of recharge to their wells and/or storage of their wells below their recharge zones;
(b) and/or adapt their cropping plans so that they can do with less water especially in rabi and summer thereby reducing the required rate of pumping;
(c) develop better understanding of the behaviour of their wells or improved crop planning;

Some of the ways in which these can be done are presented in Box 2.

Box 2: Individual and Group Strategies for Groundwater Management

	Individual Strategies	Group Strategies
1. increase r, the rate of recharge;	farm pond as recharge source; exploit deeper aquifer by more bores; dig larger diameter well below the recharge zone;	more check dams and percolation tanks; reduce pumping from the Dadhichi tank;
2. reduce x, the pumping rate;	reduce summer cropping; use piped conveyance and sprinklers;	group decision on extent and mix of summer cropping; cooperative exploitation of groundwater;
3. better crop and water use planning;	better understanding of one's well and its interaction with the aquifer;	better understanding of the interaction between wells; efficient water markets;

There are large variations in the individual responses to the water conditions. Kamabhai, an Ismaili small farmer, for example, followed a two-pronged strategy which was different from other farmers. Most well owners have 2-4 bores at the bottom of the well; Kamabhai made 15, most of them horizontal, to capture greater recharge. Whereas most wells are large in diameter at the top and become progressively smaller as they go down, Kamabhai's well was much bigger inside (especially below what he thought were the recharge points) than at the top. Kamabhai's well could be pumped continuously for days when we visited it and is well known in the village as one of the more productive and dependable wells and he attributes it to the two changes he made in the design.

The explanation he offered made sense in terms of our simple analytical framework of recharge conditions; the static storage S is largely determined by the recharge rate and the storage space available below the points where the well receives horizontal recharge. Since his well affords greater storage during the night when pumping is discontinued, he can pump through the day uninterrupted. He also argues that one of the problems of the wells which reduce to 'wait and pump' status early in the summer is that they get smaller in area as one goes down and therefore offer less scope for storage to build up when the well is not pumped.

Another unusual decision Kamabhai took was to leave a part of his farm un-irrigated and intensively apply his scarce water to only a part of his land which he has converted into an orchard. Kamabhai was happy with the outcome and his orchard looked quite good. Everyone else was applying water thinly over extensive areas and it would be worthwhile for the AKRSP to explore which of the two approaches is superior. We felt that studying the ways of enterprising and wise farmers like Kamabhai might provide elements of individual strategies which, if presented and extended appropriately, might help to improve the responses of other farmers.

For viable group strategies, the most important condition is a shared and improved understanding among well owners of (a) aquifer conditions, (b) interaction between one's well and the aquifer, and (c) interaction among different wells. In the context of Amrapur, creating such understanding would imply, among other things, mapping of all the wells over the year according to the four sets of conditions (Phases) discussed earlier. Such mapping would then form the basis of all discussion, extension and negotiations on water use strategies within the village. The project is now studying information exchange whereby farmers not water information on for use and submit them to a village-level organiser in return for a periodic analysis of their situation. The organiser can in turn collate this information on a catchment basis, for better information, and to initiate 'historical data collection and advice' records likely to be useful for community water strategies.

3 HUSSEINABAD

3.1 Village Profile

Husseinabad village of Mangarol taluka ahs a similar population to Amrapur, about 2000, but has just over 1200 acres of cultivated area. Unlike Amrapur, Husseinabad is predominantly Muslim. The village is situated on the bank of the river Noli. The river is seasonal and the government has built a series of dams to conserve and store water just before the river flows into the sea. The Sheikh had built a large dam near the neighbouring village of Sheikhpur. From the reservoir of the dam, a canal was built to transport water to Husseinabad. The village elders informed us that since before Independence until 1965, the canal has been used by farmers for irrigation. Over the years, however, due to siltation, water has become less able to flow easily into the canal. In 1967, the government decided to repair and enlarge the dam, and the government installed a 100 meter pipeline to convey water to the canal. This fix never worked and after the renovation of the dam, whatever little water earlier flowed into the canal stopped.

Mango and coconut orchards dominate land use in the village and are a major source of income. Some crops are grown too. In kharif, most farmers grow groundnut; in rabi, many grow wheat and mung[7]. Wells are the only source of irrigation although on the river bank, a few farmers are able to pump water directly from the river when it has water.

3.2 Salinity Problem

Unlike Amrapur which is over 10 km from the sea and at a higher altitude, Husseinabad is much closer to the sea. As a result, while the three year drought that lasted till 1987 left Amrapur with only a relative water shortage, it left Husseinabad in deep trouble. A third of Husseinabad's wells located on fields closer to the sea became saline. Except for some days during the rains, all water pumped from these wells is now unfit for irrigation. The fields in these parts have suffered major yield decline in all crops except kharif groundnuts. Within the next two or three years, it will no longer be possible to irrigate crops on these lands. Coconut yields have declined by 30-70%, and the poorer quality of cocomunt produced commands lower prices.

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[7] *Mung is a short duration pulse crop.*

The conditions for the farmers located in the saline zone, both large and small, is desperate. We met two owners of large orchards close to the sea some distance from Husseinabad who earn most of their income from coconut and whose earnings have, over the past decade, declined to 10 - 20% of their pre-salinity levels. We also met several small holders who were in a more miserable state. One young farmer had been forced to sell off his assets including his buffalos and a pair of bullocks.

3.3 Three Zones

These farmers are located in that part of Husseinabad where groundwater and land have become fully saline. Somewhat further inland is another distinct zone where well water has just begun to turn saline, but where salinity levels are still low, and well water can be used for irrigation. Soils in this zone have not been affected by salinity. However, it is commonly understood that with another drought year or two the saline zone will engulf these lands.

The most inland areas, are still unaffected by salinity. The wells here have fresh water during and after the monsoon, and well into the rabi and summer seasons, and the problems are water scarcity, not salinity. Rough estimates from a group of well owners suggest that about 50 wells are in the saline zone close to the sea, some 100 are in the middle zone with mild salinity levels and another 100 are inland and have still not been significantly affected by salinity.

The quality of water and its quantity are inversely related in Husseinabad. In the saline zone, where water has high salinity content, the wells abound with water. As one moves inland, the water quality improves but the well yields, at least at the time of our fieldwork, declined. If the record of other such villages in the area are any guide, in the next few years all of the village will suffer from acute salinity problem. Barber's view has been that the salinity can be pushed back and the productivity of the lands restored completely over a period of some 30 years but only if all well owners restrict pumping of wells to fresh water recharge only.

3.4 Farmer Responses on Restricted Pumping

We asked villagers what could be done to retrieve the situation. The first stock answer received was that only the government could do something about it. All feasible solutions were those linked to increasing the importation of fresh water, and most thought renovation of the canals to bring Noli water to the village to be a priority. In our discussions with well owners from all three zones, we explored the feasibility of controlling water abstraction from wells. It emerged that it was highly unlikely that well owners will individually restrict pumping of their wells to prevent or reduce salinity. Those in the safe zone are certain that wells will soon become saline regardless of how much they themselves restrain pumping if others do not restrict pumping as well. Farmers in the saline zone, who are desperate, are just not interested in solutions that take 30 years to produce results. In any case, not one of some dozen well owners we met from different zones, including a group of highly enthusiastic, young farmers, seriously believed that self-regulation or, indeed, any demand-side solution could be feasible and stable unless introduced in conjunction with an effective supply side intervention.

3.5 Transport of Water from Outside

Many well owners in the middle zone with resources have explored quicker private supply side solutions. There is already a water market of sorts in which farmers in the saline and the middle zones buy limited amounts of water from well owners inland. These transactions are highly personalised; prices charged vary a great deal (from Rs 2/hour to Rs 8/hour), and water is conveyed through open field channels with huge seepage losses. One older well owner attributed highly wasteful water use to the imposition of flat rate power tariff and an abundant power supply.

Some farmers in the saline and the middle zones have gone far inland to neighbouring villages, bought small pieces of land at exorbitant prices from private farmers just to sink a well and laid long pipelines to transport water to their fields in the saline zone. Hassanbhai, one such farmer, paid Rs 6000 for a one guntha plot (1/40th of an acre) to dig such a well where the market value of irrigated land is Rs 40-50000 per acre. In profiteering from land sales for wells, inland farmers are imposing a high potential cost on their own resource since, if this trend gathers momentum, it must either result in progressive spread of salinity in inland areas and the depletion of the inland aquifers.

There are elaborate contracts, formal and informal, in laying pipelines for long distances (1 - 3 km) to transport water. If the pipelines pass through government lands, special permission has to be secured and rent paid. If the pipelines pass through private fields, consideration has to be offered normally in the form of assured irrigation service. In one such case that we observed, the well owner had to offer 12 hours irrigation every week at a price which was slightly below the market rate. In one case, the farmer with his field under which the pipeline passed broke off from the group and dismantled the pipes passing from his field, thus cutting the supply to farmers further away from the well.

3.6 The Lohej Cooperative

One of the best known efforts to transport fresh water in to saline zones is offered by the Lohej Irrigation Cooperative in Mangarol taluka which transports water from Kantasa village along a 10000 ft pipeline to serve 150 members of the cooperative. Lohej became saline in the 1960s. Arjanbhai, the village Sarpanch[8] at that time, devised the scheme and secured government assistance for the Rs 1.5 lakh project. In 1978, when the first well turned saline, he got another grant to go further inland and sink a second well in Kantasa village. The old well continues to function, although it can be pumped for fresh water only during kharif and rabi. A secretary, a water clerk and two machine drivers constitute the team paid by the cooperative to manage its affairs. The cooperative has also invested in a tractor which it hires out to members as well as to non-members.

The area served by the system has declined by half since 1978. As soils become more saline, farmers need more fresh water to flush the salts out. The area served in a typical year recently has been as follows:

Box 3: Area Irrigated by the Lohej Irrigation Cooperative

Season	Main Crop	Area Served Acres	Pumping Hours
Kharif	groundnut	120	1200 hours
rabi	wheat	40	2000 hours
summer	millet	40	2400 hours
Total		200	5600 hours

Only a fraction of the village's farm households are members of the cooperative and the cooperative can serve only a fraction of its own members' land. After allocating a season's irrigation (less than 5 acres), if there is spare capacity left, additional irrigation is offered on request. Non-members take only a rainfed kharif crop, so do members on whose land falls outside the command of the system. During a drought year,

8 *Headman.*

many members find their relatives from saline areas camping with them in search of fodder. During the drought, the cooperative suspended normal cropping patterns and everyone grew only fodder; the cooperative also provided water to non-members to grow fodder. This helped the village and many other families from the saline areas to survive the drought.

Members also have private wells on their fields within the command, and, according to Arjanbhai, there are no formal restrictions on pumping in summer. In kharif and the early part of rabi when there is some fresh water recharge, farmers pump their own wells, which is safe. In summer, no member pumps his well since everyone knows that it will affect their soil. If this is true, it supports the point that some self-regulation can be generated with an effective supply side intervention.

3.7 Options

There are two ways Husseinabad and other villages in the area suffering similar conditions can go. First, without a major initiative to change the current trend, it would take between 3-10 years or 2-3 drought years before the entire village land becomes saline. In this event, the farm output and employment would decline to about a 10th of the present level and majority of the population will be pauperised and have to shift elsewhere to seek a livelihood. The second option is for a new ecological equilibrium to be established in the village through: (a) effective enforcement of checks on the withdrawal and wasteful use of groundwater; (b) planned efforts to increase recharge and harness rainwater in surface structures; (c) import of fresh water from points further inland without disrupting the groundwater balance there; and (d) changing to crops which can require modest amounts of fresh water or which tolerate saline water.

Of these, (b), (c) and, to some extent (d) which would require extensive interface with agricultural research establishments, could be undertaken by institutions like the AKRSP. These will, no doubt, delay the worst consequences by a few more years, but as current experience with government programmes has suggested, the slack created by (b) and (c) will most likely get used up by farmers who increase their irrigated area rather than establishing a new ecological equilibrium. For this, the village community needs to evolve demand side interventions which involve making and enforcing new rules of the game.

The responses we received to suggestions about demand side interventions was usually luke warm and often outright negative. Those whose wells have fresh water still would have no part of it; those whose wells do not, just do not care. Professor Bromley suggested that compliance to some rules and norms be the pre-condition to AKRSP involvement in the village, and this might work if the village community believes that AKRSP can deliver something substantial for each of them, or if enthusiastic community members believe it would improve community prospects, and they can sacrifice time and energy, and are willing to commit themselves in the cause.

4 LESSONS

For the next ten years or so, the Amrapur problem can be largely resolved by an assortment of physical structures that AKRSP can put up to retain and increase the recharge of wells. Likewise, in Husseinabad, conditions can be temporarily improved by the AKRSP rehabilitating the old canal and using it as a source of fresh recharge. But what is more important and useful is understanding how the village communities can, with some outside support, develop their own internal capacities to cope with such problems and to institute ***self-correcting mechanisms*** (SCMs). What would also be important and useful to understand are ways in which macro level policies - legal, infrastructural, and others, might support the development of such localised self-correcting mechanisms.

