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IRRIGATION MANAGEMENT NETWORK

NEWSLETTER

ODI/IIMI Irrigation Management Network Paper 88/1a June 1988

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 with support from the British Aid programme. 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-oriented research and dissemination. Research findings and the results of practical experience are exchanged through four Networks on Agricultural Administration, 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, Kandy

The International Management Institute (IIMI) is an autonomous, non-profit making international organization 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 is joining ODI in the publication of the Irrigation Management Network papers, to enable these to appear more frequently to an enlarged membership. It has also provided equipment to link ODI's irrigation library into an international irrigation management database centred on IIMI.

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NEWSLETTER

1. THE EVALUATION OF THE NETWORK

We are grateful to all those who took the trouble to fill in and return the evaluation form. We apologise that owing to an error by the despatch firm they were not sent airmail as intended. The results are being analysed by ODA. We shall ourselves also look carefully at your views on the kind of papers that are most interesting, and at your other comments. We hope to publish an analysis of the results in the next Newsletter.

2. REGISTER OF MEMBERS

The publication of this Newsletter has been somewhat delayed because we wished to bring out with it a new edition of the Register of Members. As you will see, this is in a new and more comprehensive format, and we hope you will find it useful. It is planned to enable you to get in touch with members having similar interests in your own country or elsewhere. One possible use would be to facilitate the setting up of a country network, with occasional meetings to discuss either papers in the main Network, or papers circulated on local topics. The lunch-time meetings held at ODI have been very useful in bringing together people of different disciplines, and with insights coming from varied experience.

Enclosed with the Register is a new Registration form, in case you should wish to update your entry. Remember you have the choice either just to fill in sections 1 - 10, in which case only your name and address will be listed in the next Register, or to fill in the complete form, in which case details of your interests and career also appear. If you provide full information, we take this as an indication that you are willing to be contacted by other Network members.

3. NETWORK PAPERS AND DISCUSSION

There are four accompanying papers. Two focus on training, one is on the management systems employed in Morocco, and the last reviews the current research programmes and future plans of IIMI.

Martin Burton has summarised the papers and discussions of the ICID Congress in Morocco on Question 41 on training in paper 88/1b, *Improving Water Management in Developing Countries: a Question of Training.* It is hoped this will enable readers to identify the ICID paper appropriate to their own situation, and to obtain copies from their local National Committee or the central office in New Delhi. Paper 88/1c by Engineer Ferrer and Dr Lucero, *Developing Partnership in the Management of Irrigation Systems,* describes the training methods for staff and farmers used in the Philippines in association with their programme for turning over parts of large irrigation systems to farmer management. It is good to have something on the practical steps that need to be taken if it is decided that farmers should have a greater role in system management, particularly at the tertiary level. The paper shows how necessary it is to have a proper legal framework, and also, how important it is to face the question of what to do with existing staff. The idea of turning over functions to farmers is attractive to governments precisely because it will enable them to save money on recurrent costs such as staff salaries. However, there are legal, social and political difficulties in removing existing low level staff. In the Philippines, sections of the systems can only be fully transferred to farmer management as and when existing ditch-tenders etc retire or can be posted.

Paper 88/1d by Mohamed Ait-Kadi, *Major Features of Moroccan Large-Scale Irrigation Projects,* describes two interesting features of Moroccan irrigation organization. The first is the scheme authority, which has a large amount of autonomy, and a wide range of duties connected with irrigation and agricultural development. Payments made by the farmers for operation and maintenance stay with the authority. The second is the layout. The development of a large irrigation project is preceded by a land consolidation programme, since many farmers have small and scattered plots. There may also be an agrarian reform programme, where large estates are divided into smaller plots. Except in the latter case, the layout accommodates different sizes in ownership (as opposed to the standard sized plots common in some new settlement schemes) and farmers retain full ownership rights, except for a ban on division by inheritance beneath a certain minimum size. The layout also accommodates the use of machinery over large blocks having the same crop, since the farmers' holdings are arranged in strips across each of the crop rotation units. The extent to which farmers use this facility varies. Some schemes use sprinkler irrigation; Ait-Kadi describes both the advantages and the problems. There is a complementary article in the February 1988 issue of *Farmer Managed Irrigation Systems Newsletter*, available from IIMI. This describes the approach to new projects which cover land on which there are existing farmer-managed irrigation systems. The present policy is to deliver an improved water supply to the head of these systems, but to leave the existing institution as intact as possible. This avoids the need to disturb land and water rights.

It is perhaps worth emphasising that the Moroccan authorities take time and trouble over the land consolidation programme, to ensure it has farmers' understanding and consent. This is a slow process in a country which has several types of tenure, including traditional tribal forms. It may take more than 5 years. It is the responsibility of the local political authority, which is represented on the Board of each irrigation scheme. In the 1960s the investigations were rushed, which led to conflicts and long delays in bringing the land back into production. (This was described in an earlier Network Paper, 7b, 1983, by David Seddon, which is still available.)

The final paper, 88/1e, *Strategy Development in IIMI*, is by Roberto Lenton, Director-General of the International Management Institute. Readers will find it useful for its definition of irrigation management, interesting for its review of IIMI's achievements and plans, and stimulating for the description of the process by which IIMI is arriving at a strategy plan based on defining its comparative advantages and the priority areas of work. In the latter it gives an example of good management useful to any institution that has arrived at the conclusion that its resources do not match its agenda. Since many agencies responsible for irrigation find themselves in this position, it may be worthwhile for them to set in motion a period of reflection so as to define the direction in which they want to move in the next five to ten years, so that the incremental changes that may be all that are possible are all tending in the right direction. In IIMI's case the discussion of strategy involved its staff, its clients and its partners.

The April 1988 Issue of the *IIMI Review* gives further details on some of IIMI's current programmes, including a methodology for measuring field-level water adequacy for rice and assessing the impact of shortages on yields, a programme on crop diversification is rice systems, and a video documentary on farmer managed irrigation in Nepal. Write directly to IIMI for further details.

4. NEWS FROM NETWORKERS

The Water Resources, Development and Management Service, Land and Water Division, FAO, Rome 00100, Italy, has a new programme *Water for Agriculture Technology Transfer System (WATTS)*. While it will ultimately cover all fields of water development related to agriculture, it will begin with irrigation and drainage. The proposed system is based on modular units of technology. These can be of different levels of sophistication corresponding to different levels of technological environment with other dimensions for economic and social factors. These last are still at the research stage. The modules may take the form of technical guidance manuals, standardized blueprints, computer software, catalogues of instruments, etc. The aim is not to replace consultants and other forms of technology transfer but to complement and assist them. An international group of experts which is advising on the introduction of this system has recently met at the University of Perugia in Italy and adopted several recommendations on its development and initiation. Those interested in participation should write either to the headquarters address given above, or to the Land and Water Officer at the Regional FAO offices in Bangkok, Thailand or Accra, Ghana.

M Cernea has written World Bank Technical Paper 80, *Involuntary Resettlement in Development Projects*, World Bank 1988. As this Paper states, resettlement difficulties and costs have been frequently underestimated, with bad consequences for those who have been displaced by dams and other new social infrastructure. This document presents the basic guidelines and procedures for World Bank-financed projects that involve involuntary resettlement. There are annexes with working tools for planning and monitoring, including checklists, work sheets and pro-forma tables, etc. The Bank issued an internal statement to staff on this subject in 1980; the present publication is a result of evaluating six years of experience since then. It is an essential document for all planners concerned with schemes that may involve the trauma of resettlement, which has to be regarded as a human as well as an environmental problem.

A recent example of the underestimate of costs and difficulties of resettlement, when there was inadequate prior planning fo this element, is in *Evaluation of the Victoria Dam Project in Sri Lanka*, EV 392, available from Evaluation Dept, Overseas Development Administration, Eland House, London SW1E 5DH, price £9.15.

Options and Investment Priorities in Irrigation Development, by Jose Olivares, *World Bank/UNDP Inter-Regional Report INT/82/001*, 1987, is the Final Report of a long study by the Agricultural and Rural Development Department of the Bank. The objective was to evolve a methodology for identifying relatively quickly the best irrigation projects, large or small, new or for rehabilitation, in a given country, without the expense of a water master plan which may cost more than a million dollars, and take 3 or 4 years and which does not always provide better or more relevant information than a shorter approach. The methodology used is in fact a prerequisite of an in-depth study, since it involved the collection of all available existing data in order to rank the areas of ignorance with reference to their importance to the objective of the study. The steps were: data acquisition; data homogenization; resources balances; performance assessment; ranking. It is worth commenting on two of these. Data homogenization related not only to recomputing prices to a similar standard, but included the recalculation of yields, cropping intensities and build-up periods if, as so often, the original assumptions were found to be unrealistic. Similarly, quantification of physical project features were checked for unwarranted differences. Performance assessment measured benefits by national objectives. In the first set of five countries the internal rate of return was used to measure contribution to the national economy; in the second set the net present worth was the preferred indicator. However, it was recognised that governments also have other objectives; these varied in different countries and included things such as food security, employment creation, saving of foreign exchange, etc. Indicators included value added per hectare; per m^3 water; employment generated per ha, etc. The report discusses the different ranking methods used. The methodology was then tested in ten countries: Morocco, Peru, Thailand, Mali, Sudan, Botswana, Zambia, Zimbabwe, Kenya, and Orissa, India. The results for each country are summarised; the full reports are with the government concerned. The methodology was found to work in most cases, but for various reasons least well in Peru and Thailand.

It is worth noting that Annex 3 is a valuable discussion of "The ex ante assessment of the Health Impacts of Irrigation Projects".

The ISPAN Consortium have produced a brochure outlining their services. ISPAN is a consortium of 8 US consulting groups, universities and other organisations, sponsored by USAID, and collaborating in providing technical, social, institutional and economic analysis, resource assessment and planning, program and project design and implementation, etc. Their area of interest is Asia and the Middle East - Requests for ISPAN services must come through the local USAID Mission or Bureau, but general information is available from ISPAN Technical Support Centre, Room 1001, 1611 North Kent Street, Arlington, Va 22209-2111, USA.

The Centre of Excellence in Water Resource Engineering, University of Engineering & Technology, Lahore 54890, has been conducting a study on conjunctive water use with traditional flood irrigation in an area of Baluchistan. They are particularly trying to identify workable social arrangements for the pumps.

5. NEWS OF AFRICAN IRRIGATION

a. Recent conferences

Two useful conferences have been held recently which brought together irrigation professionals from both francophone and anglophone sub-saharan Africa. One was held in Nairobi in January and was organized by USAID as the culmination of two related programmes. The first of these was a series of studies, based mainly on existing sources, which have resulted in the *African Irrigation Overview*, WMS Report 37, December 1987, available from Utah State University, Agricultural and Irrigation Engineering, Logan, Utah 84322-4105, USA. It is by Jon R Moris (who is now at ODI) and Derek Thom, with chapters by Donald S Humpal, Linden Vincent, Mary Tiffen and Thomas M Zalla. Earlier drafts have been available for some time, but the final volume contains new chapters and many snapshot case studies. One of the policy conclusions is that "Irrigation in sub-Saharan Africa is .... a demanding, risky and expensive option". Nevertheless, it is an option that many countries feel they have to take, though they would be well advised firstly to explore thoroughly the possibilities of expanding rain fed production and secondly of exploiting natural wetlands and of using various partial control methods. The range of the study is indicated by its chapter heads: Hydrological environments; Settings and schemes (case-studies); Technical difficulties (loss of storage dams, inoperative pumps, weed infestation of fields and canals, etc); Agronomy and irrigation (particularly detailed on rice); Socio-economic issues; Land tenure issues; Irrigation project economics; Irrigation management; Implications for donors.

The second series of papers considered at the Forum were case studies of particular schemes or situations, using a multidisciplinary diagnostic approach, carried out jointly by a US and national team. While intended partly as a training exercise, the studies were often full of insight, and were presented by participants at the workshop. Particularly interesting were studies of farmers' methods of wetland development in Rwanda and small pump schemes in Niger. It was noticeable that though the difficulty and expense of irrigation were recognised, (summarised by Ahmadou Soumaila, Director General of ONAHA, Niger) most African professionals agree with Chris Osoro, Head of the Irrigation and Drainage Branch, Ministry of Agriculture, Kenya, that irrigation is important for food security, particularly in view of the droughts and unpredictable climatic variations from which many parts of Africa have suffered for the last 15 years. It was also apparent that most were also in agreement with him that there was a need to shift to relatively low cost farmer managed projects. Migot-Adholla, now at the World Bank, thought, however, that the ultimate answer to Africa's food problem lay in improvements to rainfed farming; until the technologies for this were developed irrigation had a role. The Forum concluded with a series of group meetings which produced some clear general recommendations for African countries. These will be found in the proceedings published as WMS Report 86, available from Utah State University, address already given. Attention was given particularly to the need for financial analysis at different levels, and to energy and health problems. Synopses of the country studies from Zimbabwe, Rwanda and Niger are included.

Some of the difficulties in African irrigation were later illustrated on a visit to Mwea, long known as one of the most economically successful Kenyan schemes, where payments from farmers used more than to cover O&M costs. This position changed when the project authorities made several attempts to introduce double cropping of rice. This proved uneconomic, for several reasons. It required double the inputs, but did not double output, since the second crop was affected by colder weather. Bird damage was severe, and other pests also built up. Land preparation had to be done on wet paddy, with machinery breakdowns. There was no longer an adequate break period for canal and structure maintenance. Researchers are now looking for rice varieties that will alleviate some of these problems and also meet consumer demand for good taste. Meanwhile, Mwea has reverted to one crop per year.

The second workshop was held at Harare in April 1988, organized by CTA and ILRI. Again, this followed a sequence of work, starting from evaluations of EDF funded projects carried out by ILRI, and the development of *Proposals for Basic Principles in the field of Agricultural Irrigation Operations*, at a workshop of ACP-EEC experts held at Antanarivo, Madagascar, in May 1986. The Workshop was opened by the Minister of Energy and Water Resources and closed by the Deputy Minister of Agriculture. Papers given consisted of two kinds: Case-studies or country studies, which often frankly stated problems encountered and provoked good discussion of approaches tried in different countries; and overview papers on particular themes. The organisers had focussed attention on socio-cultural aspects, financial aspects, scheme management and links with rain-fed agriculture, though the last evoked least attention. Tenure-related issues arose frequently, for example in the Nigerian paper by Wabi, the Niger paper by Abdou Chaibou and the Sudan paper by Ahmed. Chaibou's paper also showed that Niger has gone much further in the process of handing management over to farmers' co-operatives than most other African countries. An interesting paper by Nkuba compared the results of two projects in Tanzania, the one based on high technology engineering aiming at a rapid transformation of the farm economy almost regardless of the project surroundings, and the second based on gradual improvement of existing irrigation practices, without aiming at engineering excellence. Rukuni discussed farm income and production efficiency in relation to size of plot, with Zimbabwean examples. Overview papers included approaches to improving rainfed agriculture (Reynier and Forest), user participation in planning and management (Belloncle), an overview of the evaluation results in Africa (Kortenhorst, Sprey and Steekelenberg); an overview of the results of evaluations world-wide, and particular consideration of the economic and financial returns (Tiffen).

As at the Nairobi conference, there was a strong feeling amongst many participants that irrigation had sometimes to be undertaken for social reasons, as the best way to keep people in productive employment and self-sufficient in food, and therefore, it had to be considered as an alternative to drought-relief palliatives, even if it involved high capital costs and continuing subsidies. On the other hand it was also recognised that African governments most often do not have the resources to subsidise operation and maintenance, and that ways must be found to reduce capital costs, and to increase incentives for participation and self-help. Simon Pazvakavamba gave the example of new rural planning methods in Zimbabwe, where line Ministries now have to consult with Village, Ward and District Development Committees, and to carry out preliminary investigations with the help of the local community. This is helping to produce much more realistic planning, taking advantage of local knowledge and institutions. It also ensured that projects that do not have local support do not get implemented. The role of women generated lively discussion; it was apparent different countries have different social traditions!

At the Nairobi conference there was a discussion of the need for a Network of African irrigation professionals, and a forum for the publication of papers and the interchange of ideas and experience. At both Harare and Nairobi it was also felt there was a need to learn more about Asian experience in irrigation. The problem is that there are two main professional languages involved, and a language barrier to communication. However, discussions are in process about how the ODI-IIMI Network might give more attention to Africa, and be available in French.

The Proceedings of the Harare conference, including all papers presented, will be sent to participants. A few copies will be available for other interested persons. There will be a summary of the conclusions and recommendations in English and French, which will be widely available, and which is expected to be ready in November. For further information contact PNG van Steekelenberg at ILRI, Staringgebouw, 11 Marijkeweg, 6709 PE Wageningen, The Netherlands.

b. Research in Africa

Since 1984 several institutions have been co-operating in studies concentrating around one minor canal on the Gezira scheme, in order to understand better the interactions between the hydrological, agricultural and human aspects. Two interim reports have recently come out. The first, by MRH Francis and RD Hilton, (OD 93, October 1987, available either from Hydraulics Research, Wallingford OX10 8BA, England or from the Hydraulic Research Station, Wad Medani, Sudan), reports on a collaborative study by the two institutions. The work included a canal survey, measurement of the releases into the minor and from the minor to the fields, and a comparison of irrigation water deliveries with crop water requirements. It shows how far the canal bed is from its design condition, and also, that it would not be sufficient to restore it to its original condition in the rehabilitation programme since the beds of the channels taking off from it have also risen. There were only small differences between day and night off take. The condition of most of the structures in any case make it impossible to operate night storage in the minor according to the book.

Nevertheless, there is a very close match between off take and crop water requirements, except in the final section of the canal, where supplies were deficient. Given the state of the minor canal bed and the structures, this is a remarkable achievement. The second study, by Abdulahi Osman El-Tom and Nur El-Dayem Osman, FERD, University of Gezira, Wad Medani, Sudan, gives some information on how this is achieved. Given the breakdown of both the structures and the communications systems, it requires careful watering techniques, altered according to the stage of crop growth and the conditions in the field, informal co-operation and pressures between the farmers and the low-level staff (not excluding bribes and some violence) and some deliberate blindness on the part of those above. By one means or another, the water as required is got to most of the fields. However, as also reported by an earlier study by AM Ahmed and M Tiffen (Report OD 76, 1986, available from Hydraulics Research, Wallingford, or ODI, or Hydraulics Research, Wad Medani), *provided that* the canal was properly maintained, and their requests could go by normal channels and be met, the majority of farmers would prefer the strict delivery of water by the book. The series of studies is continuing with Omar Elawad of Hydraulics Research, Wad Medani now pursuing a PhD at the University of Newcastle, and Kheiry Ishaag of the Sudan Gezira Board writing up a related farm management study at the University of Reading.

FAO have produced a report on Irrigated Areas in Africa - Extent and **Distribution.** It lists and maps known irrigated areas and schemes. FAO will update as further information is received. Contact Land and Water Development Division, FAO, Rome 00100, Italy.

Some recent research studies in Africa carried out by the USAID Water Management Synthesis Projects are listed below. UT indicates Utah State University, Logan, UT, USA, and COR for Cornell University, Ithaca, NY, USA. They have been grouped by the continent to which they relate.

Research on irrigation in Africa: Papers presented at the Forum on Irrigation Systems Research and Applications, Cornell University, 13-15 May 1986, by Lynch, B D, Ssennyonga, J W, Rukuni, M, Koita, T, Bernsten, R, Horst, L Report 63, 1987 (UT). Country studies include Kenya, Mauritania and Zimbabwe.

Irrigation REHAB: Africa Version Users' Manual, by Sikkens, R, Johnson, R, Oaks, R L, Steenhuis, T S. Report 64, 1987 (COR). This is a computer game for use in training. It requires an IBM compatible system and a colour monitor. The original version was reviewed in Newsletter 86/3a.

Design Guidance for Shebelli Water Management project, by Keller, J, Weaver, T F, Mayo, J S. Report 49, 1986 (UT). Somalia.

6. NEW PUBLICATIONS ON GENERAL ISSUES, OR ON ASIAN AND LATIN AMERICAN IRRIGATION

a. IIMI library holdings on irrigation management

A new bibliography entitled *IMIN Bibliography* on irrigation management and related technologies extracted from the Irrigation Management Information Network (IMIN) database has been published. It is a collection of material available at IIMI headquarters and Indonesia office, and at the Overseas Development Institute library. This lists published works, unpublished manuscripts, theses, periodical articles etc, that deal with the subject of irrigation management worldwide. Items are arranged alphabetically by author and title under broad subject categories. It is enhanced by author, geographical, keyword and title indexes for easy reference. Each entry has location codes indicating where the item is available.

The first volume covering 1986 has been published; the quantity printed is limited. It will be distributed free or on exchange by written request. Apply to Ramya de Silve, Library and Documentation Service, International Irrigation Management Institute, Digana village, via Kandy, Sri Lanka.

b. Books

Some important books have recently come out. First to be mentioned is *Improvement in Irrigation Management with special reference to Developing Countries*, State of the Art No 4, edited by K K Framji, available from the ICID, 48 Nyaya Marg, Chanakyapuri, New Delhi, 110 021, India, for $20. ICID is to be congratulated on much better print and presentation than in some previous publications, though one could have wished for abstracts in both English and French. The book can be recommended both as a reference book for practitioners and as a text book for training courses. It opens with a chapter by Mary Tiffen describing the advantages and disadvantages of different types of management system. Jerry Schaack writes on optimum procedures for operation and maintenance, deriving from USBR experience and practice, but indicating how the principles can be adapted to different circumstances. He emphasises the importance of involving those responsible for O and M in the planning phases, the importance of an adequate budget and proper costing based on actual costs in projects with good maintenance. A series of Appendices illustrate USBR's own standards for such thing as equipment needs for different sizes of scheme. This is obviously specific to US circumstances, and would be quite different in a country where labour is cheaper and machinery more expensive. Abernethy concentrates on the objectives of water management and methods of measuring achievement, related to the 4 different levels in a system, taking the objectives of adequacy, equity and timeliness in relation to crop production. Pereira takes a different view point in looking at the relationships between water resource planning and irrigation planning; his objective of optimising farm incomes leads to a strong emphasis on the role of farmers in system management. Small discusses the important effects of irrigation financing policies. Delavalle looks at criteria for choosing between different types of sprinkler system (in French). Country studies include the USSR, China, Taiwan, Morocco and India (Maharashtra).

K C Nobe and R K Sampath are the editors of a collection of papers entitled *Irrigation Management in Developing Countries: Current Issues and Approaches.* Many topics are covered, including on-farm research, water scheduling, gravity flow irrigation management, water pricing strategies, salinity and waterlogging, communication and technology transfer, interdisciplinary approaches to irrigation management, institutional constraints, and farmer involvement in management. Each topic is covered in reasonable detail, and the book would make a useful handbook for reference to the current issues in many aspects of irrigation management, or a comprehensive source for seminar/discussion material. It also serves as a good introduction at a high level to current irrigation management thinking. It is published by Westview Press, Boulder, Colorado, USA and the price, £36.50 in the UK, is its main disadvantage.

c. Reports

Research Needs in Third World Irrigation, edited by Abernethy and Pearce, is the proceedings of a colloquium on this subject in 1987, and is available from Hydraulics Research, Wallingford, Oxon, UK. In addition to a listing of the priority areas discussed there are some valuable individual contributions. Although the Colloquium took into consideration Britain's comparative advantage in certain research spheres in prioritising topics, researchers elsewhere would find it a valuable source of ideas. Hydraulics Research have also published for the British Section of ICID the 1988 issue of the *United Kingdom Register of Research on Irrigation, Drainage and Flood Control, 1988.* It costs £18.50 but a few copies will be made available free of charge to institutions in developing countries. Write to the address above.

The Proceedings of a *Seminar on Rehabilitation of Irrigation Schemes* organised by the British Section of ICID in March 1987 are now available from the Institute of Civil Engineers, Great George St, London SW1P 3AA. The China Water Resources and Electric Power Press, 6 Sanlihe Road, Beijing 100044, China have produced an illustrated report on *Irrigation and Drainage in China* which is a good general review.

The Water Resources Environment Institute, Khonkhaen University, NE Thailand has published *Managing Weirs in Small Watersheds: Research issues in North East Thailand*, by B Bruns and S Sethaputra. It discusses the situation where there are many small weirs on a single stream, requiring some co-operation between villages. Each weir also serves many purposes, and therefore has different groups of users. Water is relatively plentiful, though variable and the small systems are managed informally or through village authorities rather than by formal water user associations. The Institute has also republished *Lessons from the KKU-NZ Weirs*, its favourable evaluation of the KKU-NZ village weir programme which was described in ODI Network paper 9e, 1984.

Bertin Martens is the author of *Nepal Special Public Works Programmes: Modelling the Impact of Irrigation Projects*, World Employment Programme Research Working Paper, 1988, available from the International Labour Office, Geneva, Switzerland. He has produced a simple Social Accounting Matrix to study the impact of a medium scale hill irrigation project in Nepal - It is interesting since it quantifies the secondary effects which people often claim as a benefit of irrigation, showing for example the employment creating effect of the investments and increased consumption of the irrigators. These effects are felt both within the village and in the wider regional and local economy. The model is useful because it enables testing for the effect of different water charging policies - in one scenario all farmers pay charges proportional to area irrigated. In the second scenario, only the large farmers pay the full maintenance charge. The result is to decrease income inequality within the village, but through the decrease in investment by richer farmers, to cause the loss of 500 jobs elsewhere in Nepal. It is a neat illustration of the danger of trying to cure social problems through a single irrigation project; a project is interwoven with the rest of the economy, and social problems have to be tackled by national policies.

Ian Carruthers commented that planners should beware of using the undoubted secondary effects of irrigation to justify a project, since secondary effects will arise from many other types of successful projects and all should be assessed on an equal basis. Martens can be contacted at 12 Molenstreet, B-3200 Kessello, Belgium.

Reviews of pump irrigation in Bangladesh continue: Mohammed Abdul Quasem has written on the *Financial Return of Irrigation Equipment to Owners and Users: the Case of Shallow Tubewells in Bangladesh*, 1981-1985, available from the CHR Michelsen Institutt, DERAP, Fanoftv.38, N-5036 Fantoft, Norway.

Water Management Synthesis II Project Reports

The 69th WMS report consists of five volumes. The first, *Designing Local Organisations for Reconciling Supply and Demand* by David M. Freeman, looks at the critical issues involved in planning effective farmer irrigator groups. Freeman identifies four critical factors: firstly that the primary accountability of the programme staff is towards the people rather than the implementing organisation; secondly that staff should be recruited locally to avoid clashes between local people and "cosmopolite" outsiders; thirdly that the water share distribution system should be carefully designed to avoid head/tail distinctions, and to link water delivery strictly to payment of specified obligations, and finally that the organisation of maintenance activities should be satisfactory. The other four volumes follow up this framework by looking at case studies from Pakistan, Thailand, India and Sri Lanka. The report is available from WMS II Project, University Services Center, Colorado State University, Fort Collins, CO 80523 USA, at $30 (including postage).

Cornell University has concentrated on small scale, farmer managed irrigation systems. *Other Channels: Improving Public Policies and Programmes for Small-scale Irrigation Development in Asia* by E Walter Coward Jnr, Robert L Johnson and Michael F Walter of the Irrigation Studies Group at Cornell aims to "assemble the best thinking" on issues relating to small command, scattered irrigation systems. The authors define small schemes as those which are managed on a small scale, rather than according to firmly prescribed rules. They discuss the importance of achieving the right mix of government and local control, and suggest that if the balance is not quite right, it would be better to over-emphasise the role of the farmers than that of the government. However, without government input, an entirely farmer-managed scheme is seen as likely to suffer a lack of technical and financial support, and to have difficulties obtaining assistance when necessary without the risk of losing the institutional set up which they have devised.

The second substantial paper is *Improving Performance of Irrigation Bureaucracies: Suggestions for Systematic Analysis and Agency Recommendations* by Norman Uphoff, with P Ramamurthy and R Steiner. It examines a large number of issues which could affect the quality of a bureaucratic irrigation management system. It makes the distinction between the objectives of optimization and maximization, the latter being seen as more flexible, and more likely to include the intangible social aspects. They distinguish administration (which is routine in nature) and management (which can be flexible and responsive). They consider four aspects of an effective farmers' organisation. These are the locus of authority, the extent of structuring of activities, and the accountability and the responsiveness of the leadership. The first two of these are seen as critical, in that their solution should avoid any extreme position, whereas the latter are seen as factors which are too often forgotten. The paper also discusses the nature of leadership, both institutional and professional. There are four short chapters by other authors, including one in which Robert Chambers discusses his by now well known ideas on the "new professionalism" with reference to irrigation management.

The other two papers are less substantial, but nonetheless interesting contributions to the field. *Local Resource Mobilization and Government Intervention in Hill Irrigation Systems in Nepal* by Ujjwal Pradhan and *Local Resource Mobilization and Peruvian Government Intervention in Small Highland Irrigation Systems* by Barbara Deutsch Lynch are both case studies which explore the nature of farmer participation in a particular area. The Peruvian study shows how local socio-economic imbalances can discourage or alienate farmers from an irrigation project, thus detracting from the quality of farmer management possible. Social heterogeneity is identified as one of the main factors inhibiting participation. In the Nepal study, two case studies are described which illustrate the dynamics of local resource mobilization, and explore how farmer involvement might be encouraged. Awareness of existing systems and social organisation are two factors which affect participation, and it is suggested that careful attention to farmers' land rights and the successful mobilization of resources are strongly linked.

7. CONFERENCES

The first announcement has been made of the Asian Regional *Symposium on Modernization and Rehabilitation of Irrigation and Drainage Schemes.* It will be held at the Development Academy of the Philippines from 13 - 15 Feb 1989, and is organised by the National Irrigation Association, Manila, and Hydraulics Research, Wallingford, UK. The conference is intended to look at the whole process of rehabilitation and modernization, including policy, planning, design, and evaluation. The organizers anticipate a multidisciplinary approach, with contributions from engineers, scientists, research workers and planners. Any one interested should write to: Mrs Ma. Ines Pinat Bagadion, Organising Secretary, National Irrigation

Administration, Government Building, Epifanio delos Santos Avenue, Quezon City, The Philippines, Telex: 42802 (NIA PM).

A *Symposium on Land Drainage for Salinity Control in Arid and Semi-Arid Regions* will be held in Cairo, Egypt, 26 February to 3 March 1990. Contact Drainage Research Institute, Irrigation Building, 13 Giza Street, El Giza, Cairo, Egypt, or ILRI, PO Box 45, 6700 AA Wageningen, The Netherlands.

FAO have published the conclusions and recommendations of their *Expert Consultation on Wadi Development* held in December 1987 at Aden, PDR Yemen. A follow up meeting took place in April 1988 in Morocco. The meetings look at the many problems of modernising traditional spate irrigation systems. The replacement of traditional temporary dams can be very expensive; at the same time the traditional system is already changing and itself becoming more expensive to maintain since the communities are hiring earth-moving equipment for the work. Yields are necessarily low. The spates play an important part in replenishing groundwater, and the exploitation of groundwater is becoming more important. For further information contact Martin Smith, Technical Officer (water Management), Land and Water Development Division, FAO, 00100 Rome, Italy.

7. TRAINING COURSES

CEFIGRE, International Training Centre for Water Resources Management, Sophia Antipolis, BP 13, 06561 Valbonne Cedex, France. 14 November - 16 December 1988: *Small Irrigation Schemes* (all in French). It also has courses, in French and English, on environmental issues in water resource development. Write to them for further details.

Colorado Institute for Irrigation Management, Colorado State University, Fort Collins, Co 80523, USA. 26 September - 14 October 1988: *Monitoring, Evaluation Feedback and Management of Irrigated Agricultural Systems.* 17 October - 4 November 1988: *Development and Management of Training in Irrigated Agricultural Systems.* 7 - 25 November 1988: *Water Users' Associations in Irrigation Management.* 28 November - 16 december 1988: *Irrigation Systems Rehabilitation.*

International Irrigation Center, Utah State University, Logan, UT 84322-8305, USA. 28 August - 17 September 1988: International Course on Farmer Participation and Irrigation Organisation in English and Spanish. 2 October - 12 November 1988: *International Course on Operation, Maintenance and Management of Irrigation Delivery Systems* in English and Spanish. 4 - 17 December 1988: *Workshop on Policy, Planning and Strategies for Irrigated Agriculture.*

Centre of Excellence in Water Resources Engineering, University of Engineering and Technology, Lahore 54890, Pakistan. 3 - 17 September 1988: *Short Course on Remote Sensing and its Applications.*

Department of Agricultural Economics, Wye College, University of London, Ashford, Kent TN25 5AH. October - December 1988: *Micro-Computers for Agricultural Development.*

8. JOURNALS

Irrigation and Drainage Systems, 2/1/1988, contains several papers from the Kandy Symposium held in 1987. One of the interesting papers, by Beadle, Burton, Smout and Snell, takes up themes mentioned frequently in our Network, in illustrating how engineering institutional and social requirements were integrated into a rehabilitation design for the Chandra scheme in Nepal. The result should have been a system, designed in consultation with the farmers, and taking account of the limitations on government staff, which was initially expensive, but which should be cheap to operate. This adversely affected the internal rate of return. I am told that the project was not taken up by Asian Development Bank, and that the Nepal Government then went ahead on its own, not using the prepared design. The Water and Energy Commission Secretariat in Nepal is monitoring agricultural and water delivery aspects of several projects in Nepal which have used different design principles. It is to be hoped that researchers in Nepal will eventually be able to do a comparative study of the operational effects of different designs.

The *International Journal of Water Resources*, March 1988, is devoted to water resource development in Japan. An article by Okamoto, Satoh and Hirota traces the development of rice irrigation, and then describes the inter-relationships between engineers responsible for planning and design of major projects, and the farmers irrigation associations, known as Land Improvement Districts, which are responsible for their administration, operation and maintenance. The latter is in turn divided between the LID central office for the large facilities, and rural communities of farmers for smaller canals and ditches. While the government may subsidize capital costs, the LID must meet its own O and M costs, typically by requiring farmers to pay the equivalent to the price of .25 tons of paddy per hectare irrigated.

Wamana April 1988 is devoted to the issue of Command Area Development. A reaction in the early 1970's to the realisation that there was a large gap between the area that potentially could be irrigated and the area that actually was irrigated was the establishment of Command Area Development Authorities with a wide mandate to promote agricultural development. In fact in most states CADAs have come to concentrate on the field conveyance system, with items such as land consolidation, and roads, being dropped early on, and land levelling also dropping out. There were problems both in establishing water users associations, and in getting farmers to pay for programmes of work about which they had not been consulted. There was also resentment by other government departments of the way in which CADAs crossed with their own functions. Authors in this issue raise questions as to whether CADA was the right approach, and whether co-ordination and consultation would not be better carried out by strengthening the normal Block, District and Village authorities. Some of the authors are or were in charge of CADAs; another *is K K Singh of* the Administrative Staff College, Hyderabad. Those interested are urged not only to obtain this issue of *Wamana* and to join in the debate, but also to subscribe to it ($100 for institutions and $20 for individuals) as this useful journal may otherwise close down. Address: 35/4 38A Cross Road, 8th Block, Jayanagar, Bangalore 560082, India.

Robert Wade has an article in *Economic and Political Weekly* April 16, 1988 *Why some Indian Villages Co-operate.* It looks at the institutions some, but not all, villages have built up to pay common irrigators (generally by a levy on each irrigated acre) and field guards (from the village common fund and through fines on straying animals). The villages with corporate institutions are located towards the tail end of irrigation channels where water is scarce (though there are also other factors). They are absent in villages where water is plentiful. Rather as in the Thai case, this suggests farmers, or alternatively their village authorities, will only act as a group if there are essential common interests to protect.

10 June 1988

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IRRIGATION MANAGEMENT NETWORK

IMPROVING WATER MANAGEMENT IN DEVELOPING COUNTRIES: A QUESTION OF TRAINING

Martin Burton

ODI/IIMI Irrigation Management Network Paper 88/1b June 1988

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IMPROVING WATER MANAGEMENT IN DEVELOPING COUNTRIES: A QUESTION OF TRAINING

Martin Burton

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Martin Burton is a lecturer in the management and operation of irrigation systems at the Institute of Irrigation Studies, Southampton University, UK.

IMPROVING WATER MANAGEMENT IN DEVELOPING COUNTRIES: A QUESTION OF TRAINING

Martin Burton

1. THE SETTING

This paper is the second in a series summarising the reports presented and the discussions held at the Thirteenth Congress of the International Commission on Irrigation and Drainage, held in Casablanca, Morocco in September 1987. The central theme of the Congress was *Improving water management in developing countries.*

Mary Tiffen has already summarised Question 40, *Rehabilitation and modernisation of irrigation and drainage projects for improving water management, (ODI–IIMI Irrigation Management Network Paper 87/3b).* This paper deals with Question 41: *Improving water management through training.*

It is the intention of this paper briefly to summarise the reports presented at the Thirteenth Congress and to draw the reader's attention to reports which are considered to be of particular interest. This is necessarily a personal view by the author, but is based on the objectives laid down for this Question by the ICID International Executive Committee. It is hoped that the reader may be able to make reference to the reports which are published in the Transactions of the thirteenth ICID Congress, Volume 1–C. These should be available through the various National Committees of the ICID. The address of your National Committee can be obtained form the ICID Central Office, 48 Nyaya Marg, Chanakyapuri, New Delhi 110 021, India.

2. THE QUESTION: IMPROVING WATER MANAGEMENT THROUGH TRAINING

In defining the scope of the question the ICID International Executive Council laid particular emphasis on requesting details of actual training programmes which had been undertaken, not on theoretical treatments of the subject. Authors were requested to provide details of such aspects as the scope and content of the training, the methods used, numbers of participants, and an evaluation of the programme.

Papers were requested on topics which covered all aspects of a project, from water control to marketing, for water users, operation staff and managers. Note was taken that there are two complementary aspects of water management training. Firstly there is training in the scientific knowledge and physical techniques which must always form the basis of efficient management and operation. Secondly there is the development of new managerial skills such as critical path planning, interpretation of available data, organisation, staff motivation and a better understanding of staff motivation and needs.

The main headings under which papers were requested were:

41.1 Definition of training, identification of training needs and objectives

41.2 Training of water users

41.3 Training of operation and maintenance staff in the 'best' supply of water to users

41.4 Training of senior project management

41.5 Methods of training operators and scheme managers, including on-the-job training, external courses, the use of computers, simulation studies, and role-playing games, audio-visual aids, etc.

41.6 Criteria and methods for evaluating training performance

3. THE ANSWERS

There were 33 reports from 21 countries accepted for presentation and discussion at the Congress. Presentation of the reports was limited to a very brief summary and an update on the project since the report was written. Mr H Boumendil, as General Reporter, produced a most comprehensive summary of each report as well as an overall summary of the issues raised (Boumendil 1987).

3.1 Classification of the reports

Mr Boumendil produced a most useful breakdown of the subject areas of each report. They are repeated here for those interested in locating and reading reports on the individual issues. Some reports appear more than once as they cover several topics.

a) General

Identification of training needs and criteria for assessing good water management: R 1, 4, 7, 9, 13, 14, 17, 22

Training for water management (general): R3, 4, 5, 6, 7, 9, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26

Training during thorough project evaluation: R 18

Problems of functional co-ordination: R 1, 2, 15, 19, 21, 23, 26, 28, 33

General status and problems of irrigation and drainage projects: R 26

b) Training of water users

Scope and content of training at field level: R 1, 2, 3, 4, 9, 10, 11, 12, 14, 15, 16, 18, 19, 20, 21, 23, 25, 27, 28, 30, 33

Training of Water Users' Associations: R 2, 3, 10, 11, 19, 21, 23, 30

Training farmers to participate in planning and design: R 33

c) Training of operation and maintenance staff (O&M)

R 1, 2, 3, 4, 7, 9, 11, 12, 13, 15, 16, 17, 18, 19, 21, 23, 25, 31, 32,

d) Training of senior project management staff

R 1, 4, 5, 6, 8, 10, 11, 13, 15, 16, 17, 21, 22, 24, 25, 29, 33

e) Use and application of micro-computers

For improving water management of the systems: R 2, 3, 8, 10, 12, 26,

For improving irrigation at farm level: R 2, 27, 28

f) Costs of training

R 6, 13, 19, 30, 31

g) Criteria and methods for evaluating training performance

R 3, 4, 7, 9, 12, 13, 17, 20, 22, 32

3.2 Reports of particular interest

Most of the reports were informative and interesting, though one or two had little to do with the Question. Several of the reports were of particular interest, as they described actual training programmes and gave very detailed accounts of how the training was done, who was trained, what techniques were used, and what the outcome of the programme was. The reports were:

R 5 W G Matlock. Training to improve productivity in arid and semi arid lands

R 9 Chan Choong Cheong. Water management training in Malaysia

R 12 D J Bandaragoda, J J Enneking, J W Jayawardene and L C Wattel. Micro-computer modelling: A powerful aid in improved water management

R 15 P Santosa. Water management training in Citagampor, Central Java, Indonesia

R 19 A E M Van Vilsteren and Poolsawat Duanduan. Training of O&M staff water users' groups by task force

R 30 N A N'Diaye, G K Faye, N H Degboue, M Seck and F Conac. Training in irrigation at Caritas, Senegal

Report R 5 by W G Matlock argues the case for the development of appropriate training courses for irrigation staff and water users on small-scale irrigation systems in developing countries. He comments that traditional water management training programmes provided by universities in developed countries such as the USA lack relevance to developing country problems in content and method, partly because of their emphasis on large system and high technology, and partly because they ignore the difference in the agronomic, social and economic environment. He goes on to outline how such deficiencies can be resolved. The report is well written, well argued and detailed.

Report R 9, by Chan Choong Cheong, gives a detailed and well written account of developments in water management in Malaysia. The report gives a brief introductory background to irrigation in Malaysia and the problems that are being encountered in water management. Malaysia is undertaking a number of upgrading programmes for its existing irrigation schemes, which are dominated by field to field cultivation of rice. The programmes include the provision of additional irrigation, drainage, and road infrastructure, at both scheme and farm level. However, it is recognised that attainment of 200 per cent cropping also depends on increased co-operation between farmers and increased farmer understanding of the implications, advantages and constraints of new structures and different scheduling systems. The report then goes on to details the training in water management that is given at the National Water Management Training Centre (NWMTC), giving information on organisation, types of training courses, curriculum and methodologies. Most of the courses are for personnel at different levels involved in planning and operating projects, but there are also courses for farmer leaders. The Centre developed its training materials in association with a 4.6 ha demonstration farm on the campus and 4 pilot farms in a nearby irrigation scheme. The report would provide useful guidelines for any organisation considering setting up a similar training centre.

Report R 12 by D J Bandaragoda, J J Enneking, J W Jayewardene and L C Wattel, gives a good account of the development and use of a computer model to assist the relevant government agency in resources planning and water management of a 60,000 ha irrigation system in Sri Lanka. The report gives brief background information of the irrigation network and model, together with details of the data collection and processing required. It outlines the implementation and use of the package during the 1983-84 Maha season and the staff training that was necessary. In the conclusions, the authors give some useful recommendations for training of staff in the use of such packages.

Report R 15, by P Santoso, gives detailed outlines of training courses for all levels of irrigation service staff as well as for water users' associations and farmers. The particular problem that the courses seek to address is that in Indonesia, many different bodies are involved in irrigation. These include planning and design by the Directorate General of Water Resources Development, the irrigation branch of the Provincial Public Works departments for construction and O&M of the main system, the Water Users' Association for construction and O&M of tertiary system, guidance on water utilisation from the District Agricultural Service extension offices, and development and guidance of water user associations through the various levels of the Local Government system. The local government also co-ordinates all agencies involved in irrigation. There is a tendency for each of these bodies to look at irrigation from its own point of view, and to blame one or more of the others for deficiencies and illegal breaking of the rules. The objective of training is, therefore, to bring people together from the various institutions and to promote common understanding as well as to increase the knowledge and skill of the personnel. The report is of practical use to others involved in setting up such training programmes, providing details of course syllabi and training techniques. Mr Santoso usefully qualifies the benefit of the training programme by pointing out that their success in implementation is limited by a lack of facilities, such as current meters for discharge measurement and power in enforcing the water law.

Report R 19, by A E M van Vilsteren and Poolsawat Duanduan gives a most comprehensive outline of the training programmes established by a special "Task Force" training team set up by the Royal Irrigation Department for the Maie Klong Irrigation Scheme. The report details concisely the programme followed for the training of the Task Force team and the subsequent training of irrigation staff, water user groups and farmers. The report provides information lacking in many other reports on evaluation of the training programme. Though it acknowledges difficulty in attribution of the improvement of the project irrigation efficiency to the training programme, and to other aspects of scheme development, the survey detailing the positive change in farmers' attitudes to the Agricultural

Extension Department before and after the project is excellent. This was a most valuable contribution to the Congress.