SCMs might involve internal mechanisms for equitable regulation of water use or developing new sources of fresh water, or both. In either case, some form of community organisation would be needed with a widely acceptable authority structure.

Present experience suggests that, on their own, it is highly unlikely that such SCMs will evolve except where leaders like Arjanbhai apply themselves to such problems. Although studies which attribute local successes to capable local leaders may lead one into a blind alley, in our field work we came across several young people who might well be the 'Arjanbhais' of their respective villages if only being a leader did not impose a high personal cost in terms of resources, time and effort. This cost means that besides being willing and able to assume the leadership role, the potential contender must be so well off and ably supported that he can afford to delegate his personal affairs. In the course of our discussions, Bromley mentioned the importance of restoring traditional local authority structures for better management of common property resources. It is doubtful if this is possible in these villages; but it certainly seems within the realm of possibility to draft more potential leaders into the task of creating SCMs by reducing the personal cost of assuming leadership. Experimentation alone can help us identify how best to do this; and NGOs like the AKRSP might take a lead in this regard.

Given the presence of good local leadership, the process of community organisation around water management issues can be best started by involving water user groups in understanding the technical behaviour and relationships of between wells and recharge sources. Such shared understanding can form a sound basis for community planning and management of the water resources. Individual involvement can be strengthened if this also improves their understanding, and thus the use of their own wells helps them understand better and to use it more creatively. In the process, mechanisms should be created for new knowledge to be shared with other well owners. Over time, such a process would heighten the awareness among well owners of the various inter-dependencies and the opportunities for better community management of water resources. Such a process would also be essential to community initiatives in (a) identifying new sources of recharge and surface water and raising resources to develop them; (b) evolving and enforcing mechanisms for equitable regulation of water extraction and use, and (c) optimal water use planning. The scheme such as one outlined earlier for Amrapur may eventually result in such community initiatives and 'self-correcting mechanisms'.

Macro level policies can support or discourage the emergence of SCMs and individual behaviour that accentuates the problem. For instance, a flate rate charge for power may encourage profligate use of water because the incremental pumping costs under flat power tariff becomes very low. In principle, the options here are: (a) to switch to pro-rata power charge; while this will make water costlier to lift at the margin, it will by no means guarantee regulation of water use to the desired level, or (b) continue with the flat power price regime but use judiciously planned restrictions on power supply for pumping so as to limit water extraction to desired levels. There are many operational and political issues involved in this; but power supply and pricing policies can be a potent instrument of groundwater regulation in the type of areas represented by our two villages.

Legal interventions too can, in principle, help. In Burma, for example, a 1930 groundwater act is believed to have effectively regulated the rate of establishment of wells in areas through a system of licensing. In India, however, most researchers and development practitioners have serious reservations about the enforcement of groundwater laws. Experience with the implementation of siting and licensing norms, in force in most states, support these doubts. In Gujarat, for example, a groundwater act passed in the assembly over a decade ago has yet to be made into a law. Political opposition is likely to be another factor that may reduce the effectiveness of legal interventions.

In the long run, large-scale planning of water resource development must recognise the high returns from bringing surface water to coastal areas with fragile aquifers. It is an irony that mega-projects like the Narmada should increase surface water supplies in areas like Kheda, Baroda, etc, which already have good groundwater surface water resources, while additional surface water supplies are so badly needed in coastal Saurashtra.

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THE POLITICS OF WATER SCARCITY: IRRIGATION AND WATER SUPPLY IN THE MOUNTAINS OF THE YEMEN REPUBLIC

Linden Vincent

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THE POLITICS OF WATER SCARCITY: IRRIGATION AND WATER SUPPLY IN THE MOUNTAINS OF THE YEMEN REPUBLIC

Linden Vincent

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THE POLITICS OF WATER SCARCITY: IRRIGATION AND WATER SUPPLY IN THE MOUNTAINS OF THE YEMEN REPUBLIC

Linden Vincent

1 INTRODUCTION

In environments where water is scarce, competition for resources is a pervasive phenomena. Institutions for the resolution of disputes over water will be a fundamental component of indigenous water management in such areas. However, development interventions which put new pressures on resource allocation can cause serious disruption and conflict. The question facing many governments in the 1990s is how to promote evolution of water management consistent with economic and social change, and how to handle the potential upheaval, protest and resistance they fear may come from existing beneficiaries and bureaucracies.

The past thirty years of experimentation in resource management has not shown a great sensitivity and flexibility to changing needs in water institutions, and has often been contradictory. There have been attempts to introduce 'ideal' comprehensive centralised water administrations, at the same time as attempts to decentralise management to 'ideal' community administrations, with very little real understanding of the actual complexity of organisations at either level. Both these approaches lead to the separation of 'policies' from 'politics' mentioned by Sexton (1991), where 'politics' is synonymous with the local anarchy that prevents 'rational' development interventions being implemented. Thompson and Warburton (1985) issued a timely reminder that politics is not anarchy, but is the art of the possible in the cultures, economies and environments concerned.

This paper attempts to look at the 'art of the possible' in water allocation activities, using the requirement to transfer water for agriculture over to domestic water supply. Through both general debate, and actual field results, it provides an analysis of the circumstances that can encourage negotiated settlements for disputes over water, or enable serious conflict can emerge. The discussion uses experiences in disputes and conflict resolution over small water supplies in Al Jabin district, part of the Raymah sub-governorate in the western mountains of the Yemen

Republic[1] during 1985 - 87, within a Unit involved in constructing rural water supplies. Agriculture in these mountains is predominantly rainfed, depending on low rainfall that has recently also become less reliable. Irrigation water is at a premium, and most water sources are already devoted to irrigation with very limited resources for domestic water supply. New domestic water schemes had to be served either from new sources, or by increased volume from rehabilitated irrigation and domestic sources, and was in direct competition with irrigation interests. The area has a high degree of customary water management; water rights are determined primarily in relation to the permanence and variability of water sources, and their proximity to settlements, rather than as surface water or groundwater sources.

It is useful to start with a reminder that opportunism and argument are very human qualities. In many areas disputing is a normal form of social interaction, through which an individual tests his/her position and opportunities in the world (Parnell, 1988). Much disputing is highly ritualized in many societies, and does little actual damage to the society, in fact it may strengthen it. Heavy levels of verbal exchange, and changes in opinion and allegiance may seem like assault or treachery to those unfamiliar with them, but they may not be symbols of conflict to that group, which may in turn be disoriented by lack of opportunities to argue, manoeuvre and test alliances.

Dealing with disputes, even if it seems like an endless form of fire fighting, is an important source of validation, and provides important information on the reality of local water management. It is extraordinary to consider the amount of time spent in technical feasibility in most projects, when so little time is allowed for establishing trust, legitimacy and authenticity. It is high expectations of achievement (low tolerance to transaction costs), and the rapid turnover of personnel (and hence knowledge), that makes disputing a problem for a development programme, rather than a problem to the local society concerned.

Conflict, on the other hand, is a more dangerous situation. The costs to development interventions through lost time, shattered personnel and wasted equipment and construction work can be enormous. To individuals and communities who suffer loss of entitlements, or whose community

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[1] Raymah was part of the Yemen Arab Republic (YAR), which united with the Peoples Democratic Republic of Yemen in May 1990 to form the Yemen Republic. For a fuller description of water management in the YAR see Vincent (1991).

organisation is weakened, the impact of conflicts can be devastating. Yet conflict is not always negative; it is also the means by which groups can overcome inappropriate or 'unjust' distribution of resources, and conflict can empower community organisations and individuals, and may improve interaction and respect between local and central organisations. Clearly, the meaning of 'conflict' and 'conflict resolution' needs to be restated, for better understanding of how conflict emerges. Also, what general initiatives in water institutions, and changes in local organisations can promote negotiated and acceptable settlements of disputes. Finally, there is a need to understand the risk strategies involved in conflict, especially when local groups perceive a water project and associated personnel as a source of additional power to win a conflict, which they might otherwise not have provoked.

The term 'conflict' is used in this paper for more serious forms of disruption, although this is not easy to define since 'conflict' is a cultural concept, and takes different forms in different societies. Hunt (1990) notes that "... conflict arises when disagreement becomes a public issue... (p 145)", but 'public' is a difficult word to interpret in customary water management. A slightly different view is to see conflict occurring when disputes cannot be resolved within a community, so that local groups turn to a 'supra-group' to deal with 'supra-community' problems. Much of the impasse in development assistance to water programmes may exist because governments and donors do not know whether to strengthen the 'supra-group', or whether to strengthen the community so that it does not have to turn to 'supra-groups' so often.

This point is very important in institution-building in water-scarce areas, because the causes of conflict are very variable. On the one hand, we have the *depletion* of resources, such as the groundwater over-exploitation described by Shah (1991), where farmers and communities are largely characterised by *helplessness*, because there are no rules to encompass the technology, and the technology itself requires no social interaction to support it. On the other hand, we have *misappropriation* of water as a source of conflict, which require special requests for adjudication, often after *physical violence and destruction*. Here rights are well established, and groups fight to keep them or change them. The potential role of local and central organisations are quite different within these different areas of conflict.

Instead of working to design new control and enforcement procedures at state or community level, it may be better to explore advisory and support roles in the 'supra-group'. Equally, the community may want new forms of the support from the supra-group, rather than be delegated a range of management functions that cannot be handled fairly. As Shah (1991) points out, we need pragmatism in promoting both community and state management options. Rather than idealistic stereotypes, we need an environment of dialogue to explore options.

A useful framework for understanding sources of controversy in water use is provided by Bromley and Cernea (1989), who identify two sets of problems in rural management:

(a) unclear institutional arrangements, including property rights and access to water:

(b) the absence of an authority 'systems to give meaning to these institutional arrangements.

They clarify property *as a right to a benefit stream that is only as secure as the duty of others to respect the conditions that protect the stream*, a form of definition very relevant to the Moslem world. They then distinguish between state, private, common property and open access property regimes, noting the tendency for valuable resources to be under some form of private ownership, whereas less useful or inaccessible resources will usually be accessed as common property or open access resources. However, unlike open access resources, common property resources do have clear group rights and group responsibilities attached to them.

Resources, therefore, commonly have different forms of property regimes attached to them in different locations relative to settlement patterns, and we cannot characterise a catchment or aquifer as being under one type of property regime. As the property regime varies, so too will the authority systems called in to deal with disputes. One source of early mistakes in the Raymah work was to look to just one section of the local administration to answer all queries about water management. We also had to learn that, although conflict and uncertainty was emerging in one local property regime, this did not invalidate all local customary management.

Gelles (1988) also points out the importance of avoiding over-simplification and stereotypes of the community, of communal institutions, and of interactions between them. It is important to understand how different local institutions are used by many different social groups and families to deal with water management issues.

For example, in Al Jabin, groundwater can be a privately owned from a spring cistern, be a common property resource where it rose in springs in less accessible parts of the mountain, where it was nevertheless lying within tribal (village) lands, or an open access resource where it is being exploited through wells. Unclaimed water sources also existed as open access sources in valleys previously too unhealthy or barren for settlement. Different representatives were called upon for advice and support depending on what type of property was under threat.

Much of the recent debate over local resource management has focused firstly on difficulties in defining property regimes, and secondly on the loss of legitimacy of indigenous institutions as central administrations have intruded via 'nation-building' activities, so that authority systems breakdown or become unclear. Although these are important sources of disputes, there are additional causes of disruption.

Conflict is not only associated only with definition or clarification of water rights. Knell and Whiteford (1989) show that much of the conflict over small-scale irrigation in Mexico stems from the separation of land and water rights consequent to land reform, where land was redistributed, but water rights were not. Similar problems can be found in areas where the abolition of bonded labour or slavery have left land rights out of phase with water rights. The result is sharecropping of water, which may exist alongside of a completely different framework of sharecropping of land, and sometimes an antagonistic environment where locals are both patrons and clients. Ironically, however, this degree of interdependence still makes local people prefer to use indigenous resource management institutions, rather than rules and courts imposed from outside. Such courts are unlikely to be able to deal with the complex reality of water use, and may not be prepared to honour the oral evidence which has always been important in indigenous systems.

Similarly, locating tension and conflict purely at the interaction of indigenous and new administrations, misses many important lessons on what kinds of authority systems work in different kinds of resource management problems. Indigenous water institutions are not always the equitable and benevolent entities that many writers seem to believe, nor are new initiatives in central organisation necessarily harmful. Many of the conflicts in rehabilitated Andean water systems have been due to difficulties in reconstituting an authority system to enforce the property rights largely recognised by farmers. In Cabaconde, Peru, it was the limited rotation of certain common rights through wealthier representatives, when they should have had wider circulation, which led farmers to protest through a variety of new local institutions as they developed (Gelles, 1988). Bacdayan (1980) provides a success story of one village community in the Philippines that successfully laid claim to a remote, previously unutilised stream using opportunities provided within the state system, empowering itself in the process.

How then, can one separate the rhetoric used to promote centralised or decentralised initiatives for water management, to make some practical recommendations for water scarce areas? We draw some conclusions at the end of this paper, after reviewing results from Al Jabin district.