Report R 30, by N A N'Diaye, G K Faye, N H Degboue, M Seck, and F Conac, details training programmes for farmers and agricultural extension staff in Senegal. The report makes the case for the training of farmers in matters of irrigation, in rural centres, by Africans. It details some exciting programmes ranging from long term courses of two years for village secondary school leavers to training of rural school teachers in irrigated and rainfed agriculture. A novel summer holidays camp where urban schoolchildren are placed with rural schoolchildren to learn about elements of agriculture is described. The training is organised by a non-governmental organisation, Caritas-Senegal. It utilises cost-effective methods well adapted to the needs of the participants. The original paper is in French. As one example of financial training for illiterate leaders of farmer groups it quotes the paper by Guy Belloncle. An English version of this is available from ODI (Irrigation Management Network paper 9c, 1984).

In addition, reference is made to report R 4 by M A Burton, Ir Darsún Kartodirendjo, Arief Effendi, Ir Tjajo Santoso and I K Smout entitled *Training in water management: A practical approach for managers and operators in East Java, Indonesia.* This report is similar to R 15 and R 19 in detailing training programmes established for both water users and irrigation service staff. The report provides a detailed account of procedures and timetables followed in setting up the training programmes. M Boumendil describes it as a "very comprehensive report". Versions of this paper are available from ODI (ODI-IIMI Irrigation Management Network Papers 86/1d and 86/1e. The first refers to training of irrigation staff and the second to training for farmers).

4. CONCLUSIONS

The 33 reports covered many aspects of training in water management, from Master of Science courses to the training of Senegalese schoolchildren. Approximately 6 per cent of the reports dealt with training of farmers, 12 per cent with the training of O&M staff, and some 40 per cent with both.

Some 30 per cent of the papers dealt in general terms with training in water management in either educational and training institutions, or for a particular country.

One interesting point that comes out of the reports is whether training programmes should be held at specially constructed and equipped central water management training centres or whether they should be mobile. In the first instance, the trainees are away from home in (possibly) an urban or alien environment, whilst the trainers are 'at home'. In the case of mobile training units, the roles are reversed. It is the trainers who have to adjust. There is probably the need for a mixture of the two, a central training centre with adequate demonstration facilities for training programmes for more senior staff, and mobile units for irrigation service field staff, water users and their associations. The greatest benefit will be derived from such a mixture where the training staff are involved in both types of training.

The conclusions and recommendations issued by ICID following the Congress in respect of Question 41 are reproduced below:

"Congress participants agreed that it is possible to improve water management through training.

Training should be considered part of the 'business' of managing an effective organisation.

Major recommendations are:

1. Initial training of project operational and maintenance staff should be completed by the time of the project commissioning. Such specific training costs should be part of project development costs.

2. In developing training strategies and programmes for improving water management in existing schemes the following key requirements should be borne in mind:

2.1 Programmes should be developed to provide for long term needs by an effective training needs analysis, related to clearly stated and agreed organisational objectives.

2.2 Parallel programmes for management, operation, maintenance and administrative staff should be implemented.

2.3 Water users and their associations should be involved n developing training strategies and receiving complementary training.

2.4 Such training should generally be as close to the field and canal systems as possible, to ensure practical orientation.

3. ICID should develop strategies for improving institutional management processes to develop and implement effective training programmes."

Training in water management and related issues is essential for all concerned if the best use is to be made of the available resources. The reports to the Thirteenth ICID Congress have made a valuable contribution to the state of knowledge in this key subject area, and have provided some useful reference works for those involved in establishing such training programmes.

5. REFERENCES

The full set of reports detailed above can be found in the Transactions of the Thirteenth ICID Congress, Volume I-C, published by the International Commission on Irrigation and Drainage, 48 Nyaya Marg, Chanakyapuri, New Delhi 110 021, India. The summary is available from the same office, the English version being:

Boumendil, H. (1987) Improving water management through training, General Report, Question 41, Thirteenth ICID Congress, Casablanca, Morocco.

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IRRIGATION MANAGEMENT NETWORK

DEVELOPING PARTNERSHIP IN THE MANAGEMENT OF IRRIGATION SYSTEM

A M Ferrer and L C Lucero

ODI/IIMI Irrigation Management Network Paper 88/1c June 1988

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DEVELOPING PARTNERSHIP IN THE MANAGEMENT OF IRRIGATION SYSTEMS

A M Ferrer and L C Lucero

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DEVELOPING PARTNERSHIP IN THE MANAGEMENT OF IRRIGATION SYSTEMS

A M Ferrer and L C Lucero

1. SUMMARY

This paper aims to discuss the process of developing partnership between the irrigation agency and the farmers in the management of irrigation systems, through the example of the Upper Pampanga River Integrated Irrigation Systems (UPRIIS) and the National Irrigation Administration (NIA) in the Philippines. The NIA objective is to promote maximum participation of water users organised into associations, in the construction and management of an irrigation system. To fulfill this, an Institutional Development Division was created within the UPRIIS organization to provide the necessary assistance to make the Farmer Irrigators Associations (FIA) at lateral level strong and viable.

The key officials of the FIA are the farmer leaders of each rotation unit. The rotation units are the base units. The various FIA are then linked at zone level, as a Federation of Farmer Irrigators Associations (FFIA) to provide a venue for communication and co-ordination within and among FIA on matters related to irrigation system management. At each level of farmers' grouping, a corresponding O&M field worker co-ordinates with association leaders in the implementation of the different aspects of irrigation management within their respective domain. In addition, training programs are developed and provided to officers and members of the different levels of irrigation organization to strengthen their partnership with the NIA in managing the irrigation systems.

Notable benefits of the NIA and FIA partnership in managing irrigation system in UPRIIS are in getting farmer assistance in water distribution, in facilitating the maintenance of farm level facilities and improvement or repair of their canal, and in resolving irrigation related conflicts or problems at lower levels where previously they were taken up directly with the NIA authorities. Another improvement is the greater efficiency in collecting irrigation service fees which has been found in areas with FIA. In the parts of the system where the FIA have been federated, water allocation to the different associations' jurisdictional areas have been coordinated effectively with the assistance of the irrigation association federation officers.

However, one of the main problems which has slowed down implementation of the programme has been the opposition of staff who feared the loss of their jobs. This has meant the programme has only been implemented slowly as jobs fall vacant.

2. INTRODUCTION

The philosophy behind the changed management system is that farmer irrigators, who were previously treated as beneficiaries of irrigation development, should become partners in the planning, implementation and evaluation of irrigation development programmes. This means all services provided to farmer irrigators should be organised in such a way that it is within farmers' capacity to participate and that there is co-ordination between members of the irrigators' association and the staff of the agency. This is achieved by the NIA sharing decision making and delegating partial or full management of irrigation systems in stages to duly organised irrigators' association.

The change has two advantages. It makes fuller use of human resources and it also leads to a better level of financial viability in existing national irrigation systems.

3. THE INSTITUTIONAL DEVELOPMENT DIVISION

The Institutional Development Division (IDD) is one of several staff divisions that support the operations manager in the attainment of the Agency's goal. The Division's main functions are to formulate strategies and to develop plans and programs for the organization of farmers into viable irrigators' associations, and through their associations to prepare the water users for maximum participation in construction and management, and for their eventual takeover of the irrigation system. The Division provides full assistance in the legal stages of the registration of FIA with the Securities and Exchange Commission, and the negotiation and preparation of NIA and FIA contracts on joint management of irrigation systems. It also assists FIA management generally. The IDD management is headed by a Division manager, assisted by two agricultural specialists, one in charge of farmers' organization development and the other responsible for farmers' assistance and training. UPRIIS management thinks it important not only to have a programme for the organization of irrigators' associations, but also to support this with training programmes to develop the skills of the officers and members and strengthen the partnership between them and the NIA.

4. PROGRESS IN THE ORGANIZATION AND DEVELOPMENT OF IRRIGATION ASSOCIATIONS

4.1 Organizational development of FIA

Attainment of the highest possible system efficiency within the limits of water resources and engineering design as well as achieving an equitable distribution of irrigation water depends to a large extent on farmers working co-operatively for mutual benefit (Miranda, 1976).

A 5-year Integrated Agricultural Development Programme for the period 1976 to 1980 was developed after the construction of UPRIIS facilities in 1975. The programme goals were to improve rice yields, cropping intensity, water use efficiency, and the system's irrigation service fee collection.

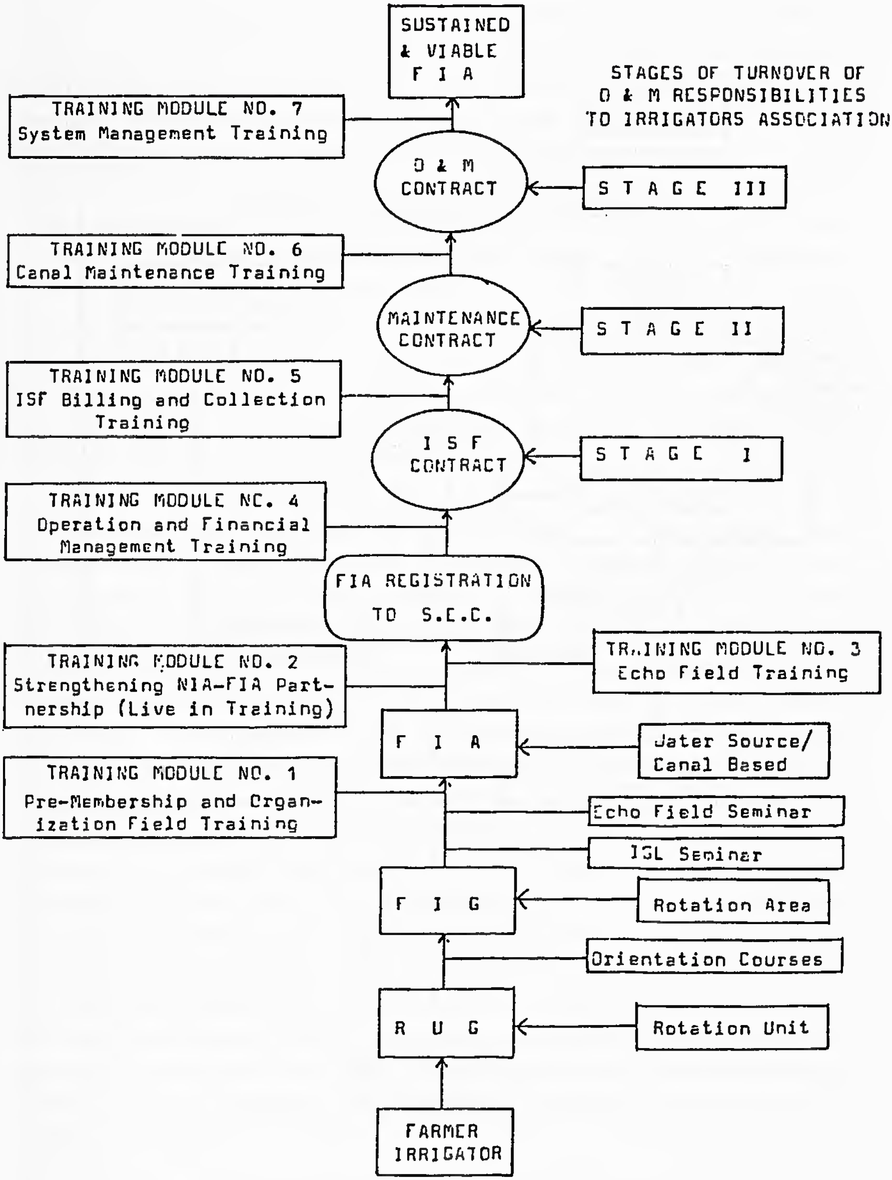

FIGURE 1: STAGES OF FARMER IRRIGATORS TRAINING MODULES AND TURNOVER OF O&M RESPONSIBILITIES TO IA.

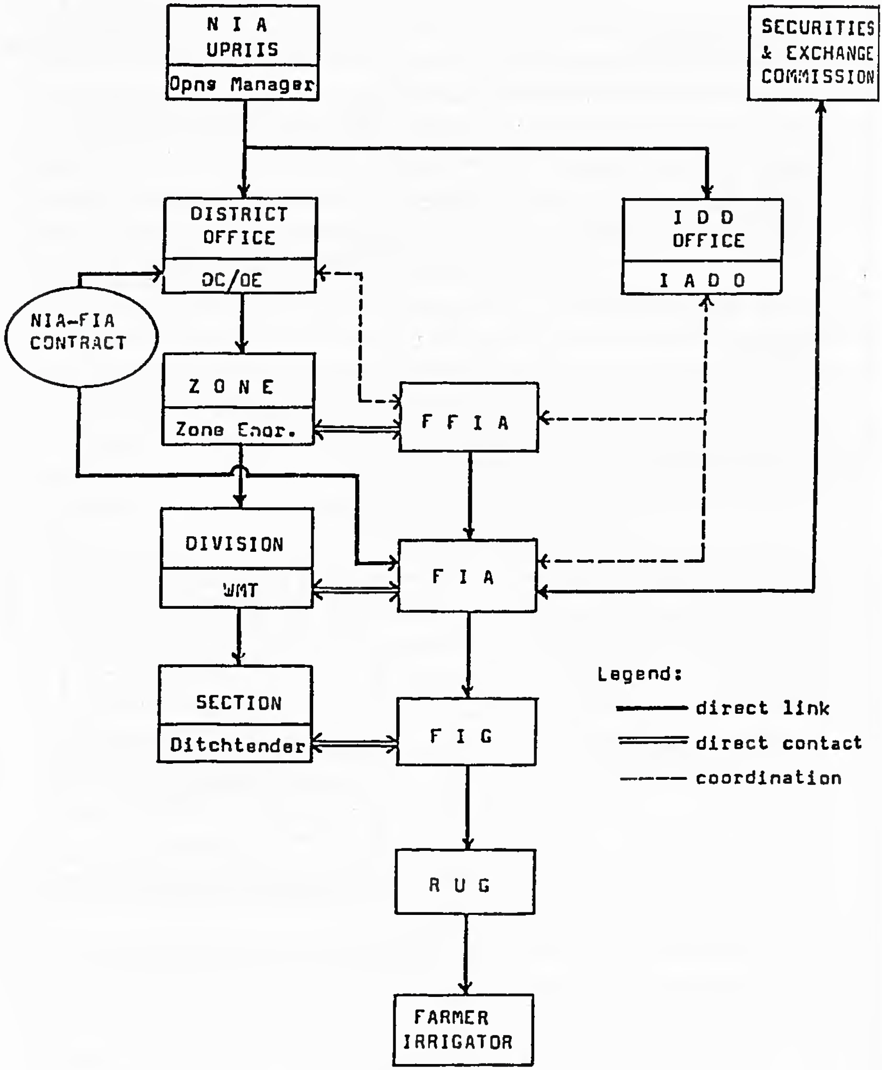

FIGURE 2: OPERATIONAL LINKAGES OF O&M PERSONNEL AND IRRIGATORS ORGANISATIONS IN UPRIIS.

One of the major activities of the programme was the organization of irrigators' groups (Phase 1) in close co-ordination with concerned irrigation field personnel and technicians of other government agencies involved in irrigated agriculture. The organization process (Figure 1) starts with the grouping of individual farmers within a rotation unit of around 10 ha, served by a common farm ditch. The organization is called a Rotation Unit Group (RUG), which forms the foundation of the FIA. The RUG is headed by the a unit leader selected by the 4 to 7 farmers involved. Its purpose is to improve farm level water distribution and utilization as well as providing a venue for better interaction and rapport among neighbouring farmers. The next step in the process was the formation of farmer irrigator groups (FIG), at the rotation area level. The FIG, composed of 3 to 6 RUGs, is headed by a chairman together with other officials, all of whom are elected by the Unit leaders.

At the end of this programme in 1980, the focus shifted to a higher level in the system. The objective was to develop the capacity of the RUG and FIG leaders to co-ordinate together on matters of irrigation system activities. This led to the formation of irrigators' groups, termed Farmer Irrigator Associations (FIA) based on a single water source or canal. The number of RUG and FIG within the jurisdiction of one FIA varies, depending on the configuration of the canal command area. The RUG and FIG leaders initially constituted the membership of the association. Among themselves, they elected their Board of Directors and from the Board, the officers of the association were elected. The officers of the association appoint the Chairman and members of the different committees, whose function is to assist the FIA officers towards a more effective management of the association. The committees are: a) education and training; b) finance and development; c) audit and inventory; d) irrigation management; e) agricultural supervision; and f) complaints. From the point of view of the NIA, the formation of FIA based on lateral canals, federating smaller groups, has the advantage that its staff now mainly interact with the farmers at fewer points in the system, and therefore have more time for technical duties.

The last step in the organizational process is the formation of a much bigger association at zone level to develop a stronger co-ordination between the farmer irrigator groups and irrigation O&M personnel. Depending on the irrigation system's make up, and based again on the single water source concept, the association formed is called Federation of Farmer Irrigators' Association (FFIA). The current officers of all the FIA within the jurisdiction of the FFIA constitute the members of the federation. They elect from themselves their set of officers to manage the affairs of the federation.

4.2 Stages of turnover of O&M responsibilities to FIA

Once the FIA is organised and registered with the Securities and Exchange Commission, it attains legal status. The process of handing over O&M responsibilities of the Agency to qualified and willing FIA starts with the negotiation and eventual signing of a contract.

The first stage is a contract on irrigation service fee collection, in which the FIA assists in the collection of payments within their jurisdictional area. The irrigation service fee collection contract specifies that in each cropping season, the NIA will provide an incentive to the FIA in the range of 1 to 5 per cent of the current service fee revenue, if the collection efficiency within the FIA area reaches 70 to 100 per cent. An additional 2 per cent of the amount collected as back payment is given to the FIA if it qualifies for the current collection incentive. To enhance competition between associations, the NIA gives priority in repair and maintenance to FIA areas with high collection efficiency.

Stage II is to hand over canal maintenance to the FIA when the post of ditch tender for part of a lateral falls vacant within its jurisdictional area. Once the FIA agrees to undertake the maintenance of the canal, the NIA pays the FIA P$830.00 per month (2,856 kg of paddy per annum based on P$3.50 per kg government supported price) for a length of 3.5 km which is equivalent to one ditch tender section.[1] This rewards the FIA for its service in maintaining the specified canal and its structures. The payment however, is subject to the monthly maintenance evaluation conducted by an evaluation committee of the Agency.

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[1] Irrigation service fees are fixed in terms of kg of rice per hectare, although they are collected in cash.

Stage III is on the turnover of O&M of a particular sub-system or part thereof to the FIA. This specifies that sub-system management activities like water distribution, maintenance and fee collection should be handled by the FIA. The responsibility to the NIA is the payment, in any manner that is agreed by both parties, of the amount invested in the construction including amortization and other related system operational expenses. When these costs are paid, the FIA will have full rights over the system.

4.3 Training programmes

Orientation courses were conducted during the formation of FIA in 1976 to 1980 to inform farmers of the benefits of group action and their eventual roles in irrigation management. Also during this period, irrigator group leaders were given residential seminars on their roles and responsibilities, irrigation plans and programmes, and leadership. Thereafter field seminars, termed field echoes, for FIG members were conducted with the assistance of the trained group leaders. With the completion of the first five year programme in 1980, training programmes to suit the higher level irrigation association organizational structure were developed.

The training of irrigation association officers and members were packaged as training modules based on the different stages and levels of association development (fig 1). Most of the training modules are scheduled during the normal irrigation period, when farmer irrigators have finished planting their crops, and irrigation is taking place at normal intervals, so that association officers and members have time to participate.

4.3.1 Training Module No 1 - Pre-Membership and Organization

This field training aims to enhance farmers' understanding and appreciation of NIA programmes on FIA organization and development. Specifically, the discussion focusses on irrigation association advantages and benefits and strengthening working relationship between water users and irrigation personnel.

4.3.2 Training Module No 2 - Strengthening of NIA-FIA Partnership in the O&M of Irrigation System

The aim of this module is to increase the FIA officers' understanding of the concept and overall programmes of the NIA for FIA organization and development, and their roles and responsibilities as partners in irrigation system management. It is a two day residential workshop on system management activities for 20 to 25 officers (Presidents and Vice-Presidents) per session.

4.3.3 Training Module No 3 - Field Echo

At this level, the goal is to enhance the member farmers understanding of the concept and overall NIA programme for FIA organization and development, the associations' roles and responsibilities in the operation and maintenance of irrigation systems, and their individual duties and responsibilities as water users. This field training is held locally jointly with the officers of FIA who have attended the residential workshop, who co-ordinate and schedule the field seminar for their members.

4.3.4 Training Module No 4 - Operation and Financial Management

This provides officers of FIA with the necessary skills for management procedures and techniques consistent with the NIA rules and regulations. Specifically, officers are expected to learn or improve their skills in the correct use of FIA corporate account books, investment, and proper disbursement of operational capital in relation to FIA activities.

4.3.5 Training Module No 5 - Irrigation Service Fee Billing and Collection

This module is designed to enable leaders and members of FIA who have an irrigation service fee collection contract to understand the nature and importance of the fee in the operation and maintenance of irrigation systems, to discuss the context of the collection contract and its related activities, learn the procedures on the preparation of irrigation service fee bills, and prepare plans and strategies to improve irrigation service fee collection in their area. Field training is usually conducted in the FIA area. Both officers and members take part. Whenever necessary, 2 or 3 sessions are conducted to maximise participation.

4.3.6 Training Module No 6 - Canal Maintenance

This formal training is given to the officers of FIAs which have a maintenance contract. It explains the importance and context of maintenance contracts with emphasis on the FIA roles and responsibilities in dealing with maintenance activities. The training also aims to provide the FIA leaders with skills in the preparation of maintenance plans and programmes.

4.3.7 Training Module No 7 - System Management

This module is a residential workshop for leaders of FIA which have a contract to operate and maintain a specific sub-system. The primary goal is to provide skills for programming, implementation, monitoring and evaluation as they relate to components and phases of irrigation system management. It also delineates the respective roles and responsibilities of the FIA and the NIA, and the linkages between them.

5. OPERATIONAL LINKAGES AND RESPONSIBILITY LEVELS OF NIA AND IRRIGATORS' ORGANIZATIONS

Understanding the water users' motivation and behaviour when they perceive themselves as stockholders and partners will become a major dimension in the management of irrigation systems. If the NIA is to share O&M responsibilities with the FIA, so it can concentrate on the more technical aspects of systems management, an effective farmers' organization is critical. In addition, the strengthening of relationships between farmer irrigators and their associations should lead to an environment where the farmer's behaviour becomes increasingly predictable and appropriate for operating the irrigation system at optimum efficiency for collective benefit (Ng et al, 1983).

5.1 Operational Linkages and Responsibility Levels

The Operations Manager, through the District and IDD officers, has worked towards the attainment of a strong partnership with the different levels of the irrigators' organizations, The Districts' O&M personnel provide the necessary linkages within their areas of jurisdiction (fig 2). We can look at this from the top down to see how they link with the farmers' organization at the bottom.