2 TECHNOLOGY AND CHANGE IN WATER USE AND MANAGEMENT IN AL JABIN

Local interests in the mountains of Raymah are complex. In many respects there is still a tribal organisation operating through the extended family, with many communal customary entitlements in control of water and access to land for fuelwood and fodder. This customary law is still largely applied through representatives selected for traditional management roles, although a new civil administration has been developing since the advent of the Yemen Arab Republic in 1970. Alongside this, however, operate extensive private interests in land and water. Landholdings are frequently large, with considerable sharecropping of production from both rainfed and irrigated land.

This tribal system has been under pressure in parts of Raymah for many years. Early influences include the impact of the Ottoman occupation on the western slopes of the mountain, and more recently the civil war, and the effects of out-migration, which has both weakened sharecropping arrangements and the scope of agreements over water use. However, a hallmark of the inhabitants of the area is an intense loyalty to their land, which has led migrants to return and attempt to invest their savings in the area despite its scarce resources. Such attachments to the land perpetuate an involvement with customary rules on resource use, which are tribal in origin, even if allegiances and ties between families and representatives are under stress. This paper, therefore, uses the terms 'tribe' and 'tribal' in discussing the organisation and operation of indigenous resource management.

Very limited rainfall records exist for Al Jabin, with annual rainfall estimated around 650 mm on the western slopes, falling to around 400 mm or less in the east. There is no data on rainfall reliability and drought frequency, but the cropping system is regarded as a stable one, reproducible in most years. The land is extensively terraced on all but the steepest slopes. Sorghum/bean intercropping is the main rainfed land use, but other pulses such as lentils and fenugreek are produced, and grass collected from fallow terraces is important for livestock and draught animals. Coffee is the main irrigated crop, with some production of vegetables and qat, which increase in importance elsewhere on the mountain, and some irrigated sorghum in wadi areas. Most crops are irrigated through flooding of bunded plots. There has been no experimentation with sprinkler or drip techniques. Drip technology is marketed but is expensive, with polyethylene pipe commanding almost the same price as galvanised iron pipe of the same diameter.

This terracing and cultivation pattern has considerable influence on the nature and volume of the available groundwater. The geology is largely metamorphic and volcanic, with groundwater only available in fissures, faults and bedding planes, and as seepage under the terraces. These groundwater resources support seepage points, springs and a number of perennial streams, although their point of emission and discharge do fluctuate seasonally. In some valleys there is sufficient infill of unconsolidated materials to conduct groundwater, but even in these wadis sub-surface flow appears to follow sub-surface drainage lines, so that its development can be unpredictable.

The settlement pattern is a mixture of villages, hamlets and isolated homesteads. In Al Jabin, the typical size of a village was 200 people, but ranges from 50 to 1500. This diffuse settlement pattern is one of the first challenges to a rural water development programme. Some rainwater is harvested in cisterns for general use, but much of the drinking and irrigation water is mobilised from springs or streams supported by groundwater flow. In the past, hand-dug wells were only an occasional feature of the upper mountain slopes, but are now expanding; usually they tap throughflow under the terraces, or colluvial deposits, in wells typically 10 - 30 m deep. They are more common in wadis, where they range 5 - 30 m in depth.

The most important innovations in water technology in the Yemen are pumps, pipes (rubber and galvanised iron), and the expansion of well construction technology. New construction technology includes both limited horizontal tunnelling and better construction of vertical wells. Although borewells have received the most attention by aid donors, these are not common in mountainous areas like Raymah, for reasons of both access and geology. The proliferation of dug wells in one wadi has already caused drawdowns in the groundwater, affecting all irrigation farmers in the wadi, and the traditional domestic water sources.

Pumps also enable the lifting of water back up a hillside, from cisterns or streams, thus enabling individuals or groups to access water that may previously have been unutilisable. However, they are expensive, and are unlikely to be left in situ in parts of the mountain some distance from settlements for fear of theft or damage. So far, pump lifting of water for irrigation has only expanded on one perennial stream where small petrol pumps are in use, with farmers resident in the locality.

Piping has probably had the biggest impact on water use on the mountains of Raymah, especially cheap rubber piping, which is used to carry small amounts of water considerable distances. While homesteads near streams draw small amounts of water from the flow, the main expansion has been in the excavation and use of small seepage points for irrigation. The main impact of this activity is to decrease the total volume of seepage down the mountain. Water levels in some wadis have fallen, and it seems that sub-surface drainage lines are changing, leading certain wells in lower wadis to dry up. While road construction, drought and deforestation are also affecting the groundwater resources of the lower mountain slopes, the private expansion of irrigation up-mountain has also had an important impact.

Roads and vehicles have also led to substantial transportation of water, both for domestic water supply and to maintain high value irrigated crops like qat, and considerable private water markets exist. They exist in situ, for example, where expansion of water for irrigation by pumping has led to separation of cultivators, water owners and pump owners, with complex sharecropping arrangements (see Makin, 1977). They also exist spatially through the transport of water, both for irrigation and domestic supply, and it is these transport markets which are strongest in Al Jabin. Some of the early water supply initiatives were brave enough to suggest that villages should continue to supply or pay for their own domestic water through transportation, as it was so much cheaper that building infrastructure. However, the shift in responsibility for water supply to local councils, plus aid preferences to install infrastructure rather than support recurrent costs has kept water transportation outside the list of technical solutions supported by aid donors. Suspicions include fears that transported water would be used preferentially for certain villages, or for irrigation.

Clearly, there is considerable innovation taking place in water use alongside of customary practices. How this is happening, and the extent to which domestic water supplies are experiencing the same success, is the subject of the next two sections.

3 TRIBALISM, ISLAM AND THE STATE IN WATER MANAGEMENT

The existence of an extensive body of Islamic law for all aspects of society, and the central importance of water in many Islamic societies, seems to mislead donors into thinking that there will be a cooperative spirit in the development of water projects, and that there will be a forum in which management solutions are easily hammered out. This is far from the case, for several reasons.

The first reason is the ongoing recognition of customary law in water management, which is actually very complex because of the practical day-to-day concessions that often underlie the ideal principles. Secondly, while the importance of 'brotherhood' and coexistence in a tribe means that disputes will be settled within customary law where possible (Mahdi, 1986), but this does not prevent disputes which are often opportunistic and irrational, and sometimes very bitter. Most disputes go to wider courts only in desperation because of cost, *unless* these new courts provide a specific opportunity to make a claim. Thirdly, religious guidelines can only be used for problems discussed in the Koran or bodies of law subsequently derived. New technologies, especially pumps, borewells and pipelines, provide huge challenges to customary and religious law which many enterprising farmers are currently busily exploiting.

Another reason is the distinction between what aspects of water management are collective and what may be privately controlled. Even though the 'Law of Thirst' insists that all individuals must be allowed to drink water, the nature of access becomes very different between water sources, and as competition for water develops. In Al Jabin, no one will ever be refused a drink of water, but the controllers of a water source can and do refuse the right of individuals to fill containers, or do charge for them. The opportunities for drinking water development offered by the Law of Thirst is confused by an additional guideline that water should never be wasted, and that any surplus water should be always made available for irrigation.

One key to understanding these guidelines on access and appropriation is the rule that water cannot be owned or charged for unless it is stored and measured. Thus in terms of water as property, water resources management is defined as collective; it is only after it is mobilised and conveyed that it can become private property. Water flowing in small natural streams, irrigation canals, and from springs and wells developed jointly, are subject to joint ownership, with upstream users having priority over downstream users. However, water contained in receptacles or tanks, or wells and springs developed by an individual on their own land, is subject to private appropriation. Some Islamic sects recognise the principle of 'harim', whereby no water project can be constructed within a specified distance of another project (Caponera). In the Yemen this distance is supposed to be 500 m for well developments, but we see no evidence of this rule operating in Al Jabin.

There are few sources of information in English on customary law for water in the Yemen Republic (Makin, 1977; Varisco, 1982, 1983). The work available, however, stresses a division between the organisation of irrigation water from flash floods or intermittent streams, and permanent flow supported from groundwater. Varisco (1983) distinguishes these as 'sayl' and 'ghayl' respectively.

Varisco (1982) cites the Islamic jurist Al-Mawardi (1960) as distinguishing three types of spring:

(1) natural flow out of the ground, which is free for all to use;

(2) springs opened up on private land;

(3) springs opened up on unowned land, the effort of which confers private ownership but with certain communal obligations.

This classification also appeared to apply in Al Jabin, where springs provided the bulk of water for irrigation and drinking water. However, for spring type (3), the ruling is rather unoccupied or uncultivated land, since all land on the mountain is divided up into local territories or 'uzlas', largely synonymous with family groups. These general rights are complicated further by the issue of whether there is land by the stream for cultivation, or whether water has to be conveyed. Thus concepts of 'free for all' and 'communal' make spring types (1) and (3) very prone to dispute.

Both Mahdi (1986) and Varisco (1983) discuss the way tribal groups develop a management strategy in relation to available technology, judicial rules and norms of social conduct. Mahdi (1986) notes how there is a dual challenge in water management; that posed by the environment, which the group overcomes by using it's technical knowledge, and that posed by other groups who compete for water. He points out the subtleties of tribal water use that can confuse any outsider trying to understand, let alone rationalise water use, and makes four observations which are relevant to Al Jabin district.

The first point is that even though rules appear precise and complex, they are actually only theoretical guides, and are often corrected and adapted to the difficulties of the moment. Peaceful coexistence is important, and rigid adherence to the rules signifies a crisis in the group.

As a consequence, rules are periodically ignored, so that while the system serves as a foundation, it is supplemented by improvisation. Such adjustments are not part of traditional law, but are derived from local customs and relations, so that it may be difficult to understand the real local daily organisation. The complications are such that tribesmen prefer to discuss their system in the ideal terms of water rights rather than the actual utilisation. Thus oral history on the actual permutations of water access, and why it was permitted, is a vital key in the operation of the system.

Thus, the role of *knowledge* in the community is emphasised well as allocation, and the responsibility for each may lie with separate individuals. By virtue of being monopolised by a few, this knowledge can be manipulated if required. It is necessary to separate out those who use the water, the oral historians, those who allocate water and those who adjudicate generally for the community, and to understand the balance of power between them. Only then can one understand how resource management takes place and is integrated into the general administration of the community.

This complex pattern of local water law can be made more difficult by the invisibility of water management functionaries on small water sources, except at times of stress. Gupta and Ura (1990) point out the 'episodic' nature of events which challenge the finely-balanced and managed agriculture in Bhutan, with management also designed as 'episodic' to deal with crisis events as and when they arose. In his case study of a highland spring system in Yemen, Varisco (1983) demonstrated that there was little need for day-to-day supervisory activities as the irrigator was capable of handing the entire sequence of activities involved in irrigation by himself. Thus although there was an elected official, the wakil (called 'aqil' in other areas) responsible for the solution of disputes, his role was entirely separate from decision-making responsibilities in the distribution process or production system.

We found a similar pattern in Al Jabin, and some of these officials did not even reside permanently in the district. What is of interest is that we were never introduced to a wakil as part of our initial discussion of the suitability of a water project. Our facilitator was the local government representative, the village sheikh or the Primary Health Care worker, who may or may not have been providing accurate information about the water source. Despite the presence of local counterparts, we failed to make distinctions on the location of knowledge until bad disputes showed us the importance of this issue. It was not hidden from us, but we just never asked to meet the right people. Because we initially failed to understand the form of local representation, we could not initially participate in a forum that reflected local water management, and thereby set the scene for some disputes to turn into serious conflict.

The final point from Mahdi's work concerns the way physical and technical constraints lead to the communal use of water, which in turn prevents other groups from using it. He describes the existence of groups within the tribe, endowed with specific territory. Each group consists of several villages, each of which is a conglomeration of lineages from several extended families. Members of the group share a strong identity in three ways - of territory, of social origins and of mutual defence. Thus there may be more than one model of communal ownership - there may be property of the group and property of the village. Thus rights may actually change their form between smaller and larger social groups. Allegiances alter depending on the location of the threat. This can help explain why an irrigator group may not allow development of drinking water supplies from a source, even if it supplies their own village or territory. Gelles (1988) also discusses the shifting patterns of groups that form in claims for water.

The way group responsibilities and opportunities are described may prevent certain forms of change being admitted, as such descriptions are value statements, and may well be linked to other rights. Also importantly, forms of agreement and coercion may be accepted within groups which are not acceptable from other organisations, especially the state.

Although the advent of the Republic has not yet changed water laws in Al Jabin, it has begun to change their administration. Traditionally, disputes moved through a series of local representatives, depending on the scale or nature of the problem. Many local leaders have derived their wealth from fees for setting 'supra-community' disputes. However, by 1985 most areas of the YAR had a centrally appointed, legally trained district officer (mudiir), available as a judicial alternative or to participate along side of local leaders in serious disputes. This extension of central courts of justice has meant a loss of power to some local leaders, and has also represented a new opportunity for the presentation of claims in water disputes.

The joint operation of both customary and new forums in communities is found in many countries, regardless of whether new water codes and new water administrations have been formed. However, this may be a very appropriate mixture for communities in a state of agrarian and constitutional change, and is not necessarily a sign of confusion and disorder. Thompson and Warburton (1985) make a powerful case for preserving plurality of institutions as the case which offers the *villager* most options. Complexity of property regimes in particular may require plural attitudes to problem solving. They also contend that uncertainty and plurality can be worked with. The art is accepting that there is not just one problem, but many conflicting problems. One cannot, and should not, determine who is right, but rather understand why certain stances are taken. One can then understand which kinds of social transaction are best handled by which form of institution.

Approving new laws is a complex issue in plural societies, and it is no accident that many countries have little actual water legislation beyond generalisations laid down in their constitutions. Some Moslem countries may observe Islamic law (the Shari'ah) in its entirety; other countries maintain religious laws for family and inheritance issues, but develop civil codes for other problems, which is why some Moslem countries have enacted central water legislation while others have not. It is also worth emphasising that the Shari'ah does not include the concept of the 'public domain' for water that operates in many Western countries, but rather has the concept of management for the community. It thus becomes extremely delicate to distinguish private and communal priorities, just as under the Law of Thirst, it may be difficult to prevent someone excavating for water. For example, in central Tunisia, farmers are not prevented from digging new wells, but they may have their extraction of water restricted in volume, in the community interest.

Caponera (1973) describes how legal development in Shari'ah law to deal with new problems may derive from five different roots, with adoption varying between different Moslem sects. It seems that both the dominant sects in Yemen recognise the principle of 'ijma' or consensus, although attitudes vary as to whether this consensus should come from the nation, the community or Moslem scholars. Controversy does lie, however, over the use of 'qiya' or deduction by analogy, because of differences in the schools of law which are acceptable, and particularly whether legal solutions from non-Islamic countries could be considered. Finally there are issues in who applies this law - tribal or religious representatives, or a civil judge. Despite this picture of confusion and complexity, Islamic law can be remarkably flexible and pragmatic. Islamic Constitutions that have adopted Water Codes have usually been assiduous in developing a constituency of interests in committees and public assemblies that enable laws to be agreed with consensus rather than public dispute.

There are some clear lessons here for donors and governments impatient to introduce new laws and new enforcement structures for water scarcity. Not only will it be virtually impossible to codify the reality of much customary management, it will be very difficult to introduce new legislation. Weak central governments have to be careful how they debate issues, to prevent 'problems' being seized by interest groups capable of making trouble. As Thompson and Warburton (1985) point out, if there are no easy solutions, then it may be better not to identify problems, and rather direct energy and money towards the inevitable, unless this becomes financially and politically impossible. It is probably no accident that the actual evolution of water management in many countries has been towards improving forums to hear case law, rather than launching new centralised water institutions and water codes.

4 INTEGRATING IRRIGATION AND RURAL WATER SUPPLY

Although the competition between water for rural water supply and other uses is featured in economic studies on water scarcity, there are few articles which examine the practicalities of joint development of irrigation and rural water supply, or the reallocation from one to the other. Annis and Cox (1982) summarise advantages from joint development as reduced construction costs and increased volumes of water for improvement in health and hygiene. However, they note that social investigations are required about the actual prospects to develop new sources or rehabilitate existing schemes.

The reality of many initiatives is much murkier. Countries like India drill all of their public drinking water wells on lands which are not privately owned, to prevent wells being subsequently appropriated for irrigation. In the YAR, there were also cases of wells originally developed jointly for irrigation and drinking water on private lands being reappropriated entirely for irrigation. Nor is separate development without its problems. Gelles (1988) provides a classic example of a drinking water pipeline broken to provide irrigation water to a nearby irrigation canal.

The prevailing wisdom in the YAR when the Unit started work was that domestic water schemes should be kept separate from irrigation. By 1985, many donors also actively avoided developing springs for domestic water supply, because of the disputes they attracted, and some donors focused exclusively on borewells. Since most villages actively sought water supply improvements, it is worth understanding why disputing became such a strong tradition in rural water development programmes.

On a mountain the 'losses' of one area supply water for other users down-mountain; villagers face complex questions on whether to opt for improvement or reallocation of existing sources, or whether to exploit 'new' sources of water, any of which may cause consequences to topographical neighbours. The advent of technology which allows the incorporation of 'unutilised' water at a point in space may be creating a spatial reallocation problem outside the scope of existing customary legal controls.

Thus villagers may justifiably fear the impact of projects on their water rights, and in reverse, new technologies and pressures may be exploited by local interests to gain greater control or access to available water supplies. There is a serious dilemma for villagers between, on the one hand, wanting an improvement and risking new technologies, while on the other hand, judging the ability of local legal forums and foreigners to protect their interests. Disputing and negotiation at least gives the opportunity to test the reality of suggestions made by water technicians. *This issue is particularly crucial when local villagers are asked to accept a technology which they cannot visualise, so that they have no real grasp of how it will affect their environment.*

Technicians in a water programme have to understand what 'new' (unutilised) resources can be brought into a system, what reallocation *in uses* can take place at a source or spatially between sources, and what reallocation can take place *in users* can take place at a source. Just because a village has a right to use a water source, or identifies a previously under-utilised source, this does not mean that it has a right to develop it. Varisco (1983) demonstrates the importance of understanding exactly what a 'share' or 'right' to water is, especially the need to distinguish between rights of access and the physical appropriation of amounts of water. In Al Jabin, conflict or uncertainty has arisen over drinking water projects, because installation of piped water to a village previously having rights of access to a water point is seen as a form of physical appropriation, and may be disputed by a neighbouring group.

A useful example of this 'access' controversy arose with two spring sources developed for irrigation, but which also gave access for drinking water. These were both situations where considerable flows from large springs were piped around coffee terraces, and where differential domestic uses were permitted, depending on the relationship that the spring developer had with the villagers. Villagers were either allowed regular daily access to the irrigation pipes, or weekly access to use flows on Friday, the day of prayer. However, scheme owners refused permission for piped connection to be made to the spring system for irrigation purposes.

By 1987, the local council of Al Jabin had drawn up a list of village water improvements required, and the sources that could be used. This list provides interesting insights into what local representatives themselves thought were possible, and had 192 projects for 428 villages. 42% of villages could not identify a new water source for an improvement, and requested assistance with cistern construction. However, 47% of villagers wanted an improvement on a 'spring', a term they used to cover all the three types of spring mentioned in Al-Mawardi's classification. Some villages had new spring sources in mind, for example, spring sources within their territory but too far away to be currently used, or locations they suspected would yield water with excavation, or springs recently exposed by new road construction. However, many projects were simply improvements to springs in existing use. 56% of spring projects linked up more than one village, but there was an obvious preference for a project to be developed for one village only. Half of the spring projects requested involved pumps for lifting water. Unlike the limited local development taking place with small pumps in irrigation, the communal pumped domestic water schemes could be supplying settlements some distance from the water source.

The Unit suspected that this programme was a 'window dressing' exercise in financial terms, as money was unlikely to be found for all projects. However, we did not initially consider that there was 'window dressing' as far as suggested sources for development were concerned. In fact several highly controversial projects were on the list. It is hard to say if there was some ignorance on rights at the village level, although there was undoubtedly some uncertainty as to whether groups would cooperate or disagree in the face of new initiatives. Certainly many villages hoped they could convert access rights into a physical connection. However, some projects were undoubtedly a means to test the commitment of new leaders, and as an opportunity to redefine water rights if possible. Given the opportunistic spirit within which some water projects were put forward, the actual approach of the Unit became all important in influencing whether disputes turned into conflict.

In the upper part of the mountain, where springs are usually small, most springs have been developed to provide a small collection chamber for domestic water. If any surplus seepage is seen as adequate for irrigation, it will be collected in a small cistern for irrigation and piped to the fields. The quantities of water involved are very small, from 0.1 litres per second to less than 0.01 litres per second, with many springs in this lower range.

At some springs water is conveyed by pipe to a collection chamber near the village, with an open pipe for the outlet of water. Most improvements are simple; to clean the collection area, or reconstruction of the seepage point to reduce wastage of water.

All such improvements on springs for domestic supply were easily undertaken as long as all regular collectors of water could be supplied by the scheme. Negotiation was required if there was a loss of irrigation water through the renovation, or of land to the project, and this depended on the relationship between the irrigator and the villagers. With small water supplies, the irrigation income loss is small, especially if the irrigated production is sharecropped. Compensation could be arranged in money, land or water elsewhere.

On the lower slopes of the mountain, the springs are larger, and usually collected into cisterns for communal irrigation based on a rotation system. These springs yield in the range 0.2 - 2 litres per second. Domestic supply is taken either directly from the cistern, or from the spring seepage above. To reduce losses and release water for domestic usage, such cisterns can be improved by concentrating spring flow, lining the cistern and canal, and increasing storage to utilise all night flow. The water can then be piped or pumped to village, as the terrain requires. It is these projects which have proved the most troublesome to develop, because of the complex interests and numbers of people involved with them. However, only occasionally were disputes linked to water rights, usually because an individual with an irrigation share lived in a different village, and wanted domestic water taken to that village. The one serious conflict we experienced on such springs was opportunistic retaliation by one family in order to discredit a local sheikh, and had very little to do with water rights.

The groundwater streams in Al Jabin seemed an obvious source of projects, and we were asked to consider them by several representatives. We estimated that streams on the western slopes ranged 0.5 - 5 litres per second. Streams on the eastern slopes tapped the major part of the groundwater catchment and surface flow ranged from as little as 0.5 litres per second to 50 litres per second on the lower wadis draining towards Wadi Rima. However, we met resistance to development for all groundwater streams, except for those with very localised flow and limited irrigation development. It is hard to know if the enthusiastic advice of the representatives was opportunism to stake a claim, or just ignorance of the complex rules that surround the use of such streams.

As soon as we examined streams in use for irrigation, whether there were complex rotational arrangements within a village, or a sequence of irrigators along a stream, we met with resistance, even though we argued that there was surplus in the scheme. Large pump lift projects were particularly controversial, as they were seen to help villages that had no family links with wadi dwellers. No one will be denied access to water, but the actual removal of a share of water will only be possible for communities with a tradition of using drinking water from the stream, or where they already have a customary entitlement to remove water for irrigation, and thus become concerned with their own internal reallocation.

The utilisation of these perennial streams is highly individual, depending on their hydrology, local settlement density, land tenure, and whether cultivable land exists by the stream or some distance from it. Such streams could fall under category 1 of Al-Mawardi's classification. They are a difficult water source for which to state general principles of use, even within one district. However, one possible distinction is between streams that rise and disappear within relatively short distances, and those which flow continuously through several 'territories'.

In the first case, offtakes are permitted, and have either gravity offtake canals or an irrigation rotation in situ, depending on local topography. Where there are a small number of irrigators, and the domestic scheme is for the small hamlets where they live, there are few problems in introducing a piped domestic supply. However, if the stream has been developed by a specific group of irrigators, they will not allow a domestic water supply system to be introduced, for fear that in the future this usage will be claimed as a right, and expanding domestic requirements permitted to reduce the irrigation component. In the second case, streams which flow through several villages are utilised only for the collection of domestic water supply and of irrigation approved by local representatives. No extensive piped offtake of domestic water was permitted in our first round of investigations.

Wells also proved a complicated source to develop. Any well located too close to an irrigation cistern or groundwater stream used for irrigation was liable to be destroyed, even if on communal lands. In one wadi, extensive well development for irrigation had led to the abandonment of traditional well sites, with villagers taking domestic water from an irrigation well. Redeveloping the traditional well for a pump lift domestic scheme proved controversial because of its effect on local irrigation wells. Nor were we only concerned about the technical impasse of such sites. We were uncertain of social tensions between the wadi dwellers, and the mountain dwellers that projects would serve. The only well sites we visited that were not immediately controversial were in wadi sites where terrain made agriculture unviable, or where they lay clearly within an uzla or related group of villages.

It appeared that virtually all types of sources could be worked with on Jabal Raymah, because local customary practice is actually very flexible. This is particularly true for small-scale irrigation offtakes, which may be developed to include domestic water supply easily within village territory, through group negotiation. Discord and delays in projects materialised as groups tested the utility of new programmes for laying new claims to water sources, or to protect their rights, but were often not serious. Sometimes disputes developed simply to air old grievances or retaliate against other groups. However, conflict blew up over all proposed schemes which threatened very uncertain communal water sources like groundwater streams, or rights to water development in 'communal' 'uncultivated' land.

This brings us to the difficult issue of what constitutes 'communal' land on a mountain. Communal lands are usually steep sections of mountain, often at some distance from the village, over which different groups within an uzla have variable rights of access and disposition. Uzlas on the mountain have clear boundaries, often running along wadis, and sometimes communal lands lie between the villages and the boundary. Unfortunately, these boundary wadis are often conveyors of water. It is common for an uzla to have springs and groundwater streams rising on communal land which the villages of the uzla do not use because of the distance of the spring or stream down mountain. Often one uzla allows access by downstream uzlas on a practical basis, but still claim the right in theory to dispose of those sources as they wish. This is a pragmatic solution as a downstream uzla or village may lay violent claim to the water source if access cannot be negotiated.