5.1.1 The Zone Level

Command areas of the Zone range from 7,500 ha to 10,000 ha. Each is managed by a zone engineer. The number of FFIA within the Zone is dependent on its topography, jurisdictional area and other physical considerations. Together with the irrigator association development officer, the zone engineer initiates the formation of the FFIA and provides continuous assistance on irrigation related activities.

The zone engineer works closely with FFIA officers in the supervision and monitoring of water allocation within the distribution canals of the federation according to schedules agreed with their member FIA. Three Zones form a District and the district chief or the operations engineer provides support in FFIA irrigation management activities.

5.1.2 The Division Level

Each Zone is divided into Divisions, whose command area ranges from 750 ha to 1,000 ha for which a water management technician is responsible. Depending on the physical make-up or characteristics of the division, this includes 1 to 5 FIA, each based on a single water source. In consultation with the zone engineer and the water management technician, the irrigation association development officer prepares for the organization of irrigation associations by identifying rotation areas and listing the corresponding FIG leaders and members.

The water management technician either meets directly with the IA officers on scheduling and water allocation to the FIA areas, or consults them through the ditch tender. He consults them on their cropping plans before the season starts and passes this information upwards for incorporation into a practical water delivery programme as well adapted as possible to needs. He also supervises the ditch tenders' maintenance of irrigation facilities and structures. The IA officers through their RUG and FIG leaders co-ordinate the irrigation water distribution within their area, resolve irrigation-related conflicts, promote the payment of ISF, and the maintenance of farm level facilities and structures.

5.1.3 The Section Level

Along the 3.5 km canal length maintained by a ditch tender are turnouts, the water source of rotation areas.

The irrigator group leaders' main responsibility concerns the timely group maintenance of farm level facilities and structures within the rotation area, as well as resolving water distribution conflict among individual farmer irrigators. The water management technician and ditch tender initiate group leader and farmers' meetings to maintain the cohesiveness of the FIG. During these meetings, NIA irrigation plans are discussed to get feedback which will improve programme implementation.

6. STATUS OF INSTITUTIONAL DEVELOPMENT IN UPRIIS

6.1 Farmer Organization

The organization of FIA initially started in 1980 and was intensified in early 1984. By the end of 1987, a total of 230 FIA were already organised with membership of 48,900 farmer irrigators. Out of the 230 organised FIAs, 159 have gained their legal status through registration with the SEC. There is a target of 28 federations of FIA (FFIA) for the whole UPRIIS system and by March 1988 7 of these had been organised.

6.2 NIA and FIA Contracts

From the registered associations, 84 FIA have contracts for ISF collection and 12 have contracts for canal maintenance. In addition, one O&M

contract was drawn up between the NIA and FIA for the Penaranda Pump Irrigation System of UPRIIS.

Up to 1986, 46 FIA had received the incentive payment made when collection of ISF exceeds 70%. Improvement is still needed here. In the UPRIIS system as a whole the proportion of fees due which have been collected was 54% in 1982, and in subsequent years 46%, 35%, 33%, and 36% in 1986.

6.3 Training Programmes

Since the intensified programmes on institutional development were launched in 1984, the following are the cumulative total attendance on the different training programmes:

Attendance at training courses (to September 1986)

Training Module No		No of FIA	Participant (Officers/Members)
1.	Pre-membership and organization	202	6,306
2.	Strengthening NIA and FIA partnership	131	181
3.	Field Echo	79	2,370
4.	FIA Operation and Financial Management	97	1,455
5.	ISF Billing and Collection	57	1,140
6.	Canal Maintenance	8	80

7. CONCLUSION

This paper asserts that if the improvement of irrigation system management is to be truly achieved, institutional development is necessary. Irrigation users should be organised to facilitate communication and a working relationship with irrigation management. Organised irrigators' associations should serve as channels for feedback and feed-forward information so as to improve the performance and services provided by O&M irrigation personnel. Most of all, the FIA as institutional organizations create awareness amongst both staff and farmers that operation and maintenance of irrigation systems in particular, and development programmes in general, should be a joint undertaking.

Setbacks were experienced in the initial phase of organising the FIA. The reluctance of water management technicians and ditch tenders to support the formation of FIA slowed down the early stages of organization. They felt their jobs were threatened by the NIA objective that the FIA should have a substantial share in the management of irrigation systems. With the Agency's pronouncements of job security for water management technicians and ditch tenders, their apprehensions subsided. This helped and they became ready to support the organization of irrigation associations as these could make their work in irrigation system management activities easier. However, there were cases where the water management technicians and ditch tenders did less field work and relied heavily on FIA officers' management capability. As a consequence, the officers concerned lost interest in participating and co-operating as they did not get the benefit of a management contract, and they became passive or indifferent. Dialogue between NIA and FIA towards improving their respective performance and linkages is a necessity towards better and effective irrigation management implementation.

Institutional development via FIA in UPRIIS is now gaining momentum. There is a greater likelihood that in the next 5 years, all identified potential FIA will have been formed and registered with the Securities and Exchange Commission. By then, the majority of the beneficiaries will have a share and a common voice in the management of the irrigation system.

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IRRIGATION MANAGEMENT NETWORK

MAJOR FEATURES OF MOROCCAN LARGE-SCALE IRRIGATION PROJECTS

Mohamed Ait-Kadi

ODI/IIMI Irrigation Management Network Paper 88/1d June 1988

Papers in this set

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88/1e: Strategy Development in IIMI by Roberto Lenton

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MAJOR FEATURES OF MOROCCAN LARGE SCALE IRRIGATION PROJECTS

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MAJOR FEATURES OF MOROCCAN LARGE SCALE IRRIGATION PROJECTS

Mohamed Ait-Kadi

1. INTRODUCTION

Irrigated agriculture has a high priority in Morocco, to meet the needs of its rapidly growing population and to expand exports both of commodities and processed agricultural products.

In Morocco there are approximately 7.7 million ha of arable land of which 1.2 million ha are potentially irrigable. Irrigation accounts for 88 per cent of the water use compared to 8 per cent for domestic use and 4 per cent for industry. Irrigated agriculture contributes about 45 per cent of the agricultural value added and produces 65 per cent of the agricultural exports.

Government policy in the agricultural sector has always favoured investments in the irrigation subsector. These investments have accounted for more than 60 per cent of the total investment in agriculture since 1965. The goal is to put under perennial irrigation one million hectares by the year 2000. This is referred to as the "million-hectares" policy.

Large-scale irrigation projects development constitutes the central thrust of Moroccan irrigation development efforts. Large-scale projects (LSI) range from 20,000 ha to 250,000 ha and represent new investments in major civil works for water regulation and conveyance with modern distribution systems. Morocco has adopted an interventionist type of irrigation policy based on a contract between the State and the farmers to build the national economy through irrigation development. Each LSI project is developed and managed by a decentralized agency with full responsibility for irrigated agricultural development.

Another interesting feature of LSI projects in Morocco is the model used for land consolidation and the irrigation system layout known as "Trame B" or "Rational Layout". The model is unique and incorporates three important complementary features:

- equitable and efficient water distribution
- annual and seasonal crop diversity
- accommodation of wide variations in individual land ownership patterns in such a way that limitations in the size of individual land holdings are not obstacles to the adoption of modern technology.

2. IRRIGATION DEVELOPMENT POLICY IN LARGE-SCALE PROJECTS

The irrigation development policy adopted by Morocco since its independence consists in a concentrated comprehensive development effort in well-defined and favoured geographical areas: the irrigation command zones. Nine command zones have been delimited, each under an organization known as ORMVA. Table 1 gives the actual and potential irrigated area in each of them.

The basic philosophy of the irrigation policy adopted is that "to attain the desired objectives, it is not sufficient - as it has been done in the past[1] - to construct irrigation canals as rapidly as possible, the State must also create the conditions enabling development to take place". This philosophy was dictated by several considerations among which the significant ones are the fact that Morocco has a relatively limited water resources potential and that the existing agrarian structures are out of date.

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[1] The first large irrigation systems merely provided headworks and main canals primarily serving large farms belonging to French colonists.

Table 1. Potential and Actual (1986) Irrigated Areas in ORMVA Projects

ORMVA	POTENTIAL (ha)	EQUIPPED (ha)
Doukkala	99,700	52,700
Gharb	208,600	83,300
Haouz	186,200	37,200
Loukkos	36,000	14,200
Moulouya	61,900	56,900
Ouarzazate	23,550	22,950
Souss Massa	35,300	26,700
Tadla	105,000	97,000
Tafilalet	21,000	21,000
Total	777,250	401,950

The land tenure situation in Morocco represents a major constraint to agricultural growth. This results from (a) skewed land distribution patterns with 80 per cent of the farms having 5 ha or less and 1 per cent more that 50 ha. The two extremes represent 25 per cent and 20 per cent of the cultivable land respectively; (b) extreme fragmentation of the holdings which affects their viability (farms have an average of 6 parcels each and an average size per parcel of 0.6 ha. Fragmentation of landholdings is due to adherence to Islamic laws regarding inheritance, large family sizes, and the desire of many people to maintain a rural foothold for the sake of economic survival, family unity, psychological orientation, etc.); (c) a lack of land titles with adverse consequences on access to credit and incentives to invest on the farm; (d) a lack of security of tenure for tenant farmers and a consequent under-use of resources. This land tenure system combines with the use of backward techniques, and the peasants' mentality, educational level and lack of resources to restrain agricultural productivity.

In order to promote the rational use of the water resources and to overcome the constraints related to the situation of the Moroccan peasant an "interventionist" type of irrigation policy has been adopted. A comprehensive framework for this policy in delimited LSI perimeters is defined by a variety of laws grouped in the "Code of Agricultural Investment" of 1969. The major provisions of this Law are:

1. The government provides the farmers with a ready-to-use irrigation system which includes not only the off-farm system (i.e. headworks and main conveyance and distribution systems) but also the on-farm system (including land clearing and levelling, on-farm irrigation, drainage and road systems). The government finances the preponderant portion of the capital.

2. The farmers have full right of ownership and are expected in return to:

   - fully develop the land within technical requirements of irrigated cultivation practices and bring it to a suitable level of productivity. General specifications of methods of exploitation, including a prescribed cropping pattern, are established at each scheme and are backed by the sanction of possible acquisition of land which is not developed.

   - pay the following charges:

     a) volumetric charges that are intended to cover 100 per cent of operation and maintenance costs as well as up to 40 per cent of original investment costs. The basic water charge increases by 20 per cent a year over five years from the first irrigated crop year. A minimum of 3,000m³/ha is systematically debited for every farmer in order to encourage the use of irrigation water;

     b) a fixed betterment levy which amounts to DH 1500/ha (US$1 = 8 DH). The Law is being revised so that this betterment charge covers 30 per cent of the investment costs. The payment of the betterment levy is due at the start of the fourth year following the completion of the project either by payment of a lump sum or in annual installments at 4 per cent interest over 17 years. Farmers with 5 ha or less are exempted totally from the payment of the betterment levy, farmers with between 5 and 20 ha are exempted from charges for the first 5 ha and farms of more than 20 ha are required to pay the full cost;

c) where appropriate a supplementary charge to cover the cost of energy used in pumping. The pumping charge is applied in full from the first year and is indexed to the price of a kwh.

3. The Law provides a complete land-related legal framework for land leases and transfers. Land consolidation is compulsory prior to provision of irrigation facilities. A minimum holding size of 5 hectares is established[2]. Land in the irrigation schemes should be divided in such a way as to create no holdings smaller than 5 hectares. The owner of a holding of less than 10 hectares is required to select a single heir so as not to create, through division, a holding smaller than 5 hectares. Furthermore, the Law specifies that within land affected by the agrarian reform, existing holdings of less that the viable size can be augmented to 5 ha. In the case of very large holdings a major part of the windfall gain can be recovered in the form of land which becomes available for redistribution.

4. The Law also provides a comprehensive framework for conclusion of crop contracts and for price supports and subsidies in order to stimulate agricultural production. Co-operative arrangements are encouraged.

The Moroccan Government regards the Law as a contract between the State and the farmers to build the national economy through irrigation development. It pays for the dams, the irrigation network and necessary on-farm development. It provides credit, selected seeds, fertilizer, farm equipment, and certain mechanized operations, usually at subsidized prices. Finally it guarantees the prices of crops such as sugar-beet, sugar-cane, rice, wheat and cotton through contracts. In turn the farmer is obligated

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[2] In LSI a farm size of 5 ha is considered viable to provide an income which can repay over time part of the off-farm and on-farm investments and leave reasonable income to the farmers.

to farm his irrigated land in the national interest, to follow the norms imposed for his hydraulic sector, and to repay the State through a land improvement tax and water charges.

3. ORGANIZATION OF IRRIGATION ADMINISTRATION

Initially, an independent office, the Office National des Irrigations (ONI), was created in 1961 with full responsibility for irrigated agricultural development in the country. ONI brought under a single roof all the various departments involved in Morocco's irrigation development. This office has introduced specialized crops such as sugar-beet and developed, in 1962, the land consolidation model known as "Trame B" which has been used in all the LSI projects ever since. In 1965-66, ONI, which became quite centralized, was dissolved in favour of a more decentralized approach and the formation of autonomous regional offices attached to the Ministry of Agriculture and Agrarian Reform (MARA)[3]. These are known as the Offices de Mise en Valeur Agricole, ORMVAs.

3.1 ORMVA's Responsibilities

Each of the nine ORMVAs services one delimited command zone. The ORMVAs are responsible for the design, construction, operation and maintenance of the irrigation networks. ORMVA technicians supervise farming operations for industrial crops and assist in the establishment and monitoring of agricultural co-operatives. ORMVA integrates all the productive services required by farmers under one management structure. They distribute inputs, provide extension and mechanization services to

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[3] The study and exploitation of water resources in Morocco are the responsibilities of the Hydraulics Administration of the Ministry of Public Works which is also responsible for dam construction and maintenances.

The Ministry of Agriculture and Agrarian Reform (MARA) has principal responsibility for the provision of public services to Moroccan agriculture. At the local level MARA operates through two separate and distinct institutional structures: the Offices irrigation perimeters, and the Directions Provinciales d'Agriculture (DPA), which have jurisdiction over the most of the rainfed cropland and the small and medium scale irrigation projects.

farmers, supervise short-term credit and provide genetic improvement and health control services for livestock.

In addition, ORMVAs are responsible for providing assistance to rainfed farmers and those dependent on traditional irrigation located within their jurisdictions. They also provide technical assistance to local communities in the design and construction of village infrastructure such as housing projects, electricity and water supply, sewage and road systems, etc.

Recently ORMVAs have embarked on a programme of disengagement from activities that do not fall directly within their mandates. The objective is to make the private sector provide all those services that are commercial in nature. A new experiment is now initiated with the ORMVA Doukkala. It consists of having this ORMVA operate like a private enterprise according to a programme contracted with MARA. This experiment is in its early stages. It aims at providing the ORMVA with more field-spending authority.

3.2 ORMVA's Organization

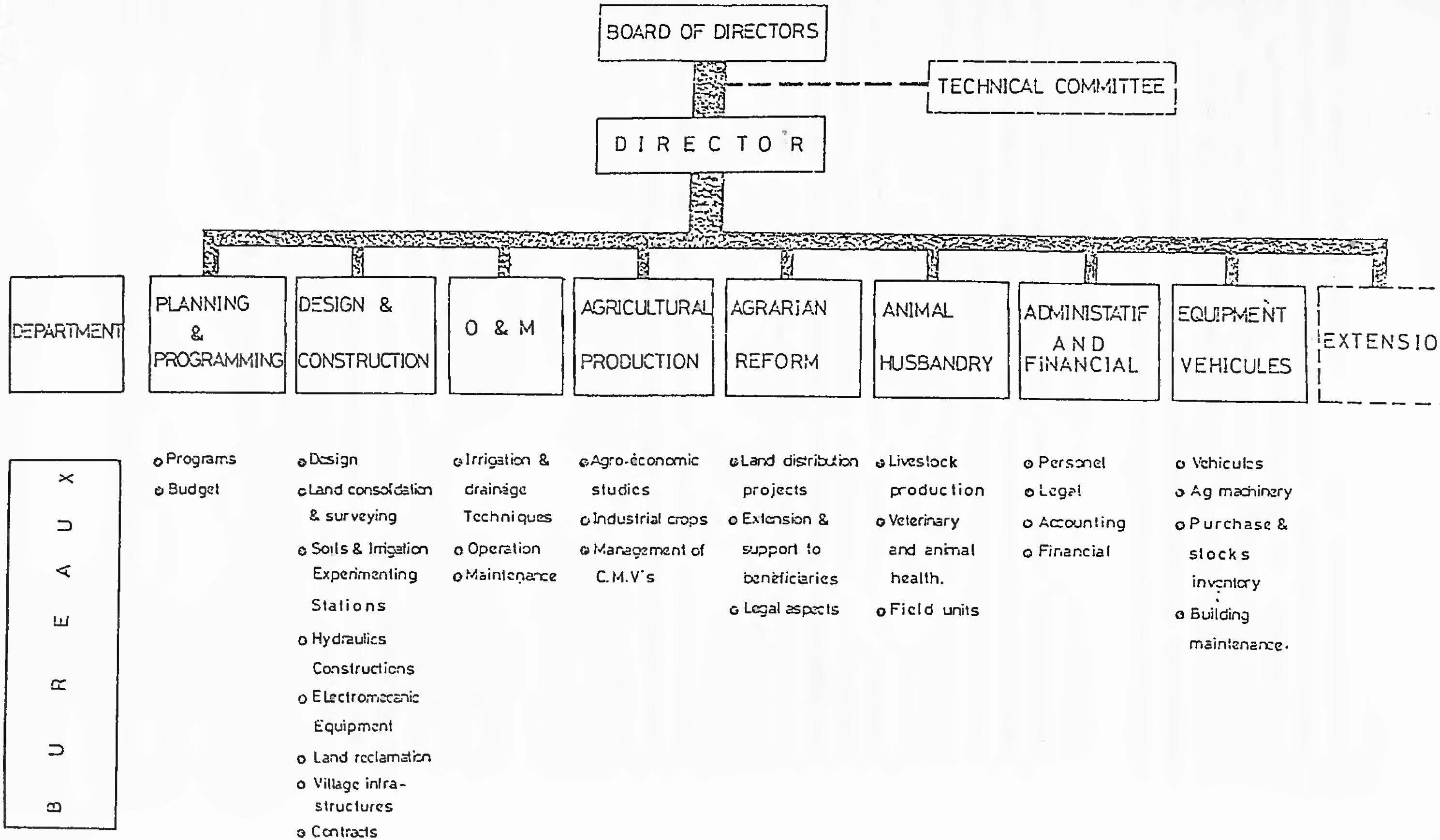
Each ORMVA is administered by a board of directors chaired by the Minister of Agriculture and composed of:

- all the directors of the central directorates of MARA;
- representatives of all the departments of other Ministries involved with ORMVAs activities;
- representatives of the national organizations of farmers.

The board meets on a semestrial basis to review the programmes and the future activities of the ORMVA, and to fix its budget.

At the local level a Technical Committee, which is chaired by the Governor of the Province and composed of local representatives of all the Ministry Departments concerned as well as of farmers representatives, meets once a month or whenever it is necessary, to examine the issues and problems faced locally by the ORMVA.

Figure 1 - TYPICAL ORGANIZATIONAL STRUCTURE OF THE ORMVAS.



A typical organization chart of an ORMVA is given in Fig 1. ORMVA is managed by a director. At the headquarters level the ORMVA is divided into departments with several bureaus or sections. Extension, which used to be a section of the crop production department, has been recently upgraded to a department with higher status and appropriate staffing. This results from the growing awareness that the ultimate responsibility of the ORMVAs is agricultural extension.

At the field level, the ORMVAs operate through the "Centre de Mise en Valeur Agricole" (CMVs). These CMVs are the basic units for plant and livestock development activities. Each CMV has one manager and at least one office employee, one employee responsible for the supply of inputs and several extension agents. For those crops for which it supplies inputs (sugar-beet, wheat, cotton, sugar-cane) ORMVA, through the CMVs, determines the appropriate varieties of seeds, as well as the type and quantity of seed, fertilizer and pesticides per hectare and specifies when the farmers will fetch and use the inputs. ORMVA provides also farm machinery services to farmers but this activity has been decreasing in light of its lack of effectiveness.

Most ORMVAs have established subdivisions which supervise the activities of the CMVs operating within their territorial boundaries and co-ordinate the activities of the various departments on the field.

3.3 ORMVA's Budget

ORMVAs are semi-autonomous organizations. Administrative and technically they are overseen by the Ministry of Agriculture and Agrarian Reform and financially by the Ministry of Finance. Each ORMVA has its own budget. Separate budgets are appropriated for investment and operations. Water charges for O and M, collected by the ORMVA, remain with ORMVA. Loans to the government of Morocco by international lending agencies for development projects are processed through the Ministry of Finance and reappropriated to the ORMVAs through the annual budget.

4. THE "TRAME B" MODEL

Another interesting feature of modern irrigation projects in Morocco is the model used for land consolidation and the irrigation system layout know as "Trame B" or "Rational Layout". The model is unique and incorporates three important complementary features:

- equitable and efficient water distribution,
- annual and seasonal crop diversity,
- accommodation of wide variations in individual land ownership patterns in such a way that limitations in the size of individual land holdings are not obstacles to the adoption of modern technology.

4.1 Land consolidation

In the "Trame B" the fragmented holdings are consolidated and reshaped in rectangular blocks of about 30 ha (see Fig 2). Each block is divided into the number of units required for the crop rotation (e.g. four when the crop rotation is a four-year cycle). The farms are perpendicular to the plots. In this way all the farms have the same length (i.e. the length of the block) and their width is equal to their size divided by this length. The crop to be grown is prescribed by the crop rotation unit which is known as an assolement. Thus, fields with one crop are contiguous, facilitating collective action (including irrigation). Ploughing can be mechanized using the public machinery pools provided by the CMVs.

Land consolidation programmes not only establish more viable family holdings by eliminating fragmentation and prohibiting future subdivisions but also allocate to each family in addition to cultivated land a plot designed for housing within new village centres often located around the traditional ones and at a reasonable distance from the cultivated land. Farmers are not allowed to build on the irrigation blocks.