However, the pressure on supplies, and the new opportunities offered by pumps and pipes have renewed interest in 'communal boundary' areas. The issue is whether the access permitted pragmatically by another uzla or landowner now has a force of law over the theoretical rights to disposal and use held by the traditional controllers. The worst conflict experienced by the Unit occurred in this situation over a spring used by two downstream villages, by village A for drinking water only, and by village B for drinking water and irrigation. The upstream group with theoretical ownership of the spring wished village A to have a piped water project, and there was certainly enough water in the system for all uses to continue. The project tipped over into a serious dispute because of the problem of 'knowledge', with village B claiming that in a previous dispute they had been awarded rights to the spring, but with villages A and the territorial group claiming that the entitlement had been obtained corruptly, and without the understanding of illiterate villagers.

Territoriality is the key issue of how water sources can be used and reallocated, whether for irrigation or water supply, with jealous protection of rights to water usage. Clear lines of authority also constrain disputes. Within one tribal area, newly discovered sources can be allocated to water supply, existing water sources will be allocated between irrigation and water supply, and rehabilitation permitted to release water for domestic use for an irrigation system, without too many problems. Disputes may arise from opportunism or retaliation, but can be resolved if careful debate and detailed clarification of agreements is encouraged. However, more serious disagreements are likely in villages with internal divisions and historic feuds over water sources.

It seems that water development is straightforward on most private land. While this seems a predictable response to market opportunities, we are also seeing the influence of local decisions on the scope of customary law. Many of the developments taking place lie within an areal configuration allowing issues to be decided by villagers and their local representatives, without recourse to wider debate or other authority systems. However, we also suspect the influence of certain landownership patterns, where innovations are allowed on a day-to-day basis because that land is farmed by powerful families, either directly or sharecropped. Thus the negotiation that can take place for individual smallscale irrigation development is much more flexible than that which can take place for communal/domestic water supply improvements, which may link up several groups or factions. An additional problem was very unclear authority lines in supra-community roles at this period for common-property regimes. Attempts by villagers to use new central forces (and donor interventions) failed because of weaknesses and inconsistencies, resulting in one conflict which became extremely destructive in property and relationships to both sides, and is still unresolved.

5 CONCLUSIONS

This paper began by noting the confusion facing governments and donors on how to recommend political changes consistent with economic changes. The answer cannot be found through experimentation with stereotypes of centralised or decentralised management systems, but by a careful study of the dilemmas facing governments and communities in dealing with resource management. We may need more experimentation in forums for negotiation rather than new rules to solve problems. The most difficult part of planning for change is to get behind existing institutions to find out what changes are needed, and are possible. This requires understanding of the economic attraction to collaborate rather than compete, of the legitimacy of 'micro-institutions' that control villagers, and the incentives for new institutions to develop and serve a locality.

Ironically, there may be more potential for community structures in areas still characterised by customary water management, despite the high level of dispute and endless attempts at misappropriation of water. In such areas heavy interdependence through sharecropping of land and water, and communal mobilisation of water and maintenance create economic reasons for cooperation, while strong traditions of 'brotherhood' in the face of external rule provide some framework for decentralised management, providing this management is not strongly focused in the hands of a ruling elite.

Sadly, in Al Jabin, there has still been very little increase in the power of villagers relative to their micro-level institutions, nor has the economic productivity of the area increased, thereby reducing incentives and possibilities to cooperate in project rehabilitation, water reallocation or resolution of territorial disputes. Some Andean water projects, while also riven with disputes, appear to have greater potential for community management in the longterm because of agrarian reform, although new local organisations still need a great deal of support to settle historic disputes before real changes can be made. Peru, like the Philippines, is at least providing us examples of the way diverse state institutions can give social and legal support, rather than just technical assistance, for water programmes.

For areas facing problems of resource rapid depletion, it will be very hard to strengthen community structures if there are no ongoing economic incentives to do so, or where there are wide disparities in income and little overall increase in political power available to individuals. As Shah (1991) points out, it is very difficult to introduce a water functionary where there is no tradition of this role, and where current technologies and agrarian relationships promote individualism.

The legitimacy of local representation is very important, not only for water functionaries, but also for local groups that make the representation to courts or 'supra-group' authorities. The Philippine study by Bacdayan (1980) shows a village council long respected by locals, interacting successfully with the State through advisers and bureaucrats sympathetic to local management. The studies by Gelles (1988) in Peru, and Knell and Whiteford (1989) in Mexico, show new local organisations with a strong political base slowly flexing their muscles in water management, with a fair judgement of the conflicts they are likely to win.

In Raymah, however, a new local council system had recently come into force, containing individuals of widely varying status. Most seriously of all, many council representatives were important landholders or religious leaders, who had previously taken the 'supra-community' role in water disputes. Our water programme became bound up in the attempts of villagers to test the commitment of their new leaders while also trying to reverse 'unfair' decisions previously made by some of these same individuals! The results of these disputes were sometimes drastic, because there was such confusion in who to turn to for 'supra-community' help. Despite central government representatives and bureaucrat with genuine interest and sympathy in supporting villagers, it seems that villagers had to stay with customary rights because they could not organise popular local representation that could also fight their case genuinely in new legal procedures on offer.

Relevant changes in the legal environment include the improvement of forums for the hearing of cases, clarification over submission of oral and written evidence, and careful attention to preservation of legal information. Continuity of personnel is also intensely important for villagers trying to obtain state assistance or take a case to court. The development of new water codes may be less essential; indeed, the actual complexity of customary law (as opposed to its theoretical form), and its rapid change over time, may make central codification very difficult. Resource management advisers should stop trying to detect if local resource management fits a stereotype, but work from the social and economic realities of the location.

Although a certain amount of physical and social research is essential before work begins, programmes may have to become operational for actual water management practices and tensions to be demonstrated. Villagers also gain more understanding of the impact of the project, which they may often cannot forecast while a project is in a theoretical stage. So, a slow but deliberate start may be necessary in water projects simply for the programme to be taken seriously.

The nature of potential opportunism needs to be considered in the early stages of a project. Careful attention has to be given to the range of local representatives likely to be involved in water management. Special attention must be given to the 'form' of knowledge and agreement on water use, especially the status of verbal and written statements that materialise in a dispute. It is often helpful to study or attend other resource management disputes in the neighbourhood, to understand procedures and loyalties. Properly drawn up agreements and discussion at the investigation, design and implementation stages, involving all villagers and all local representatives are time-consuming but can prevent much individual or family feuding. This can also help limit the damage to the enthusiasm of villagers, and the reputation of individuals, that will be caused by a stream of potential projects which never materialise.

The complexity and confusion of localities like Raymah may appear intimidating, but they should not necessarily be avoided for assistance; nor should they have technological packages superimposed upon them, simply because a development intervention needs to fulfil targets. Thompson and Warburton (1985) comment that understanding only the fixes can bring nasty surprises in implementation; understanding just the obstacles may mean never taking the risk of implementation. The 'obstacle' of local water management can be unpacked to find out the causes of disputes, and solutions developed if an appropriate forum for local water politics is facilitated.

The enthusiasm of villagers for water improvements needs support, especially where initiatives can strengthen and empower communities. It is only through new initiatives and programmes that they can resolve tensions encouraged by new technologies and changing economic circumstances.

In new political, economic and technical circumstances, the individual/community/supra-community interrelationship has to be explored carefully. What seems to be emerging from studies of disputes is that communities can manage their water resources if local institutions have the legitimacy to do so, and if social and economic incentives encourage their performance. Mismanagement and confusion not only occurs where structures are inadequate, but also where communities have no clear, accepted or agreed 'supra-community' institutions to deal with conflict. In an environment characterised by small, disparate water supplies, and limited central government involvement in local affairs or production, community management may offer most potential. However, this potential will be assisted by sympathetic agrarian and local government reform, and sensitive advice and support services to define 'supra-community' roles, rather than specific new water management structures developed at the centre.

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PERSPECTIVES ON THE MIDDLE EAST WATER CRISIS: ANALYSING WATER SCARCITY PROBLEMS IN JORDAN AND ISRAEL

Richard Sexton

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Richard Sexton

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PERSPECTIVES ON THE MIDDLE EAST WATER CRISIS: ANALYSING WATER SCARCITY PROBLEMS IN JORDAN AND ISRAEL

Richard Sexton

1 INTRODUCTION

Water management problems, when related to water scarcity, present major difficulties for analysis, particularly when they involve fully developed water systems reaching the limits of their resource capacity. It is a truism to say that water cannot be studied without reference to the socio-economic context in which water is manipulated. However, while there is agreement that water problems can no longer be viewed simply in technical terms and that water management is now a legitimate sphere of investigation for the social sciences, there is no single, unequivocal and clearly definable approach which firmly anchors water management in socio-economic reality.

It is clear then, that how we define our approach is going to determine how we understand water problems and how we ultimately come to resolve them. It is instructive that in the case of the Middle East, while the physical dimensions of Middle East water crisis are generally known, this knowledge has not helped to identify the solutions needed for resolving the problem. In many cases, the fixation with water as a physical resource has resulted in what can be described as 'supply-side' bias. There is a fear that if analysis moves too far away from water, i.e. becomes too concerned with socio-economic issues, the supposed subject - raw water - will be lost altogether! As a result, the problem of Middle East water scarcity is most often described from the supply-side alone.

Most explanations for the Middle East water crisis hold stubbornly to the view that the situation exists because demand is somehow inelastic and that water shortage is likely to have a dislocating effect on economic development. All too often the main premise of interdisciplinary analysis when looking at Middle East water problems is that the resort to demand-cutting (allocative efficiency improving) measures represents a 'failure' of water policy. However, it is my contention that Middle East water problems faced now, are 'qualitatively' different from those faced in the past. The focus on policy failure, or rather, the focus on the inability of water institutions to augment water supplies may only hinder the eventual transition to what could be described as a 'post-shortage' Middle East water economy.

An alternative approach might be to view water development as a 'demand constituting' process, since demand patterns are as much politically, economically and historically constituted as the evolution of water supply systems. To understand why particular forms of water use have evolved, it is also necessary to examine shifts in economic structure, state formation and the impact of exogenous forces (e.g. world markets in the case of agriculture). In addition, ideological and institutional factors, social structure and politics play a major role in mediating the relationship between water users and the state. How much autonomy the water sector has for making shifts in water allocation is tied to these types of relationships. Of course, such analysis does not imply that we ignore the supply-side altogether, rather the reverse is true; the two need to be integrated.

Acute water scarcity provides an opportunity for rethinking basic approaches to water problems. Water, like all economic resources, is scarce. However, it is rare to find water, in the context of the Middle East, being talked about as if it were an economic resource. There are whole sets of questions concerning water use efficiency which have not been touched upon in the current debate on Middle East water. For example, to what degree are current water use patterns locked into uses where the marginal value of the water is low? What impact has developing economic structure had on water demand? Should we assume that there is a basic incompatibility between demand-decreasing and demand-shifting measures and economic growth? Could modifications in economic structure and trade allow for reduced water demand without being economically restrictive? These questions still await answers.

This paper explores two of the most frequently cited examples of water 'crisis' in the Middle East: Jordan and Israel. Not only are they of interest for the severity of their water problems, they also have the most 'developed' and most 'planned' water economies in the region. It is in the context of managed resource development that crisis has evolved. This paper hopes to challenge some of the prevailing assumptions about the Middle East water crisis, and in doing so present an alternative framework for looking at the Middle East water scarcity problem.

2.1 The 'failure' of Water Policy

Criticism has been levelled at water policy-making in the Middle East for having failed to generate solutions for water shortage problems, particularly given the impending disaster facing Middle East countries when water requirements can no longer be met. In each case, scholarly approaches have tended to reinforce the notion that poor water policy is responsible for water scarcity. This is a view which has taken its most articulate expression in the work of Naff and Matson[1], and Starr and Stoll[2].

These authors see water shortage as disastrous to the region; likely to cause constraints on development, discord between states, and general upheaval. The 'gravity' of the problem is seen to provide the focus for analysis, and with it the weaknesses of resource planning mechanisms. Their response is to see the solution in comprehensive water management programmes and improved technical information. Lack of technical information and lack of communication across planning and decision-making structures is regarded as the 'fault' of the existing water policy and administration. Ideally, coordination around technical considerations provides for 'optimality' in resource allocation. In these accounts, both the problems of water shortage and the means for achieving a solution all lie in water policy, which has both to reform its deficiencies and find new solutions.

This view is actually not that helpful. Policies, however well thought out, can never be entirely separated from the reality in which it operates, and there will always be external constraints on effective policy, even with better information and coordination. Although information and coordination are desirable, neither requirement explains why water policy and planning has been deficient. We need to escape from static concepts like 'failure', and from stereotypes of 'better' policy, and especially the belief in instant substitutability of 'poor' policies by 'better' policies, if we are to obtain more appropriate management.

Supply-side approaches assume that water institutions are (or can become) stable administrations performing an apolitical 'guardianship' role in relation to water resources. However, water institutions are not autonomous entities, existing outside and apart from society and state. Neither do they possess independent rationality, enabling them to formulate 'correct policy'.

2.2 The "Success" of Water Policy

An alternative approach might be to view water policy as having been tremendously successful. Indeed, over the past thirty years or so, water development in the Middle East has largely achieved what it set out to do, namely, to bring about a substantial increase in water supply to agriculture. In the case of Jordan and Israel, expanding water supply was considered the key to a thriving modern agriculture. Water institutions were successful in meeting this challenge. These developments - the integration of water and agricultural planning - could not have taken place unaided, nor were they the result of poor and uncoordinated policy. Contrary to the notion of the 'failure' of water policy; policy more than proved its efficiency. It is only now in retrospect, when faced with a problem of water shortage, that we begin to talk about water policy as if policy has failed. What has been at stake is not so much policy, as policy objectives. If water institutions were established in order to expand water supply, they cannot be blamed for the resulting water shortage problem. If objectives prove contradictory then objectives will not be met.

Although Naff and Matson, and Starr and Stoll propose a number of high-technology solutions for augmenting water supply - desalination, the application of solar energy to water technology, improved irrigation technology, etc - it is clear that no amount of 'fine tuning' and sophistication in water technology can alter what is basically a problem of finite water reserves. Rather, there appears to be a mismatch between problem identification, policy prescription and cure. Policy will undoubtedly fail if the objectives involved are unobtainable. What is required are new policy objectives, not just 'better' policy.

2.3 Scarcity as a Policy Concept

In fact neither seeing water policy as 'success' or 'failure' brings us any closer to recommending changes for water policy when full utilisation is reached. In this context, an important contribution to the discussion lies with the work of Galnoor, 1980. Galnoor has argued that water shortage is not simply the product of 'poor' planning, it instead represents a distinct phase in the development of a water system. The subtlety of the distinction between different types of scarcity determines the planning orientation to be taken. Galnoor argues that: "... there is a difference between scarcity as a supply schedule and 'scarcity' as a physical constraint. This difference dictates the 'orientation' of water policy-making ... scarcity in the first sense means that water is available somewhere in the system ... In the second sense, 'scarcity' is determined by the fixed quantity (of water) that technology can supply within the boundaries of a certain system."[3]

The problem identified is in the nature of the transition in policy - "where previous water policy cannot be continued, a new one cannot be readily formulated."[4] The problem for water policy is that changes in the nature of scarcity pose major cognitive problems for formulating new strategies. The bias of water organisations, and their integration with wider state institutions, blocks the definition of new objectives, new powers and new administrative structures.

When the second condition of physical scarcity is in force, Galnoor recognises that augmentation from unconventional sources, such as desalination, may not necessarily be the answer if each "marginal addition of water supply to the system implies a disproportionately higher cost over benefit, which the society cannot afford."[5] In other words, costs involved in continuing to expand water supply which may be as great, if not greater, than the losses incurred if water was not developed. This means that water management can no longer be simply concerned with supplying water.

If, at inception, water institutions were established to 'engineer' access to water supply, this role has been made redundant. Yet water policy, now geared to a somewhat different objective of maintaining sustainable water systems, places a premium on a new function - allocation, - which also remains their responsibility. Vardi (1980), notes that in the case of Israel: "The peculiarity of the situation is emphasised by the fact that water resource management efforts usually concentrate on finding optimal ways for further development of potentially still available resources rather than on the unpleasant task of optimising curtailments in allocation to one sector in order to satisfy the needs of another one that has been assigned a higher priority."[6]

Indeed, there are a whole series of major questions concerning the functioning and competance of water institutions operating under conditions of acute water shortage. Firstly, can institutions, technically equipped to expand water supply, simply re-package themselves in order to perform this new allocative function? Secondly, optimality on the supply-side is not the same thing as optimality on the demand side, and how can the water sector pursue this in the economic sphere in addition to the technical sphere? A subsidiary question would be - how does the water sector extend its influence to these sectors?

Ultimately, the water issues of the Middle East in the 1990s are not so much concerned with desalination, improved irrigation technology, and the application of solar energy to water technologies, as they are with creating new structures for proportioning water between different end-uses. If we accept Galnoor's schema, then it is clear that scarcity existed as a supply issue when economic priorities were fixed, agriculture was a major priority and the water sector functioned to provide agriculture with water supply. The shift to scarcity as a fixed physical constraint requires a major re-ordering of priorities. It also means re-examining the imputed relationship between expanding water supply and economic well-being. This identification involves the telescoping of a number of complex relationships together, and lies at the heart of the Middle East water dilemma.

3 SQUARING AGRICULTURE WITH WATER SHORTAGE

Our discussion so far has focused on the relationship between the water sector and water shortage, showing how orthodox supply-side approaches, with their focus on water supply and related policy, fail to locate demands within the framework of a broader water economy. The assumption that there are 'only demands to be met' ignores the fact that how demand is demanded, is as important as how supply is supplied. It is evident that if water is to be supplied efficiently then water must also be demanded efficiently.

It is striking that in the accounts of Naff and Matson, and Starr and Stoll, there is no discussion of water allocation, water markets, or of the methods used by different water institutions for allocating water between different end-uses. While it is acknowledged that water is used inefficiently no indication is given to the type and magnitude of the inefficiencies involved. Positions concerning efficiency are most often sublimated to quite different arguments which advocate the introduction of water conserving, water productivity-enhancing technologies. Yet it is clear that achieving technical efficiency is not the same thing as achieving economic efficiency. End-uses can be technically efficient but not economically efficient if their marginal productivity is low. Similarly, if water is not constantly being transferred to end-uses where its marginal value productivity is high, then its use is economically inefficient. What is not discussed is whether it is desirable and economically efficient to allocate water and capital (through advanced technologies) to extremely marginal types of end-use. Should we be talking about new 'hard' technologies for water conservation and efficiency improvement, or augmenting water supply, before having looked at how water is currently being used?

However, if we locate agricultural water use within the broader water economy, we can begin to see a different interpretation of the water problem. Here agriculture is the marginal sector (the sector where its marginal productivity is lowest). Analysis of agrarian strategies demonstrate that it is not water shortage which is the problem; rather it has been the building-in of structural overcapacity in irrigation schemes. Water supplying projects have tended to generate large irrigation infrastructures with a built-in propensity to supply more water than actually required, at least in terms of the volume of production generated by irrigation projects for agricultural markets. Agricultural surpluses of crops grown under irrigation have been the norm rather than the exception. Rather than water shortage, there has been a contrary tendency, involving diminishing marginal productivity in water use in agriculture.

Agrarian strategy has thus played a major role in deciding the parameters of the water shortage problem. Getting the agrarian dimension right is therefore critical to how the water problem is ultimately resolved. Yet, it is the agrarian dimension that has been accorded the lowest priority in the current debate about Middle East water scarcity. In the two sections which follow, we shall explore in greater depth the relationship between water shortage and agriculture with Jordan and Israel as our case studies.

4 WATER SHORTAGE AND AGRICULTURE IN JORDAN

4.1 The Water Problem

Studies since the mid-1970s have predicted water shortage in Jordan. A study conducted by consultants Howard Humphreys, completed in 1977, predicted major shortfalls in water supplies as shown in the assessment in Table 1.

Naff (1985) puts the deficit more conservatively, at between 170 million cubic metres (MCM) to 200 MCM by the year 2000.[7] Estimates by the Future Group (1985) suggest that water requirements stemming from population growth can only be met by sizeable transfers of water from agriculture to domestic and industrial consumption. Even with projected gains in irrigation technical efficiency, there would still be the need for a reduction in irrigated areas in Jordan around the year 2000. 'Worst' case scenarios, assuming high population growth rates, indicate the need for a reduction in Jordan's irrigated area from 440,000 dunums to 290,000 dunums between the year 2000 and 2010 (1 dunum = 0.1 hectare).[8] Even the 'best case' scenario, involving a relatively modest population growth rate assessment assumes the need for a reduction to 330,000 dunums in the area irrigated and a net transfer of 26% of water used in agriculture to domestic and industrial consumption by the year 2010.[9]

Table 1[10] : WATER SUPPLY AND DEMAND, 1975-2002 (million cubic metres per year (MCM))

	1977	1987	2002
Supply			
Potential Resource	760	760	760
Recoverable Resource	610	610	610
Reuse	5	35	75
Total Useable Supply	615	645	685
Demand			
Domestic and Industrial	80	146	289
Irrigation	384	639	694
Total Demand	464	785	983
Surplus/(Deficit)	151	(140)	(298)

It is evident that the water problem can be expressed tangibly in terms of cuts in water supply to agriculture. Although individual figures may be in dispute, the overall picture is clear. Water shortage does imply curtailment in agricultural water use and the net transfer of resources to relatively higher value uses. What is not clear, is how we should set about weighting these large transfers of water from agriculture. Would they, as the conventional wisdom suggests, pose a serious threat to the viability of Jordan's economy, or would they, by unlocking water from marginal uses, lead to feasible economic restructuring and the development of a sustainable water economy?

4.2 Agrarian Priorities and Water Development

It is often assumed, given Jordan's special emphasis on irrigation expansion, that irrigation has been accorded this priority because Jordan is in some sense, an agrarian based society. Certainly, Jordan's largest irrigation scheme, the Jordan Valley Project, has been described as the 'linchpin and litmus test of Jordan's ability to develop a viable economy and a coherent social and economic structure'.[11] Priorities in development in Jordan have been attached to expanding water supply to agriculture and these priorities have largely determined the functions and responsibilities adopted by the water sector. For almost forty years, the water sector has been geared almost exclusively to meeting the needs of the agricultural sector.

The original planning effort for the Jordan Valley Project commenced in 1953 when it was proposed that 'idle and unproductive' land in the Jordan Valley should be turned 'into the richest kind of production.'[12] By 1966 over 117,000 dunums had been brought under irrigation. The size of the irrigated area had increased again to 130,445 dunums by 1975, accounting for 40% of Jordan's total irrigated area.[13] With the completion of the project in 1988-89, the area under irrigation was planned to total 360,000 dunums, an almost threefold increase in the size of the project area since 1975.[14] Today, the Jordan Valley Project accounts for the greater part of all water used in irrigation.

Given the focus on irrigation expansion, and the implicit underlying notion of correlation between expanding water demand schedules and economic growth, that has characterised much development assistance, the development of such a large irrigation project has passed largely without question. Yet, despite major investments in irrigation, agriculture's contribution to the economy has declined steadily. In 1984, it amounted to no more than 8.2% of Jordan's GDP.[15] Nor is agriculture particularly important from a welfare point of view. In Jordan's case it does not sustain large economically marginal, populations. In 1984, it was responsible for the employment of only 7.8% of Jordan's labour force. Ironically, because of labour shortages, 57.6% of those employed in agriculture were foreign workers.[16] Other forms of justification might be found in the form of food self-sufficiency and food security. However, the vast bulk of Jordan's food deficit is comprised of cereals, meat and dairy products, not the fruit and vegetable crops most commonly grown under irrigation in the Jordan Valley.

In exploring how water demand schedules have been constructed in agriculture we face major problems in explaining why it was decided that such large areas of the Jordan Valley should be placed under irrigation. A finer-grained analysis reveals, in retrospect, that many of the decisions made about the size of irrigated areas and the amount of water required, rested on quite arbitrary assumptions about market expansion and the type of cropping patterns that farmers were likely to adopt. Indeed, the ambitious nature of irrigation expansion and the more modest outcomes in terms of what has taken place in the way of agricultural market expansion has resulted in structural overcapacity in the irrigation network. It is this problem which we shall begin to explore now.

4.3 Formulating Water Plans, 1953-1967

The Jordan Valley irrigation project, as initially proposed by the US Economic and Technical Assistance Program (Point IV) and the United Nations Relief and Works Agency (UNRWA) in 1953, was designed to utilise the whole of the Jordan Valley's water reserve to irrigate an area of 461,000 dunums on both sides of the Ghor.[17] The later Baker Harza Report, 1955, commissioned by the Jordanian Government, proposed an even larger project utilising 760 MCM to irrigate 504,200 dunums on both sides of the Ghor to be implemented over a ten year period.[18] In both cases, project planners adopted a 'supply-side' orientation. In other words, their objective was to expand water supply according to what was 'technically' possible given the total physical resource available. Project proposals did not pay too much attention to defining the production possibilities of the areas to be irrigated in relation to markets.

Market assessment and reconnaissance played a minimal role in the early stages of project formulation. The 1954 UNRWA Report noted that marketing considerations were 'taken into account in a rough way when computing cropping patterns'. Neither did the study devote much attention to the future expansion of production in areas devoted to dry farming or to trends in irrigated areas outside the main project areas. However, in 1956 the question of market potential began to be taken seriously by UNRWA, when they realised that fruit and vegetables were promoted as key crops in almost every agricultural development scheme throughout the Middle East.[19] The IBRD (1957) Country Report noted that the: "... full development of minor irrigation sources in the valley will nearly meet the local demand for perishable fruit and vegetable crops. The subsequent development of major irrigation in the valley would therefore yield little increased revenue from such crops."[20]

On the basis of the IBRD assessment, it was plausible that a smaller project might have met all domestic food requirements, of the crops grown under irrigation, whilst utilising less than 10% (75 MCM) of the water supply and less than 20% (100,000 dunums) of the area proposed by Baker-Harza. Significantly, this was what was achieved. The failure to reach agreement over the Maqarin dam (which aimed to provide the bulk of the water required for the larger project), led to a smaller project being implemented. In 1966, 117,000 dunums were under irrigation, an area close to the size suggested by the IBRD.