4.2 Cropping pattern

The year 2000 is the horizon date of the million-hectares policy. In that year, Morocco's population is expected to reach 36-40 million. To provide

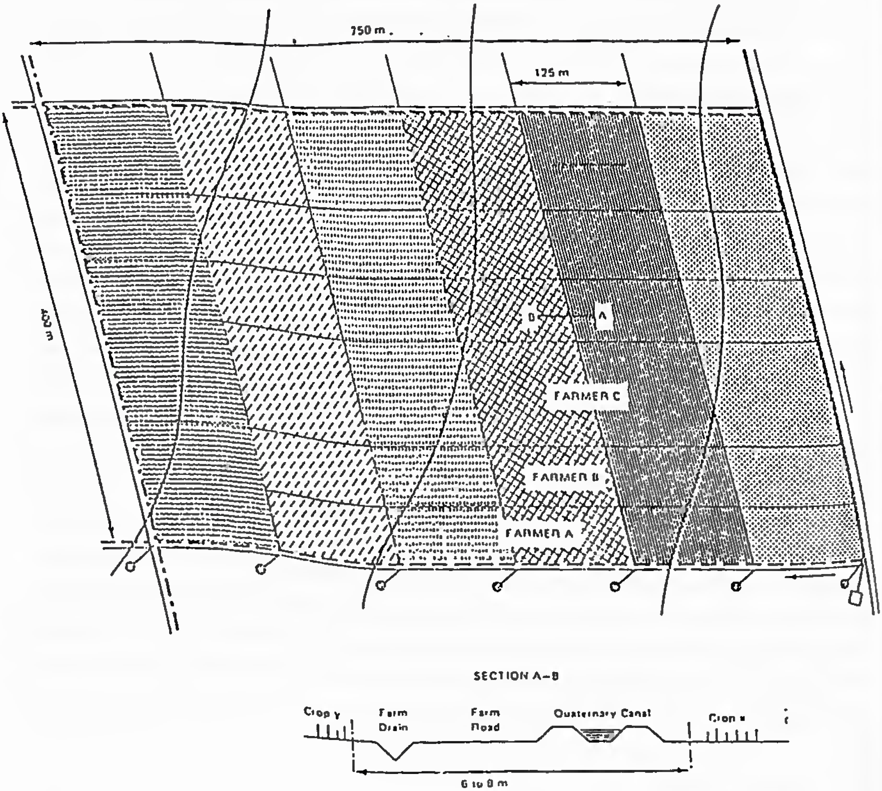


FIGURE 2 - Rational layout of an irrigation block of about 30 ha, with a six course rotation

for this population the government has developed a comprehensive agricultural development plan for the perennially irrigated areas (see Table 2). Additionally, it has developed a specific plan for most of the major food commodities produced by irrigation development.

Cropping patterns are set by the ORMVA technical committee taking into consideration local conditions and national planning goals. They are mandatory. There are several basic cropping patterns. For example where a four-year rotation is imposed it consists typically of sugar-beet, wheat, cotton or vegetables and fodder crops.

Table 2. Planned Agricultural Production in the Perennially Irrigated Areas, by AD 2000.

Production category	Hectares
Citrus	75,000
Market Vegetables	200,000
Fodder Crops	200,000
Sugar Cane	135,000
Sugar Beets	70,000
Cotton	50,000
Cereals	180,000
Olives	275,000
Rice	35,000
Miscellaneous	40;000
Total	1,260,000

4.3 The irrigation system layout

4.3.1 Gravity systems

Until 1975, the gravity type of irrigation was predominant, because surface methods are less expensive than sprinkler systems which require high investments for initial installations besides high operating costs; and because of the lack of a big irrigation industry in the country and the availability of a cheap local labour force.

In the "Trame B" each crop plot is irrigated by a permanent watering ditch or quaternary canal. Quaternary canals are trapezoidal earth ditches constructed during land levelling operation. Their spacing is regular and approximately equals the length of the furrows and border strips as determined by soil permeability and slope but also by the farm size distribution in the scheme. The spacing generally varies between 100 and 200 m. The maximum length of the quaternary canals (equal to the width of the block, ie, the length of the crop plot) is limited by seepage losses to approximately 400 m (about 5 per cent infiltration losses are allowed). Each quaternary canal is designed to carry a fixed flowrate or water duty of 30 l/s. Farmers should use siphons to supply water to their fields from the watering ditches.

Each quaternary canal is supplied through an off-take by a tertiary canal. Generally, tertiary canals are made of pre-cast concrete semi-circular elements lying on supports perpendicular to the quaternary canals. They are designed to carry up to 90 l/s (ie, 3 water duties). When they carry more than one water duty their off-takes are equipped with calibrated modules. The length of the tertiary canals varies from 600 to 2,000 m depending on whether they supply one or two or three irrigation blocks. Their spacing equals the length adopted for the quaternary canals, ie, approximately 400 m.

Water is supplied to the tertiary canals by secondary canals which are in most cases made of semi-circular concrete elements lying on supports. Length and spacing of secondary canals depend on the topography, the layout of the primary or main canals and the maximum length of the tertiary canals.

Most of the systems are upstream regulated. However, some recent systems have been developed partially (up to the secondary canals) with downstream regulation.

The "Trame B" defines an orthogonal layout of the irrigation system (see Fig 2) to which are superimposed, in a parallel manner, the drainage and road systems.

4.3.2 Sprinkler systems

Since 1975, there has been progress toward sprinkler irrigation to overcome some of the major defects of the existing surface irrigation systems such as:

- low efficiency of irrigation;
- delayed and poor utilization of existing potential; and
- the constraint of mechanical harvesting of sugar-cane: the harvesting machines require long working runs (greater than 250 m) for their economic operation while the spacing of the quaternary canals is less than 200 m.

About 300,000 ha in LSI perimeters are intended to be put under sprinkler. Typically, a collective sprinkler irrigation project in Morocco, covering an area of 1,000 to 3,000 ha consists of:

- a water supply from a concrete-lined downstream-regulated canal:
- a pumping plant complete with inlet structure for drawing the water from the canal and providing pressure for distribution and application;
- a regulating device, generally an elevated tank inserted between the network, with its variable demands, and the pumps which have a much more constant output;
- a fixed distribution network of buried main and submain pipelines to distribute water under pressure;
- off-takes (hydrants) along fixed distribution network to serve generally two adjacent crop plots of the same irrigation block. Each off-take is fitted with a flow limiter, a pressure regulator and a meter for measuring the volume of water delivered.

Farm sprinkler systems (pipes and sprinkler heads) are shared by all the farmers of the same irrigation block. The on-farm system consists of portable aluminium pipes with sprinkler heads directly attached or mounted on skids and fed by flexible hoses. For sugar-cane, sprinkler heads are individually owned by the farmers. They are mounted with quick coupling on flexible polyethylene pipes supplied from the hydrant by an aluminium manifold.

4.4 Water distribution

4.4.1 Gravity Systems

In "Trame B", at block level, irrigation is conducted collectively. Water is delivered from the tertiary canal to each crop plot on a rotation basis. Water from the quaternary canal is distributed by rotation among the farmers who should organize themselves in moving the collective siphons. Delivery time to each crop plot depends on the crop water requirements and the area to be irrigated with the fixed water duty of 30 l/s. Thus, the irrigation programme is scheduled on the basis of the number of crop plots instead of individual farms. Farmers are charged for water delivered to their fields on volumetric basis whether they have used it or not. The conveyance and distribution systems are designed to operate in a continuous way (including irrigation at night) during peak period. (but see p 5.1)

4.4.2 Sprinkler Systems

The same principles for water distribution have been adopted for sprinkler irrigation as those described above for surface irrigation, with slight differences. Sprinkler systems are designed to operate on-demand at the hydrant level. Downstream of the hydrants farmers should organize themselves to rotate the laterals and sprinkler heads as required. The dimensions of the crop plots are set so that the mobile sprinkler equipment operates continuously during the peak period for the most demanding crop. Flowlimiters of the hydrants are calibrated to prevent surplus water application by the equipment. Farmers should pay for the water on a volumetric basis, (but see 5.2).

5. FUNCTIONING OF THE IRRIGATION SCHEMES IN PRACTICE

The LSI schemes have been quite successful in terms of agricultural production. Indeed, in most of them, overall water use is now about 80 per cent of potential. Cropping intensity has steadily increased to 98 per cent but still remains below the average potential of 130 per cent. Average yields have increased steadily. This increase in yields, together with the increase in irrigated land, has resulted in substantial increases in the production of major irrigated crops. The output from irrigated area grew at about 7.9 per cent per year between 1960 and 1983. The most significant production increases have been in dairy and meat products (27%), vegetables (17.5%), cereals (17.4%), citrus (17%) and sugar (6.2%).

The enforcement of the mandatory cropping pattern has not been a major problem. To a significant degree, however, respect and non-respect of it depend on the type of assolement and crop. For example in the Gharb zone, the sugar-cane assolement is usually respected because sugar-cane is not only the most profitable crop in the planned rotation because of government price supports (up to three times more profitable) but requires less time and effort. Where the prescribed crop is not grown in the assolement it is often because sugar cane is grown instead of the assigned crop. The ORMVAs for their parts have generally been most strict with regard to the sugar-cane, sugar-beet, cotton and rice elements in rotations. They are more tolerant of change in other crops.

The "Trame B" has served for over twenty years as *the* model for LSI projects in Morocco. This is not due to habit but mainly because the technical designs associated with it are considered, with minor exceptions, extremely satisfactory. However, it has raised several management problems some of which are described below.

5.1 Gravity systems

There are three major defects of gravity systems:

- Farmers have stuck to their traditional and inefficient methods of farming including irrigation. Land levelling is often damaged.

Breaches instead of siphons are used to supply water from the quaternary canals to the fields. In some areas excess water applications have caused serious waterlogging and salinization problems (Tadla and Doukkala);

- Settlement of tertiary or secondary canal supports due to lack of geotechnical studies often cause leakages and even collapses of sections of the canals. Leakage problems are also aggravated by the stealing of the rubber seals placed between canal elements;

- In some irrigation schemes farmers refuse to irrigate at night (El Antaki and El Bekri, 1984). This causes not only under-irrigation with adverse effects on yields but also waste of water even though farmers are charged for all the water delivered;

- Perhaps the most significant problems are related to water distribution. The standard procedure built in to the rational layout is often not followed. Most ORMVAs have established a rotation system based on delivery time to each individual farm upon request. The global demand remains of course restricted by the design capacity of the system. This procedure has not only generated a tremendous amount of bureaucratic paperwork (Ait Kadi, 1979) but also caused some anarchy in the system operation. Back and forth movements of the water in the canals associated with short period of watering of quaternary canals cause important water losses (Ait Kadi, 1986). Why is it so? The most significant reasons appear to be: (i) in the early stages, cropping intensity was low and consequently water was relatively abundant; (ii) non-respect by the farmers of the mandatory cropping pattern and layout due mainly to lack of enforcement of some land-related provisions of the Law (reparcellization due to inheritance for example[4]) and lack of adequate extension; (iii) ignorance of the standard procedure by those in charge of system operation!

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[4] Reparcellization is often the result of the land consolidation procedure which considers only the land titles and not the existing farm units.

5.2 Sprinkler systems

ORMVAs having sprinkler irrigation had to face some serious management problems among which the most important ones are (Ait Kadi, 1986):

- Breakdowns of pumping plants have sometimes caused serious problems mainly because of the long delays required for repairs. This results from: (i) lack of trained maintenance personnel; (ii) lack of spare parts; (iii) lack of authority at the field level to spend money for undertaking urgent maintenance work.

- Water meters have largely disappeared from the hydrants. Thus, most of the ORMVAs charge for water on a volumetric basis calculated from the total volume measured at the pumping plant and the crop area.

- From the beginning the management of the mobile sprinkler equipment has been a major concern to the ORMVAs. The acquisition of pipes, valves, sprinkler heads, etc, often imported, has suffered from the lack of national quality standards. Furthermore, defective equipment has often escaped through the checking system before its distribution to the farmers and has had to be replaced afterwards. Therefore, later on, farmers thought they should rely on the ORMVAs to replace their deteriorated equipment. Who should receive and be responsible for the equipment at the block level? In the absence of formal water users associations most ORMVAs have preferred working through a representative elected for each block. This has not been always successful. Therefore, all the farmers of the same block are made responsible for shared equipment. Often they immediately divide it among themselves. The result is an anarchy in the use of the equipment and nobody irrigates adequately. This situation has led the designers to seek to individualize the portable equipment whenever possible. This was possible for example in the agrarian reform lots which all have the same size (ie, 5 ha) by rotating the standard layout by 90 per cent. As stated earlier, even if the farmers are fully responsible for O & M of portable equipment they are still given considerable assistance by ORMVAs.

Most management problems, described above, are mainly the result of neglecting O & M during the early stages, on one hand, and the very small attention paid to the social component of the system and the lack of adequate extension on the other hand.

In general, O & M has been a neglected aspect of irrigation development until quite recently. Indeed, before 1976, O & M divisions were located either in the Equipment Department or the Crop Production Department and had a low status within the ORMVAs. (Ait Kadi, 1986). Staffing for O & M was inadequate and personnel were not properly trained. It was difficult to attract people because design and planning staff were more highly regarded. The O & M budget was small because the emphasis was on equipping the systems and most of the budget was devoted to that end. Since 1976, much greater attention is being paid to O & M issues. In most ORMVAs an O & M department has been created with higher status and appropriate staffing but still with a very limited budget. In recent years, O & M expenditures have been only 65 per cent of those estimated as needed for adequate operation and maintenance of the network. The collection rate with respect to water charges has steadily increased but remains still low (43 per cent of total amounts due, though in some schemes it is close to 100 per cent). With recent increases, the level of water charges should recover 100 per cent of O & M costs in gravity systems and about 65 per cent in sprinkler systems.

Furthermore, the primary responsibility for O & M still lies with the ORMVAs officials. Although, theoretically, the "Trame B" intrinsically provides the basis for local irrigation associations by bringing farmers together in organizing the irrigation process, in using the system, and in collectively carrying out some of the cultivation work, in effect the creation of Water Users Associations that would formally undertake part of the O & M duties has been slow and is really at its early stages in most LSI schemes. However, it is worth mentioning the attempt made in the Haouz zone to make the traditional farmer organization undertake some of the O & M responsibility of canal maintenance up to the secondary canals. The experience has been successful mainly because the layout of the modern system was superimposed on the traditional one in a manner that did not upset the existing traditional social organization.

A new law in 1984 was designed to facilitate the process whereby ORMVAs create Water User Associations with responsibility for O & M to the maximum extent possible.

The "Trame B" is a "coherent whole" where collective discipline is an essential prerequisite (Ait Kadi, 1986). The importance and role of the farmer as the nodal point for efficient and effective use of the system has been neglected. The success of the "Trame B" depends on the capability of farmers in adopting and utilizing the growth environment of agricultural production that is created. From the beginning in most ORMVAs, there has been a lack of focus on extension activities. However, there is now a growing awareness that the ultimate responsibilities of the ORMVAS is agricultural extension education. An extension Department has been created in all the ORMVAs and it is hoped that Water Users Associations will serve as a communication link and forum for disseminating information and assistance on improved water use, agricultural practices and technologies.

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IRRIGATION MANAGEMENT NETWORK

STRATEGY DEVELOPMENT IN IIMI

Roberto Lenton

ODI/IIMI Irrigation Management Network Paper 88/1e June 1988

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STRATEGY DEVELOPMENT IN IIMI

THE INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
FOUR YEARS OF DEVELOPMENT

Roberto Lenton

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STRATEGY DEVELOPMENT IN IIMI

THE INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
FOUR YEARS OF DEVELOPMENT

Roberto Lenton

This paper was originally presented as the annual Gerald Lacey Memorial Lecture at a meeting of the British National Committee of the ICID, at the Institute of Civil Engineers in London on May 23 1988. Dr Lenton noted his pleasure at the association between ICID and IIMI, and at the honour of being asked to give the memorial lecture to a former principal of the University of Roorkee, which he had often visited when he worked in India.

1. INTRODUCTION

First, I would like to outline briefly IIMI's origins, history, and mission. Second, I will highlight some of our achievements. And third, I will discuss at some length the Institute's current strategy for achieving its mission and objectives. This will be a brief summary of the "fourth revision" of the strategy document, which has been prepared by my colleague Charles Abernethy on the basis of a series of staff strategy workshops held over the last few months. Further changes are likely before our strategy receives final approval by IIMI's Board and Support Group as a guide to the Institute over the next five to ten years.

2. ORIGINS AND MISSION

2.1 Origins and establishment

IIMI is an international institute whose efforts are devoted solely to the subject of irrigation management. It was established in July 1984. The decision to create IIMI was made in late 1982, when representatives of 15 international donor agencies assembled to form a support group. However, the process that led to IIMI's creation began much earlier.

The subject of water management in agricultural development first surfaced at a meeting of the Technical Advisory Committee of the Consultative Group for International Agricultural Research (CGIAR) in the early 1970s. The possibility of establishing an international centre to carry out multidisciplinary research in water management was discussed at some length, and at the close, TAC, as it is called, commissioned the first of many study teams to consider the possibility of such an initiative. Three motivating factors helped develop a clear consensus to establish the Institute.

First, it was widely recognised that deficiencies in the management of irrigation, and related institutional problems, were becoming a major constraint to the realisation of agricultural production potential.
Second, the international centre approach, characteristic of the CGIAR, had been successful in alleviating other constraints to agricultural production; many felt that a similar impact could be made by establishing an irrigation management centre. Third, as it became clear that problems in irrigation were specific to particular locations or countries, many people foresaw a critical need to strengthen national institutions and programmes.

Despite the debates and lengthy discussions that prevailed during that period, the Institute that we have today is very much along the lines of what was suggested in the early '70s. And that is a multi-disciplinary, decentralised, international centre, which works in operating irrigation systems in developing countries in collaboration with the agencies that operate those systems. IIMI, in effect, goes to where the problems are.

2.2 Mission

IIMI's staff and management have evolved the following mission statement in order to express concisely the set of objectives formally given to the Institute in its founding charter:

> "To strengthen national efforts to improve and sustain performance of irrigation systems in developing countries, through the development and dissemination of management innovations".

2.2.1 Management innovations

These are IIMI's end product. The term covers the range of ideas, practices, devices and approaches taht can be used to improve irrigation managment. It covers not only management practices per se, but also the 'upstream' policies that one needs to facilitate good management. It also includes the 'downstream' technologies that are needed to make irrigation systems more manageable. Furthermore, the term 'innovative' is uded in the sense that it is used in development economics; it implies technical change, bnut not necessarily a new idea. The application of a principle used in one system to another is one example of what we have in mind.

Second, development and dissemination is our mission. We are not only in the business of developing better means of managing systems; we hope also to work to extwnd the learning to those responsible for implementing change.

3. INITIAL ACCOMPLISHMENTS

3.1 Organization

In the initial years following IIMI's establishment, and under the leadership of its first Director General, Dr. Thomas Wickham, the Institute moved rapidly to develop research, training, and information programmes in several Asian countries. IIMI's organisational achievements in the four years since its establishment can be listed.

IIMI now has resident programmes in Sri Lanka, Pakistan, the Philippines, Indonesia, and Nepal. During 1988, four new programmes will be established in Bangladesh, Sudan, Morocco, and Burkina Faso. In each of those countries, IIMI has developed collaborative relationships or agreements with the host governments and a large number of national irrigation-related research institutions and agencies.

IIMI has also established collaborative agreements with a number of international institutions that work in developing countries. These include not only collaborative arrangements with the International Commission on Irrigation and Drainage (ICID), but also with the Centre de Formation Internationale a la Gestion des Ressources en Eau (CEFIGRE), the Overseas Development Institute (ODI), and other key institutions. It has also signed formal agreements with the International Rice Research Institute (IRRI) and the International Food Policy Research Institute (IFPRI). In 1988, the Institute's budget is over seven million dollars, almost double our budget last year.

Through its Information Programme, IIMI has built up a library with approximately 5,000 titles, a database with 2,200 listings, and a mailing list with 3,400 names from 116 countries. IIMI has published nearly 40 titles and disseminated about 60,000 copies. Through its collaboration with ODI, IIMI has assisted the development and sissemination of the ODI-IIMI Network papers and newsletter.

3.2 Research

In research and program development, IIMI has made progress in several areas.

3.2.1 Irrigation management for diversified crops in rice-based systems

IIMI's first two years of research in Sri Lanka, the Philippines, and Indonesia have helped to identify the technical and socio-economic constraints to effective irrigation management for non-rice cropping in rice-based systems during the dry season. IIMI staff, and the staff of its collaborating agencies, are currently pilot testing recommended management practices in systems operated by those agencies. More recently, IIMI has joined IRRI in research to further strengthen both institutes' efforts in this area.

3.2.2 Mobilisation of resources for irrigation O&M in South and Southeast Asia

In early 1986, IIMI concluded a study to document and assess the way financial and human resources are mobilised to support O&M costs in Indonesia, South Korea, Nepal, the Philippines, and Thailand. The study found that the mode of financing, (i.e., whether an agency receives funds directly from the government treasury, or is semi-autonomous and dependent on collecting funds directly from users), has significant impact on its responsiveness and performance. Five country reports were prepared for publication, and a series of recommendations made to the ADB and its member countries on appropriate strategies for resource mobilisation.

3.2.3 Irrigation institutes

IIMI's research on institutional issues has been carried out as a closely integrated component of its other research activities. It has focused on two levels: farmers' irrigation behaviour, including agricultural decision-making, communication, and implementation processes; and the interactions among farmers and agency officials. IIMI has carried out extensive research on the behaviour of farmers, and farmer-agency interactions, particularly in Indonesia, Sri Lanka, and the Philippines. Research on internal agency processes and how they affect the actual management and performance of irrigation systems was initiated in Sri Lanka and Indonesia; this work is currently being expanded, and is now shifting to give greater attention to testing management innovations in collaboration with irrigation agencies.

3.2.4 Irrigation performance monitoring and evaluation

IIMI's research in this area has focused on developing methodologies for monitoring and evaluating the performance of irrigation systems. In the process, IIMI has developed a methodology for measuring field-level water adequacy and equity of water distribution for lowland rice irrigation systems. The methodology is based on three indices for measuring the frequency, duration, and intensity of water stress, all of which have correlated well with yield data from Indonesia and the Philippines.

3.2.5 Rehabilitation processes

In 1987, IIMI initiated a major ADB-assisted study in Sri Lanka which focuses on the Uda Walawe System Rehabilitation Project, a relatively capital-intensive rehabilitation scheme which includes covenants for farmer participation. The result of this work will be a series of recommendations for improving the rehabilitation process in Sri Lanka and elsewhere.

3.2.6 Design and management interactions

IIMI initiated two projects in Sri Lanka in 1987 that consider the impact of design on management. The first comprises comparative studies of the impact of alternative designs on performance and manageability across a number of irrigation systems. The focus is on four irrigation schemes that exhibit different design concepts for water level control in their main canals, and for discharge control at their offtakes. In the second study, IIMI is testing a pilot application of a flow simulation model. The project is applying a model elsewhere to solve the dynamic hydraulic equations of an operating main canal. If successful, the simulation model will give staff a tool to test a variety of main system design and management scenarios. It will also offer a training tool for system managers to familiarise themselves with modern techniques of canal regulation.