It is, therefore, of some significance that during the early 1960s, even with the smaller size of the area being developed under irrigation, output kept pace with demand. In trying to summarise Jordan's early experience, it might be concluded that the failure to construct the Maqarin dam saved agriculture from an incipient over-production crisis, although at the time, it was the stalemate over the Maqarin dam which seemed to jeopardise the integrity of Jordan's agricultural planning.

4.4 Market Expansion, Irrigation Expansion, 1973-1990

Irrigation expansion resumed in 1973, following a particularly turbulent period in Jordan's history. A new ambitious irrigation plan emerged to achieve what the earlier pre-war 1967 plans had failed to do, namely, the 'full' development of the irrigable area of the east Jordan Valley (Israel having occupied the western side). For our purposes, it is important to recognise that irrigation expansion was premised on production for export. Market assessment largely assumed a rapid expansion of regional markets, but perhaps as important, Jordan's ability to retain and expand its market share.

There was an opposing view that the expected expansion in market demand could have been met from yield increases alone. Indeed if surpluses were to be avoided, a reduction rather than an expansion of Jordan's total irrigated area (particularly vegetables) was required.[21] However, the optimistic assessment of market demand and supply prevailed, and significant expansions took place in the size of the irrigated area, both inside and outside project areas.

In 1985, a total area of 523,854 dunums was under irrigation, with 276,753 dunums, or 52% of the area accounted for by the Jordan Valley project.[22] This represented a 35.8% expansion in irrigated area over its 1975 extent. Of course, the rapid expansion of irrigation did not itself preclude a reduction in the area under vegetables. However, actual shifts in cropping patterns did lead to a concentration on vegetable production, a trend which has since continued. Despite government research and more than twenty-two different recommendations on cropping patterns for the Jordan Valley between 1953 and 1982, cropping went largely unregulated.[23] In the period 1976 to 1986, vegetable production in the Jordan Valley never averaged less than 69% of the total cropped area, rising to 78% in 1984.[24]

Accordingly, it is possible for agricultural surpluses to exist alongside water shortage. Throughout the 1980s, market prices have been depressed, production surpassing the absorptive capacity of both local and export markets. In the 1984-85 agricultural season prices reached an extremely low level, forcing the introduction of a compulsory cropping pattern. Although attempts have been made to reduce the area under some of the main vegetable crops by as much as 40%, a combination of yield increases and creative crop planning by farmers has sustained production at its pre-cropping pattern levels. Perhaps more worrying for Jordan have been USAID (1988) projections for future surpluses. Even with 'generous' domestic demand assumptions, USAID predict that future surpluses of Jordan's main irrigable vegetables (the quantity available for export) will rise from 36% of total production in 1987, to 55% by 1992.[25] Yet trends in export markets do not support this projection. Data for the period 1979-87 indicates that although vegetable exports peaked in 1984 (after a steady climb over the preceeding 5 years), it is a trend which has since petered out. In 1986, for example, vegetable exports by volume had fallen to 58% of their 1984 high.[26]

Although it is too early to say that Jordan's agricultural exports are in decline, there is no corresponding trend to suggest that if export markets were to expand, Jordan would be party to this market expansion. The Gulf states, which were major importers of Jordan's horticultural crops during the 1970s and early 1980s (due to labour force expansion and the oil boom) have moved to internationalise their markets. Turkey, with its lower labour costs, has proved highly successful in taking-out a large slice of Jordan's market share in Gulf countries. With the construction of Turkey's South East Anatolia irrigation project, which aims to irrigate an area the size of East Germany, Jordan's market is likely to tighten still further.

4.5 Development and Water Supply

Thus much of Jordan's development policy towards agriculture and water has proved inconsistent and sometimes contradictory. Irrigation has been justified from a national development standpoint in terms of the need to feed expanding populations, increase incomes and to provide a suitable agrarian base for a growing economy. However, a deeper examination suggests a certain illogicality behind these positions.

First, from the point of view of the agricultural sector, continually expanding productive capacity through irrigation development is not beneficial unless markets are expanding at the same time. Irrigation expansion - which creates agricultural surpluses and inadvertantly lowers farm prices (below levels possible even with productivity increases) - is wasteful, not only for the national economy, but also for the agricultural sector and the water sector. Furthermore, agricultural surpluses have thrown both agricultural policy and water policy into disarray. While in principle, the water sector should be cutting back on agricultural water supply, the agricultural sector is moving in the opposite direction; trying to find ways of keeping expensively developed irrigated land in production.

In addressing vegetable over-production, quite desperate measures are now being envisaged to tackle the problem. Rather than taking land out of production, consideration is being given to providing incentives to encourage farmers to grow irrigated wheat. Although justifications may be found, for example, improved crop rotation and a reduction in import dependency, economically, the overall impact will be negative. Even if the domestic price of wheat and yield levels were to increase two-fold, the average revenue productivity of land, water and labour used to grow the wheat would rank only 16th in a list of 20 alternative crops being grown in the Jordan Valley. The international price for wheat would have to rise from US$ 128.6 per ton to US$ 257 per ton before Jordan derives any comparative advantage from growing cereals under irrigation.[27] From the water resource angle, the shift is in the wrong direction, crops with low marginal value productivity are being expanded whereas water supply constraints suggest that these crops should be contracting.

Second, we must also recognise that from the point of view of economic structure, Jordan is not an agricultural country. Although the 'supply-side' approach would have us believe that water has been crucial for Jordan's development; macro-economic policies adopted have all tended to contradict this assessment. The aim of using irrigation expansion to enlarge Jordan's agricultural productive capacity by encouraging agricultural exports, has been severely frustrated by fiscal policy. The value of the Jordanian dinar has been kept high (pegged to Special Drawing Rights, the International Monetary Fund's global unit of account), thus eroding Jordan's competitive edge in agricultural exports. Debt service and economic growth have been financed largely by foreign exchange earnings - aid receipts and workers remittances - not by agricultural trade.

If there are any doubts as to the marginality of agriculture in Jordan's overall economy, it is worth just looking at a few indicators. In 1984, Jordan's total commodity export earnings were JD 234.1 million.[28] Export earnings from fruits and vegetables accounted for just 8.5%, or JD 19.7 million of total export earnings.[29] In contrast, remittance earnings in the same year amounted to JD 415 million.[30] A policy which gave preference to agricultural export over remittance earnings would clearly be absurd given that the value of all agricultural output in 1984 amounted to no more than JD 97 million.[31] The assumption that Jordan's agriculture and economy is somehow dependent on water supply and irrigation is evidently at odds with the government's own assessment. A more realistic interpretation is that both agriculture and the broader economy are reliant on the ebb and flow of remittance earnings, and how Jordan ultimately sets out to define its relationship at a broader economic level to the Gulf.

5 WATER SHORTAGE AND AGRICULTURE IN ISRAEL

5.1 The Water Problem

Studies have predicted water shortage in Israel since the mid-1970s. In 1983, estimates suggested that by the year 2000 Israel faces a gross imbalance between supply and demand of 730 MCM per annum (49% of the country's average annual replenishment), although 370 MCM per annum could be made up from re-use options and spill reductions. In 1986, total water use amounted to 1,987 MCM.[32]

In addition, current levels of utilisation have further compounded problems with water quality. In order to stabilise reserves facing degradation, there is a requirement to allocate growing quantities of water for recharge and water quality control purposes. Optimum strategies for 'effective long term protection' against salinity would require a 50% reduction in abstraction from Israel's main coastal plain aquifer. A nitrification alleviating strategy would involve a 50% reduction in fertiliser use and continuous artificial recharge of 25 MCM per annum over a period of ten years.[33] Partial solutions, which would aim to utilise the natural buffering characteristics of aquifers by relocating the centres of recharge and abstraction to more advantageous locations, have so far proved prohibitively expensive.

While the technical dimension of Israel's water shortage problem has been understood and planned for by the water sector, technical knowledge has not been translated into realisable policy. In 1975, planning forecasts by the Water Commission projected a curtailment of the water allocation to the agricultural sector of 35% by 1985.[34] The 1977 estimate by *Tahal* water corporation assumed a reduction of 20% by the year 2,000.[35] Although the estimates vary, there has been a consistent and unavoidable requirement for major reductions in agricultural water use.

5.2 Agrarian Priorities and Water Development

Like Jordan, irrigation expansion in Israel assumed a quite special importance in the early stages of the country's development. Agricultural development plans reflected an underlying continuity from the pre-state period when it was envisaged that the economy of a Jewish state in Palestine would be agrarian based. Although economic and social circumstances changed radically with the formation of the new state, objectives and priorities went largely unchanged.[36] As a consequence, agriculture was the beneficiary of 45%, or more, of the state's Development Budget between 1948 and 1962.[37] Between 1955 and 1961, 77% of gross capital formation in agriculture, water and land reclamation was accounted for by capital sources provided by the state.[38] Rapid expansion in irrigation and water was therefore an inevitable consequence of development priorities defined through the state.

In 1948, only 300,000 dunums were under irrigation, representing 18% of the total cultivated area. From 1948 to 1965, the cultivated area grew by 253% while the area under irrigation grew by 516%. During the 1950-65 period, two-thirds of the increase in cultivated area was being accounted for by increases in the irrigated area. In 1986, the irrigated area was 2,193,000 dunums, or 50% of Israel's total cultivated area.[39]

Between 1948 and 1965, water supply to irrigation increased from 230 MCM to 1,329 MCM (from 15% to 88% of the country's total renewable water stock). Full utilisation was reached in the early 1970s.[40]
By the 1980s water shortage had begun to bite, with agriculture receiving a diminishing share. In 1986, the sector consumed 881 MCM, its share of total water use having fallen to 61%.[41]

Despite the major investments which agriculture received, the model agrarian economy never materialised. Agriculture developed, but not at a pace which kept pace with growth in the economy as a whole. Even during the period of its peak expansion, agriculture was never able to command more than 13.3% of Israel's net domestic product or employ more than 16% of the total labour force.[42] Indeed, during the 1970s and 1980s as the economy continued to deepen, agriculture's position declined relative to the rest of the economy. In 1984, agriculture accounted for 4% of net domestic product and 5.5% of the labour force. It is also estimated that one in three of the labour force are superfluous, with the sector requiring no more than 3% of the total labour force.[43]

Yet, this does not imply that Israel's agriculture has not been successful. In terms of its ability to produce, it has been entirely successful. The domestic market reached saturation in the early 1950s. Shifts were made to export production in the early 1960s. Plans in 1985 assumed that 42% of Israel's total agricultural production would be exported providing 60% of the value added in agriculture.[44] In the same year, two-thirds of Israel's farmers were making a living from export production.[45] Though the quantities exported were considerable, they accounted for just 7.7% of Israel's total exports.[46]

Again, when trying to assess the impact of water scarcity and the curtailment of water supply to agriculture, it is important to take a broader view encompassing the economy as a whole. Similarly, it is important to be clear about the purpose, and the type of externalities involved in keeping large areas irrigated on a permanent basis. In this respect the experience of Israel has been remarkably similar to that of Jordan.

5.3 Building in Structural Overcapacity

One feature that has underlain all attempts to expand irrigation in the Middle East is the belief that it is desirable to irrigate as large an area as possible. Israel is no exception; throughout the 1940s and 1950s, there were major debates about Palestine's water resource potential and how much water could be allocated to the Jewish state from water reserves lying partially within its border. Much of this discussion was motivated by the very dubious assumption that by simply expanding irrigation, it was possible to absorb increasingly large numbers of people into irrigation projects. As a result, when irrigation projects were planned they were planned big.

In the case of Israel, irrigation development proceeded on the basis of a rather optimistic assessment of the area's total water resource potential. Water shortage emerged initially as a product of successive overestimations of water availability. It was assumed that Israel had an average annual replenishment rate of 2,700 MCM per annum, and the irrigation network was designed in relation to this figure. In the period 1948 to 1961, estimates were revised downwards to the figure for average annual replenishment of 1,500 MCM. The water system and irrigation network being constructed had overcapacity, 180% greater than the total water resource available.[47]

Significantly, the new findings concerning Israel's water potential did not preclude the possibility of agricultural surpluses. In the period 1948 to 1953, rapid agricultural expansion gave rise to incipient overproduction in vegetables and fodder crops. This development took place within the first four years of the state's establishment. It is estimated that agriculture's relative prices fell by 23% in the subsequent period, 1954-1961; real incomes had fallen by 10% by 1959, and the total open subsidy received by the sector to close the differential between non-farm and farm income had come to represent 29% of net farm income by 1961.[48]

Both the 1950 Four Year Plan and the 1953 Seven Year Joint Jewish Agency/Ministry of Agriculture Plan had assumed that market constraints would not be a problem. The export sector had remained largely unplanned, since it was assumed that any domestic surpluses could be exported. This proved not to be the case, and the Seven Year Plan was abandoned in 1956. It was not until the early 1960s that attempts were made to reconstitute the sector on the basis of low value staples, citrus, industrial and other export-orientated crops. The shift from vegetables to heavy water-using crops such as cotton and citrus placed an even greater strain on scarce water supplies.