3.2.7 Assistance strategies for farmer-managed irrigation systems

IIMI's efforts in this area have been concentrated in Nepal, where over 80 percent of irrigated area is owned and managed by farmer organisations or farming communities. In one study, IIMI collaborated with the Water and Energy Commission Secretariat to identify irrigation systems in the Indrawati River Basin with underutilised land and water resources. The purpose was to develop and test approaches to exploit these resources more effectively. In the process, IIMI developed a methodology to rapidly assess the efficiency and institutional arrangements of farmer-managed irrigation systems.

3.2.8 Professional development and information exchange

In its Professional Development Programme, IIMI co-hosted three annual six-week training courses in association with the Economic Development Institute (EDI) of the World Bank and the ADB (in 1986) through which 71 participants from 16 countries have benefited. IIMI has also supported five Master's degree Fellows from four countries; six pre-Doctorate Fellows from four countries; five post-Doctorate Fellows from three countries; and two Special Awardees from two countries. The Institute has sponsored or co-sponsored ten workshops with participants from countries throughout Asia and Africa.

4. STRATEGY

4.1 Criteria for developing IIMI's strategy

The field of activities covered by IIMI's mission is vast, and requires the services of people of many disciplines and skills. However, IIMI is not a large institution. As I found in my first year as Director General, there is a strong temptation to respond to many needs, and thus to spread our resources too thin.

It is thus important for the Institute to determine what it does best and where it will have the greatest impact. There are many specialised irrigation institutions working around the world, such as ICID. IIMI has to strive to ensure that it does not become involved in activities that other institutions are already doing adequately.

For these reasons, about a year ago IIMI embarked on a process to prepare a comprehensive programme strategy to clarify IIMI's overall mission, and its comparative advantage in relation to other institutes. By the end of the year, IIMI will complete a strategy document to help ensure that the Institute remains on course over the next five to ten years.

IIMI's concern, according to its title and its mission statement, is management methods in irrigation systems. It is appropriate to begin, therefore, by defining the domain of irrigation management as follows:

> "Irrigation management is the process in which institutions or individuals set objectives for irrigation systems; establish appropriate conditions, and identify, mobilise, and use resources, so as to attain these objectives; while ensuring that these activities are performed without causing adverse effects."

Before I proceed to analyse this field, it is desirable to clarify what "irrigation" itself includes, and the analytic framework which we feel is appropriate for studying its management.

Definitions of irrigation are numerous. The word is used with two levels of meaning: a narrow, functional one, and a broad one that incorporates social, institutional, agricultural and other connotations. In its restricted, functional sense (which we shall distinguish by calling it "irrigation technology") a suitable definition is:

> Irrigation technology is a set of human activities which aim to augment and control the supply of water to the soil, for the purpose of enhancing the production of crops.

This "water-delivery" definition constitutes the original meaning of irrigation. However, the word irrigation has acquired a much broader sense, especially in developing countries, where governments often make large investments in irrigation systems for various purposes of national policy. When we speak of managing irrigation, it is not enough to consider only whether water is manipulated correctly. Though this is certainly vital, it is also necessary to ensure that a variety of human, agricultural, and economic aspects are taken into consideration, before we can assert that an irrigation enterprise is adequately managed and sustainable.

Because irrigation can be interpreted at these two levels, the terminology "irrigation water management" is frequently used, meaning the arrangements for delivering water to fields at prescribed places, amounts and times. But when people speak of "irrigation management," they usually mean management systems related to the broader scope of irrigation. This also is IIMI's interpretation.

There are many methodologies for analysing management. The system used here is adapted from the management model of Professor A.A. Kampfraath, Head of the Department of Management Studies of Wageningen Agricultural University in the Netherlands.

The concerns of irrigation management can be divided into five very broad categories:

1. Setting <u>objectives</u>.

2. Establishing adequate <u>conditions</u>, and acquiring resources, for the achievement of those objectives.

3. Controlling <u>processes</u> towards achievement of the objectives.

4. Arranging all these activities in ways that are appropriate to the external <u>context</u>.

5. <u>Renewing</u> or re-conditioning the system so as to enhance its capacities.

Some would add a sixth concern: performance monitoring, to see whether or not objectives are achieved. That is certainly a vital task of managers. It must, however, be treated as an integral part of our third concern, process control, which cannot be performed properly in the absence of monitoring and its associated follow-up activities, evaluation and feed-back into corrective measures.

Next we can identify a number of major sectors or factors which determine the effectiveness and efficiency of irrigation management, and thus one level of irrigation performance. The following scheme of fourteen major factors includes most of the questions that give rise to practical management problems. They are grouped into five sets, representing objectives, conditions, processes, context, and renewal.

1. Irrigation policies

2. System installation
   Institutions
   Governance

3. Management of water
   Management of land
   Management of crops
   Management of institutions
   Management of finance
   Management of facilities
   Management of information

4. Contextual factors

5. Improvement of physical facilities
   Institutional reform

Some of the factors identified in this analysis (such as the management of water) are usually subject to the direct control of a managing agency, and some (such as the management of land and of crops) are usually not. Since the performance of the system is significantly affected by those aspects that are outside its direct control, a managing agency cannot ignore what happens in these sectors. It must find ways of influencing them.

From among the management factors identified above, IIMI has identified six themes on which it will initially build its programmes. These have been selected by taking into account IIMI's institutional culture, its programme principles, and its comparative advantage. Let me briefly describe each of these three criteria.

4.2 IIMI's culture

Certain values are widely shared among IIMI's Board and staff. These values govern the conduct of its work, and guide the Institute in making choices between alternative courses of action, and in determining priorities that are consistent with its mission. They are:

- Promotion of multi-disciplinary, collaborative, field-based research. This involves using real irrigation systems as field laboratories, rather than developing special experimental facilities, and employing a systems approach.

- Emphasis upon solving real problems. This in turn implies ensuring that impacts reach clients and ultimate beneficiaries and collaborating with client agencies to adapt and implement management innovations, and maintaining a relatively small nucleus of headquarters staff, with a majority of staff placed in direct contact with practical management problems.

- Ensuring that IIMI's products and services achieve standards of excellence. This implies international recruitment of the most qualified specialists in the field, drawn from all parts of the world; undertaking long-term programmes when such effort is required; and focusing efforts on those things that IIMI can do well.

- Fostering the increased autonomy of client agencies, in keeping with IIMI's mission to strengthen national efforts. The ultimate criterion of success will be the elimination of the need for IIMI to continue its assistance.

4.3 Programme principles

There are certain principles that must guide the methodologies of IIMI's studies, and will animate all its work, regardless of the particular programme theme. All of these principles are permanent characteristics of IIMI's work. It is possible that, with the passage of time, it will prove desirable to extend or redefine some of the six research themes described later; but IIMI sees the principles enunciated below as durable and fundamental:

- Measurement of irrigation performance, and the use of quantitative performance measurements as the objective criteria of the success or otherwise of management innovations and changes.

- The formulation of objectively-testable hypotheses about the various cause/effect linkages, to develop a capacity to predict the consequences of interventions.

- Analysis of interactions between the design of an irrigation system and its management in a given environment.

- Analysis of effective irrigation institutions, and of institutional change and reform.

- Application of the principles and practices of modern management to the management of irrigation systems.

4.4 IIMI's comparative advantage

There are already a range of groups and institutes, in many countries, which have programmes of work that are in one way or another aimed at the improvement of irrigation or of irrigation management. For example, many specialised institutions exist which are studying one or a few aspects of irrigation systems. A large number of training courses in irrigation are offered around the world, particularly on the technical aspects of irrigation engineering. Information exchange systems and information databases in irrigation exist at the ICID Headquarters in New Delhi; the ODI, London; and the Commonwealth Agricultural Bureaux International (CABI).

Thus, IIMI is by no means the only institution playing an active role in improving irrigation management. It has, however, certain features that are unique to it. These features define IIMI's comparative advantage, vis-a-vis other institutions in the field. IIMI will develop its activities in such ways as to use and develop the following special features:

- An international status, and open international recruitment policies, enable IIMI to be a neutral, objective observer, not identified with a particular country, particular discipline or a particular solution to irrigation management problems;

- A multi-country focus enables the Institute to test potential irrigation management innovations in various contexts, and to promote inter-country exchanges of ideas and experiences;

- A long-term presence and resident staff in selected countries enable IIMI to participate in sustained action research on important irrigation management problems, and to develop familiarity with the environments that influence them;

- An emphasis on collaborative investigations and problem-solving helps IIMI to work effectively in this mode with a number of different national agencies simultaneously in a given country, rather than being tied to specific projects or agencies;

- A combination of core and project funding facilitates a broad, multi-discipline "programme" approach, and provides IIMI with sufficient flexibility to address key long-range irrigation management problems.

There are other institutions characterised by some of these features. IIMI will aim to build up partnerships with these, and to take advantage of complementary strengths.

On the other hand, IIMI does not aim to develop its strengths or research facilities, in any one discipline, in order to rival the existing single-discipline institutions in fields such as hydraulic engineering, irrigation agronomy, or computational modelling. It recognises that its comparative advantage does not lie in that pursuit. IIMI's policy will be to develop co-operative, not competitive, relationships with established institutes in such fields.

5. SELECTION OF PROGRAMME THEMES

In selecting a limited set of major themes, IIMI does not imply that it will neglect all other aspects of irrigation management. All those fields that were identified earlier are within IIMI's general field of interest, and it must be aware of developments in all of them. But on the other hand, it is necessary to recognise that IIMI cannot aspire to do everything.

The selection of themes guides staff recruitment policies, and helps IIMI to arrange an appropriate balance of interests and disciplines. Further, by giving its programme a thematic structure, IIMI can make best use of a small nucleus of headquarters staff, whose function is to integrate or synthesise the results of many country studies, in order to perceive general trends, and to make inter-country comparisons.

In arriving at a particular set of six themes on which to build its programmes, IIMI has been guided by three considerations, which are derived from the values, principles, and comparative advantage of the Institute:

1. Clients' needs. IIMI will address problems that correspond to needs felt and expressed by its primary client group, irrigation agencies, and will aim at developing practical solutions;

2. Impact potential. IIMI will work on those problem areas in which solutions seem likely to have maximum impact.

3. Comparative advantage. IIMI will concentrate on themes where it possesses a comparative advantage relative to other institutes studying aspects of irrigation. This implies special attention to multi-discipline questions, and to integrated management rather than single-discipline questions.

From the fourteen major factors of irrigation management IIMI has selected six on which it is initially focussing its efforts and building its programmes. These are: (1) Irrigation Institutions; (2) Management of Water; (3) Financial Management; (4) Management of Facilities; (5) Institutional Reform; and (6) Governance.

5.1 Irrigation Institutions

Under this first theme, IIMI concentrates on the question of determining the most appropriate management conditions. This means assessing necessary management resources of all kinds: numbers, quality, knowledge and skills, and deployment of agency personnel; other essential resources such as information gathering arrangements, communication systems, logistic facilities; the degree to which field decisions are conditioned by operational rule systems. It includes analysis of the ways by which (for a new irrigation development) the set of managing agencies is initially determined, as well as the interfaces between components of that set. It also includes study of the ways by which objectives (both overall and at subordinate levels) are set; and of the mechanisms for monitoring actual performance, and for responding to non-achievement of objectives.

5.2 Management of water

This theme concerns processes in the physical system. It encompasses operations of a canal system down to the delivery of water to farmers or farmer groups, so it implies awareness of crop needs for water, and of the constraints on water delivery that may be imposed by such aspects as soil type or land shaping.

The past decade has seen a number of field studies on tertiary water distribution, often going under the name "on-farm water management". There have been far fewer studies of what are referred to as "main-system" operations, and on the basis of impact potential this is chosen as an area where the lack of past analyses suggests considerable possibilities of improvement.

5.3 Financial management

Having identified the management conditions that a system requires, there arises the associated question of mobilising resources (usually financial) in order to secure and sustain these conditions. This problem is currently exercising many managing agencies: by our first criterion, clients' interest, it is a prominent issue. Expenditure may be defrayed in many ways: sometimes by recovery of irrigation service fees from beneficiaries; or by contributions partly in cash and partly in labor, by beneficiaries; or funds may come more or less directly from national treasuries. IIMI's comparative advantage lies not in the narrower financing questions of how much should be collected and from whom; but rather on the broader, interdisciplinary questions of the interactions between finance, agency performance, and overall system performance.

5.4 Management of facilities; maintenance and rehabilitation

Irrigation systems deteriorate physically, like any other man-made thing. Structures may rust or be wilfully damaged; weeds grow and sediment accumulates in canals; all sorts of factors like animals, vehicles, garbage, cause the banks and beds of canals to become deformed from their initial shape. Nearly all such deterioration detracts from the system's capacity to meet its objectives.

Management must develop an appropriate response to this fact, and the responses virtually always fall into one of two categories: maintenance or rehabilitation. These can be considered as continuous or discrete methods of accomplishing the same basic objective of keeping the system approximately in the condition for which it was intended. There is a substantial difference, however, in that a rehabilitation, conducted after a significant number of years, is usually also taken as an opportunity to upgrade and update the system: to enhance, in other words, the performance objectives of which the system is capable.

5.5 Institutional reform

The first three themes described above relate mainly to aspects of performance and management within an established institutional system. There are times when it becomes appropriate to make fundamental changes to an existing set of institutions: to introduce new ones, to abolish old ones, or to relocate the interfaces and redefine areas of responsibility between institutions. The process is similar to modernisation of the physical system: it involves (partially) returning to the system design stage, and establishing new management conditions. However, it is often much more difficult to achieve, because existing groups and institutions may resist the change.

A current example of this is the trend to promote development of farmers' organisations and to turn over to them certain functions, such as channel maintenance and perhaps fee collection, which were previously discharged by agencies of government. Studies of this "turn-over" process will form IIMI's main activity initially under this theme. A number of countries now have active policies in these directions, so IIMI's interest in it conforms to the criterion of clients' needs.

5.6 Governance

Governance is a significant part of the total set of management conditions, yet its relationship to system performance criteria such as productivity or cost-effectiveness has been remarkably little studied. A wide variety of governance models are in use, ranging from centralised ministries of government through single-system parastatal corporations to farmer-managed systems in which government agencies have no controlling voice. And, within the farmer-managed sector itself, there are a great many variants.

IIMI has chosen, initially, to focus on studies of the farmer-managed governance type. Irrigation systems built and managed by farmers exist in many countries, and in some they constitute the majority. They vary greatly in size and in organisation. Government agencies and non-governmental organisations in many countries have established active programmes aimed at assisting farmer-managed systems, and fostering improvement in them. There is considerable donor interest in funding such assistance.

6. IIMI'S APPROACH

IIMI proposes to continue to operate in a decentralised way through its headquarters unit and a number of strategically located units in other developing countries. This multi-country structure will allow IIMI to address a range of issues beyond those that could be examined in one country alone; it will also allow IIMI to achieve a significantly greater impact than could be achieved with a centralised system.

In keeping with its mission to strengthen national capacities in irrigation management, IIMI proposes to build its field-work mainly in the form of a set of country programmes. The logic of this is clear: unlike many other kinds of agricultural research, nothing of significance in irrigation management can be studied in a laboratory, and because of location-specific influences, relatively little can be studied theoretically. IIMI must therefore put its staff into direct contact with diverse irrigation-management situations in the field. Country programmes provide a vehicle for doing this.

Field programmes can be organised at differing levels of involvement, according to circumstances and resources. The CGIAR Study Team proposed six different levels of IIMI involvement, of which IIMI is initially developing three. These are non-resident programmes, in which IIMI undertakes those functions that can be done intermittently, encouraging national participation in network research; country resident programmes, in which IIMI fields international staff to pursue collaborations in action research and in training; and multi-country or regional resident programmes, in which a small staff group is based in one country, but is intended to relate also to a number of neighbouring countries.

In deciding where it should establish country programmes, and at which of the various levels of activity these should be operated, IIMI is guided by six criteria: receptivity (presence and inputs strongly desired by significant national irrigation institutions); need (to ensure that our outputs are likely to have beneficial impacts); Range and extent of irrigation (numbers of projects and diversity of irrigation types); Technical interest (countries with special concentrations of effort, or notable success, with some aspect of management); institutional strengths (for example, strong national research institutes); and administrative arrangements (legal and fiscal status).

In implementing its country programmes, IIMI intends to make partnerships and collaborative ventures a key element in its approach. The types of institutions that can be IIMI's partners include: national irrigation-managing agencies and associated research and training organizations; international agricultural research centres; other centres of excellence; and international lender and donor organisations.

Collaboration with national agencies is fundamental, for four reasons:

- IIMI's mission is an enormous one, relative to the staff and financial resources directly available to support it. To achieve a sufficient impact, IIMI must involve others, act as a catalyst, and extend its efforts, through collaborations with several national partners, rather than concentrate its efforts at single locations.

- The development and testing of management innovations involves major problems of implementation, and cannot be done without the active collaboration of existing managing agencies. To be effective, IIMI's researchers must do more than prepare reports: they must be partners in a joint effort, with clients, to develop innovations, and to see whether and how they can be implemented;

- Innovations development requires first a thorough understanding of each existing agency, and its human, financial and other constraints, before the most relevant modifications can be proposed. Such understanding can best be evolved through the close relationship with the agency which a collaborative project entails;

- Research collaboration with national partners is an excellent vehicle towards IIMI's goal of strengthening national capacities.

7. GEOGRAPHICAL CONSIDERATIONS

The problems of irrigation management, and indeed the objectives and the modes of irrigation, vary a great deal in different parts of the world. Differing terrain, climate, population density, and economic level are major determinants of these different approaches to irrigation. Superimposed on this are often certain national attitudes or orthodoxies that usually have some kind of historical roots: countries have developed their own styles of irrigation, and sets of management institutions that enshrine these. Part of IIMI's task is to foster comparisons between alternative approaches to management, and the sharing of experience between countries, in the pursuit of generic answers to certain management questions.

IIMI is itself located in the rice-based humid tropics of Asia, so it naturally began its operations in that zone. It extended at an early date into the arid and semi-arid regions through its work in Pakistan. These seemed natural choices: the dependence on irrigation in these regions is high, there are large managing agencies to study and interact with, and there are objective reasons for saying that the potential gains from improved management could be great.

In 1985, IIMI began to explore the possibility of working in Africa. This operation was undertaken in a deliberate fashion, beginning with missions to review the possibilities, leading to the development of a strategy document for the zone. On the basis of that strategy, country operations will begin in 1988.

It is not likely in the immediate future that IIMI's resources will grow to the point where it can safely undertake the substantial extra effort of embarking on resident programmes elsewhere, even though work in Latin America and in East Asia (particularly China) would hold great interest. A phase of consolidation and programme development in the present zones must precede that, and any added resources that become available should probably be aimed at making more comprehensive efforts in areas in which we are currently active. IIMI will however aim to initiate programmes, at least at the visiting level, in Latin America and China before 1992.

In the longer term, however, IIMI should aspire to have a fully international set of programmes, with country programmes in all five zones mentioned above. The possibility of achieving that is not in IIMI's hands alone, but depends on the flow of donor funds. When it seems that the time is becoming ripe for such extension, the Africa approach, with an initial exploratory team drafting a zone strategy paper, will serve as a model. IIMI now has the experience that at least a three-year time-lapse must be anticipated between the first exploratory visit and the first country programme activity, so a degree of forward planning of this kind of initiative will be necessary.

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odi-IIMI

IRRIGATION MANAGEMENT NETWORK

NEWSLETTER

ODI/IIMI Irrigation Management Network Paper 88/2a December 1988

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 with support from the British Aid programme. 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-oriented research and dissemination. Research findings and the results of practical experience are exchanged through four Networks on Agricultural Administration, 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, Kandy

The International Management Institute (IIMI) is an autonomous, non-profit making international organization 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 is joining ODI in the publication of the Irrigation Management Network papers, to enable these to appear more frequently to an enlarged membership. It has also provided equipment to link ODI's irrigation library into an international irrigation management database centred on IIMI.

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NEWSLETTER

1. NETWORK PAPERS AND DISCUSSION

All but one of the current set of network papers concentrate on the Indian subcontinent.

Venkata Reddy's paper *Development of Well Irrigation in Canal Commands: The Prospects and Some Emerging Issues*, paper 88/2b, compares two villages in Karnataka, India, one where canal and well water is used conjunctively and another where only canal water is used. Reddy shows how positive environmental and economic effects such as the reduction of waterlogging and salinity, higher value crops and higher cropping intensities can be induced by longer rotational cycles for canal water when well and canal water are used conjunctively.

Not surprisingly, Reddy finds size of landholding positively related to well ownership. His recommendation is to adopt community wells to provide access to well water for small landowners and to promote increased conjunctive use. However, his material also points to the relevance of previous ODI-IIMI papers which have shown that groundwater markets can be an instrument to achieve more equitable irrigation outcomes.

Even more directly than Reddy's, L R Khan's paper, *Environmental Aspects of Groundwater Developments in Bangladesh: An Overview* (88/2c) is concerned with environmental issues. Khan provides an overview and introduction to some of the possible environmental implications of groundwater use in Bangladesh, a country where, over recent years, irrigation has come to depend increasingly on the exploitation of groundwater. Since the importance of environmental degradation is now being recognised, an introductory investigation of some of the issues in the irrigation sector may help to instigate some new thoughts and initiatives.

In a more detailed follow-up of his introductory paper on the National Water Management Project (ODI 87/3d), Jeremy Berkoff outlines an approach to canal water management which is important in the context of the privatisation versus planning debate. Berkoff in *Irrigation Management in South India: The Approach of the National Water Management Project*, (88/2d) describes a combination of system design and management under which effective external control of water supply at higher points in the distributary system delivers predictable and sufficient quantities of water at specified intervals to the cultivator. This then provides scope for farmers' individual choice in water use and cropping patterns. It also allows for individual or collective action at the local level in the negotiations for adequate and well-timed water supplies. At the same time, greater control at a higher point in the system remains an instrument to affect farmer behaviour in cases where individually and collectively optimal choices diverge. The approach is reported to pre-empt tail-ender problems in the tertiary since minor distributaries below the last externally controlled outlet are either filled to capacity or distributaries are left entirely empty so that there is no water which could be diverted by the better positioned cultivators.

Berkoff's paper stands out for its detailed description of project design and management and their implications. As does Reddy, Berkoff recommends longer rotational cycles for canal water supply. While Reddy expects to encourage well use, Berkoff argues that a shift away from paddy cultivation is achieved through the creation of planned water shortages. Berkoff's paper is appearing in our Newsletter in slightly revised form after first publication in *Wamana* (October 1988).

Mick Moore's paper, 88/2e, *Maintenance before Management: A New Strategy* is relevant not only to Sri Lanka but to field-level water management planning in general. Moore outlines some of the complexities of farming systems and environmental conditions to demonstrate the difficulties of achieving effective external intervention in local water management. planning. He argues that the locally negotiated processes of water distribution are too complex and too finely tuned to environmental and social conditions to be improved upon by external intervention. On the other hand, for the Sri Lankan small-scale irrigation sector, Moore suggests that one thus far neglected but potentially fruitful area of external intervention is system maintenance.

Rajan K Sampath, 88/2f *Some Comments on Measures of Inequity in Irrigation Distribution* argues that questions about equity cannot always be answered by analysing inequality. His concept of "benign inequality" captures this. What is needed to answer questions about the equity outcomes of irrigation and other development policy outcomes is firstly, an agreed understanding of what is equitable. Secondly, as Sampath argues, there needs to be an investigation of whether unequal outcomes are in fact inequitable in a particular context.

Sampath's paper contains a convincing criticism of Abernethy's (ODI-IIMI 86/2d) undifferentiated use of the terms equity and equality. Sampath also suggests a methodology to enable practitioners to determine the importance of equality for the creation of equitable outcomes. What Sampath does not yet (?) offer is a workable indicator of inequity. But then, there will always be more work to be done.

2. NEWS FROM NETWORKERS

There have been some responses to recent network papers. Hervé Plusquellec writes:

"I particularly appreciate this time the paper from Mr Ait Kadi (88/1d) on major features of Moroccan large-scale irrigation projects. However, I feel that a more complete picture of the large scale irrigation schemes would have been given if the author had also discussed one of their unique features, ie, the hydraulic design of irrigation distribution systems in Morocco. The irrigation systems in that country were "designed for management" thanks to a number of innovative, simple but efficient control technologies reducing the burden of operation and inadequacy of water allocation found in most developing countries. The ORMVA's have therefore been able to concentrate on the primary objective of irrigation: crop production and extension services."

Following the note on the World Bank's new guidelines on resettlement, Michael Cernea has sent some additional comments pointing out the scale of planned resettlement over the next few years and the volume of anthropological work which has been commissioned to see that this is done in a sensitive manner. Cernea argues that in recent years, anthropologists have contributed significantly to the resettlement planning around some of the largest dams in the world (eg, the Narmada dams in Gujarat and Madhya Pradesh, the Itaparica dam in Brazil and others involving the resettlement of tens of thousands of people). As a consequence, anthropologists have now become an integral part of the resettlement planning process.

An impromptu presentation at ODI by George L Chan (Guangzho Institute of Geography, Guangdong Academy of Sciences) and his paper *Energy Aspects of the Integrated Farming System in China* drew attention to some new developments which are based on the traditional Chinese dyke-pond system. Professor Chan described how the century old dyke-pond system which integrates irrigated farming, animal husbandry and fishbreeding by recycling and utilising all waste products, has been made more efficient by utilising modern bio-technical processing technologies. A digester increases the nutrient value and energy efficiency of agricultural waste products. The Chinese development, one version of which is also documented in the *Environmental News Digest* (Vol 6 No 1 1988) provides the same yields as current high-cost fertiliser and pesticide-intensive cultivation techniques. However, cultivation costs are much lower and, probably most importantly, environmental degradation and consequent long-term yield reductions are avoided.

Some recent articles by Robert Hunt have reached us. In an examination of the *Size and Structure of Authority in Canal Irrigation Systems* (24 June 1988 unpublished) Hunt challenges the standard assumption (cf Wittfogel 1957) that large canal irrigation systems necessarily have a central authority. Hunt argues that the majority of the approximately 100,000 canal irrigation systems in the world do have central authorities but also shows that there are acephalous systems without a constituted authority. New avenues of thinking for canal irrigation management could well be opened up by this.

Two earlier articles by the same author (*Organisational Control over Water: The Positive Identification of a Social Constraint on Farmer Participation* IIMI conference 16-18 February 1987 and *Appropriate Social Organisation: Water Users Associations in Bureaucratic Canal Irrigation Systems* in *Human Organisation* February 1987) argue that a lack of control over water allocation constrains the participation of water users associations in canal irrigation systems.

A long-term socio-economic impact evaluation has commenced for the multi-million dollar Left Bank Outfall Drain Project in Pakistan. The work is being done by Sind Development Studies Centre of the University of Sind, in collaboration with Wye College, University of London and ITAD Ltd, (Information Technology and Agricultural Development). A core survey programme is underway, based on a sample of watercourses, which will produce a time series of baseline and impact data throughout the life of the project. This will be supplemented by in-depth surveys of individual farmers, a regional impact study and special studies into other sociological and economic aspects of the project.

A discussion meeting on water management in the Gezira scheme was held at ODI on 14 October. The presenters, Mary Tiffen, Marcus Francis and Omar El Awad argued that it is the maintenance of minors, rather than water wastage or water stealing which leads to inefficiencies and water shortages in the Gezira scheme. It was concluded that more effort should be put into improving the maintenance of minors and into getting sufficient amounts of water to the minor, rather than on blaming the farmers for inefficient water use. Omar el Awad pointed out that it was a quick survey amongst farmers, carried out by Abdelgadir Mohammed Ahmed and Mary

Tiffen, which pointed out the need to examine maintenance rather than modes of system operation (night storage or not) as a main problem area. The papers on which the talks are based are available from Hydraulics Research, Wallingford, Oxon, UK, OX10 8BA, and Hydraulics Research, Wad Medani, Sudan.

An informal interdisciplinary working group on small-scale irrigation has been formed in the UK to act as a point for information and ideas exchange and to publicise the idea of small-scale irrigation. The first meeting took place at Loughborough University. For further information contact Richard Carter at Silsoe College, Bedford MK45 4DT, UK.

3. NEW PUBLICATIONS

a. Books

Village Republics – Economic Conditions for Collective Action in South India by Robert Wade Cambridge University Press 1988 238p. This book will be particularly valuable to those concerned with organisational issues in irrigation. In a study of 31 villages in a canal irrigation system in South India, Wade finds a correspondence between increasing water scarcity, as expressed in village tail end location on irrigation canals, and the degree of collective action. This he explains with the larger net benefit derivable from collective action in tail end villages. The book's arguments are supported by a wealth of very readable detail on village forms of corporate organisation. Wade's data indicate some of the conditions under which self-interested, "atomistically rational" individuals can achieve collective rational outcomes. His finding that successful collective organisation is not necessarily associated with a high level of ideological commitment is very relevant in the present context of privatisation.

Managing canal irrigation – a practical analysis by Robert Chambers, Oxford IBH Publishing Co 1988 279p (forthcoming with Cambridge University Press), is already available from India, from Mohan Primlani Prt Ltd, 66 Janpath, New Delhi 110 001. The point of departure is the poor record of canal irrigation in the eradication of poverty among resource-poor farmers and the landless. Chambers blames "narrow professionalism" and lack of interdisciplinarity among agricultural and irrigation engineers and social scientists for a number of "blind spots" in irrigation knowledge and action. He argues that a concentration of research and action on on-farm development (OFD) below the outlet and a consequent neglect of main system management issues such as water scheduling, delivery and communications are the major shortcomings of present irrigation analysis and policies. Other identified knowledge and action gaps are night irrigation, farmer action above the outlet and the motivation and incentive structure of irrigation managers. The book documents a large number of issues which appear familiar but do not have the status of "professional issues". The book then differentiates between a number of modes of evaluation and analysis of irrigation situations and systems in terms of their relevance to poverty eradication, their capacity to address gap issues and their cost effectiveness. Chambers concludes by suggesting lines of action which use the situation-specific "room for manoeuvre" of all actors in the irrigation field ranging from women, landless labourers and tail-end farmers to senior officials and donor agency staff. The author is to be commended for detailed research and innovative and controversial arguments.

L'Irrigation au Sahel by Geert Diemer and Ellen van der Laan 1987 Editions Karthala, Paris, analyses village institutions, patterns of power and control in social life and agricultural production of Halpulaar (Toucouleur) society in Senegal and traces their effect on the introduction of small-scale irrigation schemes. The study, in French, is particulary relevant to the recently increased interest in utilising local managerial and organisational resources to manage irrigation systems. It is a useful reminder that a precondition for using local capacity is the identification and understanding of the organisational principles of existing, often long-standing local customs and organisational structures. The ODI-IMN Paper 8b contains an early summary of this research.

Irrigation investment, technology, and management strategies for development edited by K W Easter, Studies in Water Policy and Management No 9, 1986, Westview. The first three chapters introduce "a whole systems approach model" to irrigation management. Then follow a number of case studies on India (by R K Sivanappan and V Rajagopalan, M von Oppen K V Suba Rao and T Engelhardt, K Palanisami and K W Easter) on Thailand (by

Sam H Johnson, Yuavares Tubpun and A Apinantara and J Sriwasdilek). There are also a study on water charge systems in Egypt (by R L Bowen and R A Young) and on water trade on Punjab watercourses (by R Renfro and E W Sparling). The book ends with two policy-oriented chapters. E W Coward on alternative ways of creating property through irrigation investment argues that property created by irrigation projects must fit in with local property patterns in order to attract indirect investment. Finally, in view of the model and the case studies, K W Easter makes a range of policy recommendations which focus centrally on the importance of rehabilitation and maintenance activities. Easter suggests that an incentive structure can be created if those who maintain systems hold the property rights and if water charges are clearly linked to maintenance activities.

Management von Bewässerungssystemen: Ein Orientierungsrahmen by Walter Huppert and Hans W Walker GTZ/BMZ Eschborn 1988. The book attempts to cover the middle ground between undifferentiated management principles for all irrigation systems and the individual case approach which lacks the scope for systematic management guidelines. An English edition is to appear soon.

Engineering Against Schistomiasis/Bilharzia Guidelines Towards the Control of the Disease by E G Pike 1987 MacMillan. A comprehensive book, written by an engineer, which will be of value to those in search of methods to prevent or combat the disease.

Performance Control for Professional Management of an Irrigation System-a Case Study from System H in Sri Lanka is a research paper also recently published by IIMI. It argues that management in particular of water distribution, rather than water per se is the key independent variable which determines the productivity of irrigated agriculture. From this the conclusion is reached that the public agencies responsible for public irrigation management have a unique opportunity to increase agricultural efficiency and raise farmers' incomes by improving their own management systems. The study distinguishes between administrative and entrepreneurial styles of management. This is considered particularly important in periods of crisis management.

b. Reports and manuals

Irrigation Management Research in Sri Lanka: A Review of Selected Literature IIMI Occasional Paper 52p. This is an important up-to-date review of irrigation management literature which reports on lessons learned and questions raised in Sri Lankan research sine 1978. Four major topics are dealt with: 1) System operation and performance 2) Organisation and management 3) Rehabilitation and modernization of irrigation systems and 4) Resource generation and mobilization. An appendix reports on crop diversification issues.

Nature and Impact of the Green Revolution in Bangladesh by Mahabub Hossain (1988) International Food Policy Research Institute Research Report 67 1776 Massachusetts Avenue NW Washington DC finds irrigation the leading factor for HYV adoption and concludes that the productivity advantage of small farmers is reduced with the diffusion of new agricultural technologies. Hossain also finds that larger landowners, who tend to control the water, realise higher profits from irrigated cultivation than smaller landowners. At the other end of the socio-economic scale, the asset- and landless are found to gain through increased employment in the on- and off-farm sector and through a higher wage level.

Irrigation Management for Diversified Cropping, IIMI, 1987. A collection of workshop papers and discussion which addresses the advantages and constraints to crop diversification in different country situations throughout Asia, as these reach rice self-sufficiency.

Smallholder Irrigation Manual for Schemes with Basin Irrigation Vol I and II by the Ministry of Agriculture and Fisheries (Agricultural Education Department, The Hague, Netherlands) Volume I deals with extension and covers water supply and management including farmers' participation and organisation. Volume II deals with design and covers the physical requirements of systems in relation to crop type, topography, and soil. Matters of canal construction and water management are also addressed. The publication is directed at irrigation and extension staff and provides methodologies and information on irrigation systems. While the physical aspects covered would be applicable to a great variety of contexts, the discussion of farmers' participation and organisation refers more to the African context because of its assumptions about women's role in farming.

Proceedings of the Workshop on Indo-Dutch Tungabhadra Water Management Project Munirabad Karnataka, International Institute for Land Reclamation and Improvement July 1988 is an evaluation of a protective irrigation scheme. The major problems identified are waterlogging, salinisation and the violation of prescribed cropping patterns under localisation. One of the suggestions is that also advanced by Berkoff in his paper for this issue, namely that flow sizes be allocated to chaks and that farmers be allowed to grow the crops of their choice with their water allocation.

A Casebook on Small-Scale Irrigation in Africa for NGOs which are getting involved in the irrigation sector, is now available. It is edited and compiled by Silsoe College, UK in collaboration with FAO's Freedom from Hunger Campaign. The book is based on case studies carried out mainly by local NGOs in eight African countries. The case studies cover a wide variety of technical alternatives and forms of NGO-government collaboration. The findings of the book support the increasingly popular argument that NGOs can ensure increased farmer participation in planning and management.

An audiovisual production - improving the operation of canal irrigation systems by Hervé Plusquellec. A set of 454 slides in seven parts accompanied by a commentary on audiotapes and a book which summarises the programme. A worldwide range of experience in upgrading, rehabilitating, operating and automating canal irrigation systems is demonstrated and would be useful to many training institutions. The package is available from The Economic Development Institute of the World Bank, Washington DC 20433 for $175. While the price will put it out of range of many members, the book (154p) can be obtained free, and is so fully illustrated that it is useful in its own right.

The Wye College irrigation game: Stop the breach by L E D Smith and J P Youngman. An irrigation management role-playing game which provides an insight into the practice of irrigation management. Players act as farmers or scheme managers and make decisions on the operation of a scheme which is simulated by microcomputer. The game does not need a colour monitor and is provided with full instructions for IBM compatibles with 128 KB RAM memory and a wide carriage dot matrix printer.

d. Journals

The *Economic and Political Weekly* is an obvious source of material for the focus of this issue on the Indian subcontinent. In Vol XXIII No 13 James K Boyce writes on *Technological and Institutional Alternatives in Asian Rice Irrigation*. The article describes and analyses the variations in the pace and character of irrigation development in 18 Asian countries. Five main sets of determinants of irrigation development are then identified. In conjunction with a set of critically discussed statistical data, these five factors 1) population pressure, 2) geography, 3) agrarian structure, 4) cultural factors and 5) the state are then analysed and discussed. The article raises a number of issues concerning participation and the state. Those who have a particular interest in Bangladesh and West Bengal should refer to Boyce's book *Agrarian Impasse in Bengal: Institutional constraints to technological change*, 1987, Oxford University Press which identifies irrigation, drainage and flood control as the major technical constraints to agricultural growth in the area.

The *Economic and Political Weekly* Vol XXIII No 13 March 26 1988 also carries an article by Tushaar Shah and K Vengama Raju on *Groundwater Markets and Small Farmer Development*. It is suggested that groundwater markets can be used as an effective public policy instrument to achieve equitable development outcomes. Shah and Raju argue that the benefits from groundwater irrigation derived by resource-poor cultivators, who do not own water-extraction mechanisms, increase as local groundwater markets operate more efficiently. The article develops Shah's previous paper which we published as 11d, 1985.

The *Economic and Political Weekly* Vol XXIII No 19 carries the article *Indian Irrigation: An Assessment* by B D Dhawan which reviews the productivity effects of different types of irrigation in India. One of the major problems identified is the adverse impact of irrigation development on the production of pulse crops. For a number of South Asian countries it may now well be time to look at the nutritional implications of the rice self-sufficiency strategy more closely.

The International Journal of Water Resources Development September 1988 contains two articles of particular interest. Mandal, Dutta, Khair and Biswas *Feasibility of Irrigation Canal Linings in Bangladesh* discuss the financial implications and performance of six types of canal linings for different soil types and water conditions for LLP and DTW schemes. They conclude that there is scope for canal lining on sandy soils (27% of Bangladesh area), but that there is also a considerable amount of unexploited scope for improvement through compaction of earthen canal surfaces.
In the same issue, N H Rao and P B S Sarma's article *Water Resources Utilisation in an Irrigation Project in India* proposes a strategy based on water conservation and the use of groundwater in the monsoon season for the full exploitation of reservoir potential in the subsequent seasons.

SPORE July 1988 carries an interesting lead article which questions the productivity and output benefits achieved from the "irrigated rice plantations". These have been initiated in a number of African countries over recent years in order to alleviate increasing rice import bills. Supported by interesting detail, the article argues that more extensive and diversified farming systems should be recognised for their value to the farmer and to the economy as a whole. *SPORE* is published by CTA, PO Box 280, 6700 AJ Wageningen, The Netherlands, and is available free on request to members in ACP countries.

The ODU Bulletin No 11 July 1988 (published by the Overseas Development Unit Hydraulics Research Ltd Wallingford Oxfordshire OX10 8BA) has an overview article on *WatermanagementinThirdWorldIrrigationSchemes: Lessons from the Field* by K Sanmuganathan and P Bolton. This summarises experiences from a number of irrigation management studies and offers a number of conclusions for scheme operation and management. The original studies which the article draws on cover Sri Lanka, Sudan, the Philippines and the Punjab. These are available free on request from ODU.

Wamana (September 1988), a journal particularly aimed at Indian irrigation professionals centres on the training of irrigation officials in public agencies. Motivation and incentive structures, training needs, facilities and methods and the role of trainers are discussed by a number of authors. O K Patel adds a quest for interdisciplinary undergraduate courses in India in irrigation water management to avoid uneconomic trial-and-error phases in the field for single-discipline professionals in an interdisciplinary subject.

Wamana's (October 1988) lead article by Sundar argues for systems design to support interaction between irrigation authorities and users so that group formation and cohesion can affect system management. There is also an article on *Water cooperatives in Ukai-Kakrapar Command Area* by C H Shah which gives an account of the reasons for success of four water cooperative societies.

Wamana is available for $100 per annum for readers outside India and we are pleased to say it is now going to continue publication. For details write to A Sundar, from 1/1/89 at a new address: Lakshmi Nivas, Dr Ananthakrishna, Iyer Road, Nenmara 678 508 Palghat District Kerala, India.

World development Vol 4 1988 pp 489-500 *The Management of Irrigation Systems: How to Evoke Trust and Avoid Prisoners' Dilemma* by Robert Wade compares the South Asian (Indian) situation where a lack of trust between farmers and irrigation officials leads to "anarchical" unrestrained water use on irrigation canals, and the East Asian situation (Japan, Taiwan, South Korea) where rule keeping in the use of irrigation canal water tends to be much more common. Wade identifies a number of variables such as topography, climate and system design features to explain the difference and develops a typology of irrigation systems with reference to the likelihood that rule-breaking will occur.

Agricultural adminstration and extension 29 (1988 pp 265-280) carries an article by Willem de Witt on *Moorish Village Irrigation Schemes in Southern Mauritania.* De Witt examines Coward's 'ecological' approach which derives the conditions for human organisation in irrigation schemes from the physical infrastructure of schemes. De Witt finds the ecological approach not helpful to the understanding of the organisation of Moorish Village irrigation schemes in Mauritania and argues that greater importance needs to be attached to traditional leadership patterns and social structure.

The *Farmer-managed Irrigation Systems Newsletter* has an article by David Groenfeldt which describes how private irrigation contractors in Uttar

Pradesh have been displaced by state-managed irrigation development programmes.

In *The Rural Sociologist* (Vol 6 no 4) Mark Lusk and Pamela Riley (*Irrigation Development and Public Choice Theory*) summarise a number of theoretical frameworks for the development of irrigation systems and then concentrate on public choice theory, "the economic study of non-market decision-making" (p 282). This focuses on the implications of individual incentives for water provision and common resource management problems. The article argues that incentive structures produce rule-breakers. This creates scope for the investigation of incentives such as payment for increased water use, farmer involvement in the formulation of water use rules and the effectiveness of sanctions to address common management problems such as free-riders, tail-enders and water monopolies.

In *IIMI Review* Vol 2 No 2 August 1988, *The Changing Concept of Management in Irrigation* by Mark Svendsen suggest the adoption of an irrigation management taxonomy which borrows from management science argues that this will open up new areas of thinking and co-operation between the traditional irrigation disciplines.

Also in *IIMI Review* Vol 2 No 2 August 1988, *Performance control for professional management of an irrigation system - summary of a case study from Sri Lanka* by Namika Raby and Douglas Merrey argues that the "entrepreneurial mode" of irrigation management, ie, the manipulation of rules to suit changing opportunities, is suited to small systems and the lower sections of large systems, while the "bureaucratic mode", ie, the implementation of normative rules fits the upper levels of larger systems.

4. CONFERENCES, WORKSHOPS AND COURSES

a. Reports on past events

The *Seventh World Congress for Rural Sociology* was held in Bologna, Italy from 26 June to 2 July 1988. Walter Coward (Cornell University International Agriculture Program Ithaca New York) convened five sessions on *The Sociology of Irrigation.* Participants addresses to obtain copies of papers should be requested through him.

Session 1, entitled *Local irrigation groups* had 5 contributors. Robert Hunt's introduction *The Social Organisation of Irrigation: The Irrigation Community* introduced a number of concepts, such as that of internal and external jurality, which were used throughout the subsequent discussions. Shyamala Abeyaratne spoke on *State and Village Community in Irrigation Management: Some Aspects of Small Scale Irrigation in Sri Lanka.* R Hossain and R van der Velde presented a paper on *Intervention and Innovation in Farmer-managed Irrigation Systems in Northern Pakistan* with a detailed micro-level account of an attempt to mobilize rural people around income generation activities and of the changes which occurred through such mobilisation efforts. U Pradhan and B Lynch analysed the incentives and disincentives for different actors in their paper *Agency Expectations and Local Interests: The Myth and Realities of Local Resource Mobilisation for Small-Scale Irrigation* which arises from their case studies in Peru and Nepal. This paper should be particularly useful to those attempting local resource mobilisation in irrigation projects. In his paper *Irrigation Services by the Landless in Bangladesh: Negotiations between Sellers and Users* Geof Wood discussed some of the outcomes of an innovatory approach to rural poverty via irrigation which has been undertaken by Proshika, a Bangladeshi NGO. Under this approach, land-and assetless groups of rural people are given property rights to irrigation equipment and thus become "water sellers" in agriculture. An in-depth study of the outcome of the experiment in such "social entrepreneurialism" in Bangladesh has just been completed by Wood and Palmer-Jones. Those interested should contact Wood at the Centre for Development Studies, University of Bath, Claverton Down, Bath BA2 7AY, UK.