These developments dictated new conditions and constraints. In order to sustain farm incomes without losing productivity, (whilst increasing productivity in water use), the most feasible option was to substitute labour and water with a third production factor - capital, (i.e. improve agriculture's technical efficiency). Throughout the 1970s, the capital intensity of Israeli agriculture increased. One impact was to reduce the quantity of water needed per unit of production. This has allowed for a gradual transfer of water from agriculture to other sectors, but not enough to solve either the water problem or to equalise the marginal output of water in agriculture. A second impact has been a declining capital-output ratio. Improved technical efficiency in water use necessitated a permanent capital allocation for stock renewal. In 1964, depreciation constituted about 53% of the total gross investment in agriculture, by 1970 the ratio had soared to 70%.[49] The debt crisis now afflicting Israel's agriculture suggests that this level of stock renewal cannot be sustained.

Finally, efforts to substitute water with capital have not diminished the two mutually reinforcing pressures working on the water sector; the demand for increased access to water, and access at a lower cost. Water has represented a disguised income subsidy, priced at a nominal value below cost. This has not only increased effective demand for water but has also weakened the relationship between the real cost of water and its marginal product. The Israeli irrigation network, in consequence was designed with structural overcapacity. Not only has there been a propensity to utilise water supply over and above average annual replenishment; its productive capacity has also been responsible for generating price instability and declining profitability.

5.4 Agrarian-Centred Water Institutions

The rapid development of Israel's agriculture could not have taken place without an exemplary performance from the water sector. Although estimates of water potential were greatly exaggerated and problems subsequently emerged in agriculture, these considerations do not detract from the water sector's undoubted achievement. The water sector's ability to meet expanding agricultural water demand arose largely from its institutional structure and the clear identity of interest that existed at policy-making and planning levels between the agricultural sector and the water sector. Such an identity of interest went beyond the bounds of purely formal liaison and coordination.

It is here where Galnoor's distinction between shortage as a supply-schedule and shortage as a physical constraint is important. Water institutions have been successful only in meeting the problem of shortage as a supply-schedule. In the water shortage as a physical constraint phase, water institutions have proved unsuccessful. One explanation lies in the organisational forms adopted. Although water institutions evolved effectively to meet the supply-schedule problem, it is those same organisational structures which now preclude the movement forward to solving the physical shortage problem.

From inception, water planning functions were incorporated within a framework established by the Ministry of Agriculture (MOA). Co-ordination was to be conducted 'in-house.' There was to be no separate Ministry of Natural Resources dictating water resource policy.

This is clearly seen in the provisions of the 1959 Water Law, which made the Water Commissioner responsible to the Minister of Agriculture and a National Water Council. The National Water Council was established to advise the Minister of Agriculture on water affairs,[50] and had at almost every level some form of affiliation with the agricultural sector. The National Water Council had no powers other than to give advice and make recommendations to the Minister of Agriculture. Policy-making and planning was conducted by the public corporation, Tahal 'Water Planning for Israel Ltd." Tahal is controlled by the government which has a 52% stake and the Jewish Agency and the Jewish National fund, each with a 24% stake.[51] The latter two organisations are both concerned with agriculture, the Jewish Agency through settlement activity, the Jewish National Fund through the Israel Land Authority. The Israel Land Authority controls 90% of Israel's Jewish cultivated area.[52] Tahal advises the Minister of Agriculture rather than the Water Commissioner. The final institution in what comprised a polyglot structure of inter-linked institutions was Mekorot, charged with the construction, maintenance and licensing of water infrastructure. The state was represented through the position held by the Minister of Agriculture on the Board of Directors.

We can observe the linkages between water institutions and the agricultural sector in three crucial areas: (1) the predominance of agrarian representation at all levels of water policy formulation, and the centralisation of judicial and water functions within the MOA; (2) interlocking shareholdings which secure the controlling position of agrarian centred institutions; (3) fragmentation and weak linkages between component elements of the water institutions. It is within this framework that the institutions of policy-making and water planning evolved. Water resource development in Israel was a product of planning frames and organisational forms which arose almost entirely within the agricultural sector.

During the past two decades, as the water shortage problem has grown in magnitude, the water sector has been drawn even closer to the institutional framework of agriculture. Galnoor (1980), has observed that there has been a weakening of the long range planning unit, Tahal: "important functions have been transfered to the planning divison of the MOA and to Tahal's traditional rival - Mekorot."[53] Rather than strengthening the autonomy of the water sector, these developments have merely served to strengthen its internal divisons, and increase its dependency on the MOA.

Throughout the 1980s, the water sector has conducted a policy of ad-hoc crisis management. Competition over budgets with the Ministry of Agriculture, and the growing peripheralisation of small farmers has led to confrontation over quota and pricing issues, and a lack of funds for basic development work. Moreover, the water sector has never succeeded in winning for itself, the basic policy instrument required for grappling with water shortage. In 1990, Gidon Zur, the Vice-Water Commissioner acknowledged that: "... the Water Commission doesn't have the authority to dictate the way in which water is used. It can only reduce [the amount of] water."[54]

In practise, the quotas that the Water Commissioner has imposed have been applied stringently only in drought years or and the immediate period after. There has been no sustained effort to use quotas as a policy instrument for building-up water stocks. Similarly, the water sector has no control over water pricing. This has always been determined by the MOA in consultation with the agrarian-dominated National Water Council. The final decision comes from the agrarian-influenced Knesset Water

Committee (government). In 1990, the Water Commissioner announced drastic cuts in water supply of between 13 and 25%. However, the Water Committee was prepared to continue price subsidies amounting to US$ 200 million, despite the expected shortfall of 400 MCM in water supply.[55]

It is perhaps ironic that the only body actively promoting water conservation is the Treasury through its budget cutting activities. Since 1985, the Treasury has intervened on several occasions to bring down water subsidies, aware that it is a cost that the economy as a whole can no longer afford. Yet, pricing, a formal signalling and pricing mechanism has never been developed as a policy instrument by the water sector.[56] Indeed, it is true that the water sector has had very little control on Israel's overall water economy, following the completion of its initial task of expanding water supply to agriculture.

5.5 Emerging Farm Crisis

Water shortage has developed against a background of growing difficulty in the farm sector. Over the past decade, the sector has seen the withdrawal of subsidy support and increased competition in its main European markets. Problems have been compounded by indebtedness, a product of wreckless borrowing practises during the early 1980s, but also linked to sector's expanding requirement for capital to finance stock renewal. Two of its key export branches, citrus and cotton, have experienced market collapse, and a recovery in the forseeable future is most unlikely. Overall, economic conditions for agriculture are likely to deteriorate still further, underpinned by worsening terms of trade. It is probable that if a major contraction in agriculture is not brought on by water shortage, then the contraction will occur all the same, brought on by the deepening agricultural recession. What is not clear is the response of planners and policy-makers, will they sit Canute-like until the crisis overwhelms them, or will they start to square the water and agriculture equation?

The impact of the recession has been felt most acutely in the Moshav cooperative farming sector, where it is estimated that 83% of Moshav have ceased to be economic and 30% are beyond saving.[57] The Kibbutz, the collectivised farming sector, (where only 26% of labour time is actually spent in agriculture), has been adversely affected by the collapse of cotton. In the private sector, it is the citrus growers that have been hit. The net affect has been the abandonment of agriculture and a fall in land prices. In 1987, 8,000 persons, or one-tenth of the total agricultural labour force, left agriculture. Between 1980 and 1990, land prices fell from US$ 6,000 to US$ 1,000 per dunum.[58]

However, farm recession also stems from a process of structural change. The decline in exports has been structural (as have changes internally within Israel's agriculture). Disappointing export performance is linked to a major re-alignment of market forces within the European market, responsible for two-thirds of Israel's total agricultural export.[59] Projections made by Tovias in 1988 predicted a fall of between 8% and 20% in Israel's total fruit and vegetable export to the EC, as a result of competition from Spain, trade diversion and the dumping of production in non-EC markets.[60] The European position has been to encourage Israel to expand its industrial base for export, since it is here that Israel has most to gain from EC enlargement.

6 THE CONCEPTUAL POVERTY OF THE 'SUPPLY-SIDE' APPROACH

The overview presented here indicates that there is more to the Middle East water problem than just water supply. The current emphasis placed on projecting even greater water deficits and expanding water supply is unlikely to solve the Middle East's water problem. Similarly, high-technology options, which aim to improve technical efficiency, will probably have only a marginal contribution to make. At best, these approaches can only postpone water crisis and, in doing so, generate huge costs and inefficiencies. At worst, they will detract and even negate from the central task of restructuring water in agriculture and redirecting water from end-uses with low net incomes per unit used. Even if we assume that further capital-intensive technical efficiency measures were applicable to countries with intensive agriculture, there is no side-stepping the need to improve the marginal value productivity of water. These are the considerations which should legitimately form the core of any agenda on Middle East water scarcity.

Evident also from our account is the degree to which water issues are intimately intertwined with the emergent agrarian crisis in both Jordan and Israel. Indeed, there appears to be an underlying symmetry in how water shortage and production overcapacity problems have evolved. Given this double-edged character to the water crisis, suitable approaches to looking at water problems in the Middle East have not materialised.

Supply-side approaches tend to assume that water institutions are essentially 'prefigurative' and stable, that they relate solely to the task of managing water systems according to some 'intrinsic' interest defined through the water system. From the demand-side, this approach is brought into question when it is realised that water institutions have evolved in order to perform a 'historically specific' task. It is through their 'specificity' of function, i.e. in opening up water supply, they have gained the appearance of autonomy of action. Meeting water supply targets has given water institutions a highly visible profile. However, a major part of water policy decision-making has been carried out de-facto by the agricultural sector. Historically speaking, water institutions in the Middle East have had little jurisdiction over how water demand has been constituted. But how much room is there for cogent responses to water shortage given the constraints faced by water institutions in both Jordan and Israel?

First, it is important to recognise that economic structures are dynamic and not static. The economies of Jordan and Israel have undergone considerable change in recent years. It might be the case that structural change has created more, rather than less room to maneouvre around water shortage. The fallacy of the supply-side approach is that economies are believed to grow in a linear direction, with all economic sectors growing proportionately to each other. An inelastic demand curve is presented as the inevitable result. Thus we also arrive at the idea that "... internal development ... may be seriously constrained."[61] This notion continually overplays the importance of agriculture in economic development, reinforcing the idea that agriculture has some prior claim to water. Similarly, it overplays the actual weight that agrarian interests have, politically, in maintaining the status quo. There is no 'structural imperative' that ensures agrarian interests remain dominant, rather, the converse may be true. The deep and sustained crisis afflicting agriculture in Jordan and Israel suggests that the political base of such interests is being eroded rather than sustained.

Second, while economies in the Middle East are prone to economic crisis, this does not detract from the essential task of restructuring. It would be erroneous to assume that agricultural expansion, or the maintenance of the status quo in agriculture, represents an adequate response to economic crisis. Economic crisis relates to broader economic and political questions and requires a solution, quite independently of anything that might happen in regard to agriculture and water. Projects which aim to allocate scarce capital resources to expanding water supply and improving water use impinge directly both on water and on the economy as a whole. If capital is to be deployed where water-end use economic efficiency is low, then there is an opportunity cost is involved, involving an inefficient capital allocation and a drag on the rest of the economy. Similarly, if restructuring is to take place in agriculture and water, it is also dependent on a shift towards industrial and non-agricultural growth, a shift which is also logical from the viewpoint of the overall economy.

Third, the exercise of cutting back on the least valuable use of water in agriculture, involves only crops which in most cases are already economically marginal. Net value product may be lost to the sector but the overall productivity of the sector will increase. Such a development will have a knock-on effect to other sectors through backward and forward linkages. In viewing the nature of the restructuring process there is a tendency to believe that absolute declines are involved whereas, in fact, what is being discussed are shifts in resource allocations between different economic sectors.

Finally, the mechanisms and policy instruments for achieving such a transfer of resources are not new. They can be found in a number of other policy-making areas. In the context of the European Community's (EC) Common Agricultural Policy (CAP), the problem of farm surpluses is being tackled through a combination of direct income support and 'set-aside' policy. However, such mechanisms are not normally associated with water policy or water institutions. Supply-side approaches have failed to see that the quite exceptional conditions posed by Middle East water scarcity require something other than conventional water management practises. It is in this quite different context that we begin to locate the changes required of water institutions and water policy under conditions of acute physical resource scarcity. Rather than devising new and increasingly sophisticated water plans, the onus is on the formulation of new policy objectives for 'demand-decreasing' and 'demand-shifting' measures and the establishment of new reformed institutions capable of bringing about its delivery.

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