Session 2 on *The state and irrigation* had four contributors. N E Tapay *Irrigation as a Key Factor in Food security: The Impact of Farmer Participation on the Performance of a Communal Irrigation System in the Philippines* argued that irrigation performance has been strengthened by collective participation structures. Jayantha Perara spoke on *Irrigation Policies and Agricultural Development in Sri Lanka*, Jamshed Tirmizi, in *Society and Irrigation Organisation in Pakistan* presented an analysis of kinship and social structures and rang a pessimistic note with regard to the likelihood of successful community action for canal maintenance in Pakistan. Geert Diemer in *Paradigms of Irrigation Development: A View from Africa* outlined a number of common assumptions of made by irrigation engineers and the dilemmas this poses for the anthropologist in irrigation. Diemer also pointed out the contradictions between engineering approaches and indigenous irrigation practice in Africa.

Session 3, entitled *Issues of farmer participation* had five contributors, Mark W Lusk and Bradley W Parlin on *Bureaucratic and Farmer Participation in Irrigation Development.* This paper has appeared as the WMS Report No 89. David Groenfeldt spoke on *Distinguishing Utility and Futility in Farmers' organisations for Development: Lessons from Sri Lanka.* James J Layton and Frank A Santopolo *Organising Farmer Participation Efforts in Irrigation: How Social and Physical Environmental Factors Influence the Organisation Process.* Jeffrey D Brewer *Changing an Irrigation Bureaucracy: The Sri Lankan Irrigation Department* and Kanda Paranakian on *Farmer Participation in Irrigation Projects* in Thailand.

A session on *Conceptual issues* covered a variety of issues. In his paper *The Institutional Context of Irrigation Development in Africa* J Ssennyonga criticised the failure of irrigation agencies in Africa to recognise irrigation as part of a set of on- and off-farm household strategies. Harold Capener spoke on *Opportunities Missed: A Collaborative Relationship between Farming Systems and On-Farm Water Management Research.* J D Marzouk-Schmitz' paper *Logiques d'une Technique Endogene: L'Example Des Joola de Basse Casamance (Senegal)* outlined the details of an indigenous five dam irrigation system. Matsuda's paper *Development of Irrigation System and Changes in the Social Organisation in Rural Communities* outlined how, in a rural community in Japan, where traditional small-scale irrigation systems had corresponded to authority structures, the change to a larger-scale dam irrigation technology and the increase of off-farm income opportunities brought new patterns of social differentiation and social relationships.

The last session, had Murry Leaf, on *Irrigation Sociology and the Four F's.* Marion Glaser on *Land Tenancy and Shallow Tubewell Irrigation: Alternative Patterns of Agrarian Change in Bangladesh.* Venkata Reddy on *The Sociology of Major Irrigation in India: Some Dimensions* and Mary Tiffen on *The Integration of Socio-Economic and Institutional Criteria into Planning* *and Design Concepts During the Preparation of Irrigation Feasibility Studies.*

The proceedings of a DSE/ZEL workshop held in Manila in October 1987 are now available. The publication *Dialogue and Training in Irrigation System Management* discusses major problem areas in irrigation systems management, identifies gaps in dialogue and training and proposes some amendments. A main argument throughout the report is that the "software", in particular the human capital aspect, of irrigation development and the need for interdisciplinary cooperation in the irrigation field needs to receive more attention. The concentration on technology and capital aspects in present practice is criticised as too predominant.

The Intermediate Technology Development Group (Agriculture and Fisheries Sector) held its *Forum 1988 – The Rational Use of Water* on June 24–25 at Rugby, UK. Three papers were given on water management in Peru. Patrick Mulvaney discussed the way people organise to in situations of extreme water scarcity. The discussion revolved around the distinction between formal and informal (or indigenous and imported/imposed) organisations. Theresa Ore's paper described the development of irrigation management in Peru, relating the changes in political and social structures to the distribution of water resources. She concluded that the campesinos (indigenous, small farmers) had gained land in recent years but had extremely restricted access to the water needed for cultivation. The third paper was given jointly by Rod Edwards and Alfonso Carrasco. They discussed the conflicting demands on water resources for irrigation and microhydro. This provoked great disquiet among the engineers and social scientists and brought some discussion on the setting of priorities for water and the nature of engineering efficiency as against development optimisation. Mulvaney's and Ore's papers appear in *Waterlines* October 1988.

Eleven research papers covering 1983–87 work which were presented at a National Seminar on Irrigation Management in Nepal Bharatpur, Nepal (4–6 June 1987) are now available from IIMI, PO Box 3975, Kathmandu, Nepal. Several of the papers examine the relationship between organisational structure and resource mobilisation especially as a result of project expansion. The papers also introduce more recent methods of data collection and scheme appraisal.

b. Forthcoming conferences

The Asian Regional *Symposium on Modernization and Rehabilitation of Irrigation and Drainage Schemes* will be held at the Development Academy of the Philippines from 13 - 15 May 1989, organised by the National Irrigation Association, Manila, and Hydraulics Research, Wallingford, UK. The conference is intended to look at the whole process of rehabilitation and modernization, including policy, planning, design, and evaluation. The organizers anticipate a multidisciplinary approach, with contributions from engineers, scientists, research workers and planners. Any one interested should write to: Mrs Ma. Ines Pinat Bagadion, Organising Secretary, National Irrigation Administration, Government Building, Epifanio delos Santos Avenue, Quezon City, The Philippines, Telex: 42802 (NIA PM).

The triennial international conference, World Water 89, will be staged at the Wembley Conference & Exhibition Centre in London from 14-16 November 1989. Details are available from World Water 89, Westrade 89, Westrade Fairs Limited, 28 Church Street, Rickmansworth, Hertfordshire WD3 1DD, UK.

Southampton University will be holding an international conference on Irrigation: Theory and Practice on 13-15 September 1989. Details available from Institute of Irrigation Studies, The University, Southampton, SO9 5NH, UK.

There will be a symposium on Land Drainage for Salinity Control in Arid and Semi-Arid Regions from 26 February - 3 March 1990, to be held in Cairo, Egypt. Further details from Drainage Research Institute (DRI), Irrigation Building, 13 Giza Street, El Giza, Cairo, Egypt.

There will be a 15th WEDC conference on *Water, Engineering and Development in Africa*, Nigeria, 3 - 7 April 1989. Themes to include treatment and distribution of water, on-site sanitation, irrigation, appropriate technology. More information from WEDC, Loughborough University of Technology, Leicestershire LE11 3TU, UK.

An *International Workshop on Appropriate Methodologies for Development and Management of Groundwater Resources in Developing Countries* has been organised for 28 February - 4 March in Hyderabad, India. More information from the organising secretary, C P Gupta, National Geophysical Research Institute, Hyderabad 500 007, India.

There will be an *International Conference on Channel Flow and Catchment Runoff* on 22 - 26 May 1989, at Charlottesville, Virginia, USA. For more information, contact B C Yen, Department of Civil Engineering, University of Virginia, Charlottesville VA 22901, USA.
There has been a call for papers on the theme *The People's role in Wetland Management* for the *International Conference on Wetlands*, Leiden, The Netherlands, 5 - 8 June 1989. More information from Leids Congres Bureau, PO Box 16065, 2301 GB Leiden, The Netherlands.

5. TRAINING COURSES

The following have been notified to us:

a. Short courses

International Irrigation Centre, Utah State University, Logan, Utah, USA. 8 January-18 February: *Applied Microcomputer Use In Irrigation And Drainage*-Basic Course; two week add-on options extend to 4 March 1989. 8 January-16 December 1989: *Course on Computer Assisted Irrigation System Management.* 19 February-18 March: *Potential Crop Production From Irrigated And Dryland Agriculture.* 26 March-6 May: *Waterlogging, Drainage and Salinity Control.* 12 April-6 May: *Waterlogging and Salinity Technical Study Tour of US Western States.* 7 May-17 June: *On-Farm Irrigation Design and Evaluation.* 11 June-8 July: *Applied Remote Sensing in Agriculture.* 11 June-8 July: *Applied Remote Sensing in Agriculture.* 18 June-8 July: *On-Farm Irrigation Scheduling.* 9-29 July: *Main System Irrigation Scheduling.* 16 July -26 August: *On-Farm Water Management.* 30 July-26 August: *Instructional Methods and Products for Irrigation Training.* 20 August-23 September: *Soil and Water Conservation and Management.* 27 August-16 September: *Farmer Participation and Irrigation Organization.* 27

August–30 September: *Design of Wells and Pumps for Irrigation.* 6–23 September: *Soil Conservation & Management Study Tour of US Mid-Western States.* 1–21 October: *Maintenance of Pumping System Components.* 1 October –11 November: *Operation, Maintenance and Management of Irrigation Delivery Systems.* 19 November–2 December: *Financial Management of Irrigation Systems.* 3–16 December: *Workshop on Policy, Planning and Strategies for Irrigated Agriculture.*

Mananga Agricultural Management Centre, PO Box 20, Mhlume, Swaziland. 20 March–14 April 1989: *Management Of Irrigation Projects, for experienced irrigation managers and planners* (in association with Silsoe College, UK).

Colorado State University, Fort Collins, CO 80523, USA. 5 June–28 July 1989: *Agricultural Marketing in Developing countries.* 3–28 July 1989: *Microcomputer Workshop on Irrigation Data and Project Management.*

Irrigation Research Academy, Bangalore 560 082, Karnataka, India. 20 March–14 April: *Management of Irrigation Projects.* 20 March–14 April: *Computers in Management.* 24 April–19 May: *Food Policy Management.* 29 May–28 July: *Management Development Programme.* 7 August–1 September: *Senior Managers' Course.* 7 August–1 September: *Rural Credit Management.*

The British Council, 65 Davies Street, London W1 2AA. 2–14 April 1989: *Sanitary Microbiology, Leeds/Malham.*

Volcani International Courses, PO Box 6, Bet Dagan, 50–250 Israel. 10 October–8 December 1988: *International Course in Irrigation and Soil Management.*

FAO Course on *Applied Micro-Computer Use in Irrigation and Drainage Management*, Perugia, Italy. 24 October–12 November 1988. Contact: M Smith, FAO/AGLW, Rome.

b. Academic courses

University of Birmingham, PO Box 363, Birmingham B15 2TT, UK. 9 January-7 July 1989: *Course in Water Resources Technology in Developing Countries.*

VITUKI, H-1453 Budapest, Pf 27, Hungary. 1 February-31 July 1989: *International Post-Graduate Course in Hydrology.*

The Director, International Agricultural Centre, PO Box 88, 6700 AB Wageningen, The Netherlands. 20 August-1 December 1989: *Postgraduate Course on Land Drainage.*

December 1988

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IRRIGATION MANAGEMENT NETWORK

DEVELOPMENT OF WELL IRRIGATION IN CANAL COMMANDS: THE PROSPECTS AND SOME EMERGING ISSUES

M Venkata Reddy

ODI/IIMI Irrigation Management Network Paper 88/2b December 1988

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

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

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DEVELOPMENT OF WELL IRRIGATION IN CANAL COMMANDS: THE PROSPECTS AND SOME EMERGING ISSUES

M Venkata Reddy

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DEVELOPMENT OF WELL IRRIGATION IN CANAL COMMANDS: THE PROSPECTS AND SOME EMERGING ISSUES

M Venkata Reddy

1. INTRODUCTION

Inadequate and undependable water supply in Canal Command Areas has necessitated the development of well irrigation. The shift in cropping pattern from traditional crops to modern high-yielding hybrid varieties on the one hand, and preference for growing high value commercial crops on the other, have induced farmers to adopt well irrigation to supplement canal water. However, several institutional and technical constraints are encountered in accomplishing well irrigation. Some enterprising farmers who overcome those constraints have constructed wells which enabled them to obtain higher crop yields. Well irrigation, apart from helping to obtain higher yields, has increased cropping intensity and arrested the rise in the water table. The advantages of well irrigation and the problems encountered by the farmers to invest in well irrigation in one of the major irrigation projects in the Karnataka State of India have been brought out in this paper.

2. THE PROBLEM

The need for well irrigation in canal command areas may not be immediately obvious since heavy investments have already been made in canal irrigation projects with a view to providing water for a predetermined area and cropping pattern. It is expected that an irrigation project provides sufficient water to meet crop-water needs in the entire area notified for irrigation. The idea of well irrigation which calls for additional investments by the farmers then looks redundant. But, contrary to the theoretical postulate, in practice farmers in the command of major irrigation projects in India are faced with severe water scarcity. This is supposed to arise owing to several factors: violations of the cropping pattern envisaged in the project plan; unauthorised utilisation of water by some influential farmers; and fixation of water duties on the basis of macro parameters, which do not conform to actual field conditions. Irrespective of the reasons for water scarcity, it is believed that it has led not only to lower crop productivity, but to social tensions and litigation among farmers in irrigated tracts. Bagchi (1973), quoted by Stone (1984), held the view that in the longer term, canals assist in the creation of rural structures which are exploitative and obstructive of efforts to promote growth. Further, the rate of return on investment in public surface irrigation projects is low, but can be raised by raising performance standards of infrastructure in new projects (Abbie et al, 1982). Owing to these serious problems posed by major irrigation systems, a supplementary source of irrigation becomes imperative.

Attempts are being made to evolve suitable strategies to optimise benefits of canal irrigation and minimise its adverse effects. For one possible avenue, the conjunctive use of surface and ground water, well irrigation becomes important. Dutt (1987) defines conjunctive use as

"the development and management of multiple water resources in a co-ordinated manner such that the total yield of the system over a period of years exceeds the sum the yields of the individual components of the system resulting from an unco-ordinated operation. It is not merely providing ground water supply and distribution system as a back-up for a surface water system or vice-versa. Rather it is a concept in which one system complements and supplements the other to compensate for the inadequacies of both."

Thus, conjunctive use is likely to promote higher intensity of cropping and productivity by supplementing canal irrigation, prevent adverse effects like waterlogging and salinisation by arresting the rise in the water table and help reclaim waterlogged areas by lowering the water table, through ground water abstraction. In view of these anticipated multiple advantages, the

Government of India has acknowledged the necessity of well irrigation in canal command areas and spelt out its policy in the following manner:

"The conjunctive use of surface and ground water would be encouraged in the minor irrigation programme. The dug-wells programme in the command areas would be encouraged under the command area development programme, for supplementing canal irrigation. The conjunctive use programme under the various development sectors would be co-ordinated so that the existing irrigation facilities are put to the best use and the gestation period of irrigation utilisation under major and medium irrigation schemes is reduced." (Seventh Five Year Plan, Vol II p 80)

The need for conjunctive use of surface and ground water has been emphasised by many researchers. According to the Irrigation Commission (1972), the conjunctive use of ground water in canal systems can create great economic benefits. O'Mara and Duloy (1983) and Sidhu et al considered conjunctive use of surface and ground water as essential to ensure timely and adequate supply of water which will help to increase agricultural output. It will also minimise or reduce the adverse effects of canal irrigation, because surface irrigation causes a secular rise in the water table owing to increases in percolation, thus leading to waterlogging and salinity (O'Mara, 1984). Thus, Dhawan (1987a) is of the opinion that the exclusive development of either source of water can prove unproductive in the long term. Whenever surface or ground water irrigation are developed in isolation from each other, the experience has been consistently bad with regard to resource conservation (Dhawan, 1987b). Unless the added recharge to ground water is withdrawn through dug wells and tube wells, the water table in canal command areas rises continually, leading ultimately to waterlogging and salinity affecting crop yields adversely. "Exclusive reliance on ground water as a source of irrigation creates the problem in a reverse manner. Over-exploitation of ground water, especially in arid areas, where rainfall as a source of groundwater recharge is poor, leads to a permanent lowering of the water table. A declining water table, apart from creating conditions of uncertainty and scarcity, can damage the ground water resource when saline water from adjacent areas intrudes into the void left by excessive ground water withdrawals" (Dhawan, 1987b). While there is consensus on the need for conjunctive use, the empirical verification of problems and constraints for conjunctive use needs to be looked at carefully. Thus, an attempt is made in this paper to examine some of the issues relating to well irrigation in one of the major irrigation projects of Karnataka State, India.

Materials and methods

It is hypothesised that shortage of water in a traditional canal irrigation system induces or forces farmers to adopt conjunctive use of surface and ground water. This hypothesis is examined in the context of an old canal system, Gokak canal, now in the Ghataprabha command area in the northern part of Karnataka State. Two villages have been selected for the study: one village where well irrigation in conjunction with canal irrigation is practised and the other where canal irrigation alone is in use. All 88 farmers using canal irrigation in the two villages selected for the study were interviewed. Their experience with and suggestions on conjunctive use were collected through personal interviews with the help of a structured questionnaire. The sample farmers were divided into two categories, namely, well owners and non-well owners. They were further stratified into four land holding groups.

The study region - a background

The Gokak canal, one of the oldest irrigation systems in Karnataka, was built in 1894. It takes off from the weir across the river Ghataprabha at Dhupdal in Gokak taluk. The canal runs for about 24 km in length to irrigate an area of about 5722 hectares. Over time, the area irrigated under Gokak canal has increased to about 6456 hectares owing to initially unauthorised but subsequently regularised extension of irrigated areas. A storage dam to irrigate about 3.2 lakh hectares, has now been built at Hidkal, about 20 km upstream of Dhupdal weir. After the construction of the dam, Dhupdal weir is used as a reservoir to release water to Ghataprabha Left Bank Canal, which takes off from the weir. Gokok canal forms a part of the present Ghataprabha Left Bank Canal. The water duty assumed for the command area is 40 hectares per cusec. It is a protective irrigation system where only lightly irrigated crops are expected to be grown. However, on 10 per cent of the notified area, sugarcane cultivation is allowed.

The designed discharge of Gokak canal has been increased from 90 cusecs to about 160 cusecs. Violations of prescribed cropping pattern and the concomitant over-use of water for sugarcane crop has led to a water shortages. In order to ensure uniform supply of water for all, the irrigation department introduced a rotational system of water supply in the early 1960s. The area under Gokak canal is divided into two blocks: Upper rotation block and Lower rotation block. In the Kharif[1] season, a farmer gets water once in 17 days, and in the Rabi season, once in 21 days.

The sample households - a profile

Of the 88 selected farmers, 54.6 per cent belong to the dominant caste of the region, Lingayats. While 40.9% belong to all other caste Hindus, Scheduled castes and Muslims constitute only about 2% each. Small farmers with two hectares and below constitute 39.8% of all farmers, followed by 28.4% who own between two and four hectares, 18.2 with between four and six hectares, and 13.6 % owning more than six hectares. The majority of the sample, 58%, is illiterate. About 18 per cent of the farmers selected for the study have lower primary education, while about 11 per cent have higher primary education; 8% have secondary education, and 4.5 per cent are degree holders.

3. CONJUNCTIVE USE OF WATER IN THE STUDY REGION - AN OVERVIEW

In the study area, conjunctive use of surface and ground water is a recent phenomenon. Normally, farmers in canal command areas do not visualise the need for well irrigation. This is partly because they expect sufficient water from canals, and partly because the canal water tariff is low and not charge on a volumetric basis. Because of these reasons, farmers tend to waste water by over-irrigation and improper management. In addition, the area under irrigation in Gokak canal has increased over a period of time

[1] The crop seasons in an agricultural year are known as the Kharif, Rabi, and Summer seasons. Kharif season is from June to mid-October, Rabi from October to February, and Summer from the middle of February to May.

without suitable concurrent changes in the water distribution network. According to official figures, which are generally under-reported, the relative share of sugarcane has also increased from about 14% in 1980-81 to about 17% in 1985-86. All this contributes to water shortages in the study region. After the introduction of rotational water supply (RWS), dug well irrigation has become popular to supplement inadequate canal supplies. Farm size details are shown in Table 1.

The table reveals that about 61% of sample farmers adopted well irrigation to supplement canal water. Except a solitary farmer who constructed a well before the advent of canal irrigation, all others did so after obtaining canal irrigation. The table shows that of these, about 83% opted for dug wells only after the introduction of RWS. This supports the view that water scarcity induces farmers to seek conjunctive use voluntarily. Further, it is seen from the table that land holding size and well ownership are positively related. The percentage of well owners has increased from about 37% in the first land holding size class (small farmers) to about 90% in the third land holding size class. It has, in fourth size class, declined to abut 66%. The obvious reason for the lower percentage of well owners among small farmers is the absence of economic viability of their tiny holdings to have an independent well for irrigation. On the other hand, it is not immediately clear why the percentage of large farmers in the fourth size class of land holding is relatively low. Table 4, which lists problems and constraints for well irrigation by farm size class, shows that brackish underground aquifers and the restrictions imposed by the irrigation department regarding distance between canals and proposed wells in the command area are the main reasons why big farmers do not own wells. In the study area it appeared to be a coincidence that big farmers were affected disproportionately by these constraints. Table 2 below gives an overview of the factors which led farmers to invest in well construction in canal command areas.

Farmers gave five reasons for investing in wells despite already having access to canal irrigation. Insufficient canal water, arising from deviations from prescribed cropping patterns was reported by about 89% of the farmers as the prime reason. As already mentioned, the area under sugarcane increased more than it should have according to the project report. 81% of farmers invested in wells in order to grow sugarcane. This implies that the

Table 1. Sample households by size of land holding

Sample no	Size of land holding (ha)	No of house -holds	Percentage of households owning wells	Construction of Well (percentages)			
				after canal irrigation	before canal irrigation	after intro- duction of RWS	before intro- duction of RWS
1	up to 2.00	35	37.1	100.0	-	84.6	15.4
2	2.01 to 4.00	25	72.0	100.0	-	72.2	27.8
3	4.01 to 6.00	16	93.8	93.3	6.7	93.3	6.7
4	6.01+	12	66.7	100.0	-	77.7	22.3
TOTAL		88	61.4	98.3	6.7	83.3	16.7

Table 2: Reasons for investment in wells

Reasons	Number of farmers reporting the reason (%)
a) Supply of water from canals is not adequate	48 (88.9)
b) To grow sugarcane crop	44 (81.5)
c) The gap between rotations is too long	42 (77.8)
d) Location of land in the tail-end	31 (57.4)
e) Possible to arrest water logging	17 (31.5)
Total number of respondents: 54	

farmers will bring more areas under sugarcane in future. Generally, farmers use more water for sugarcane per annum than for other irrigated crops. This happens because a) water rates are not charged on a volumetric basis, and b) unlike other crops, sugarcane tolerates excess water without showing symptoms of over-irrigation immediately. However, even if the full quantity of water according to the original duty and design is released, it is insufficient, so that farmers wanting to grow sugarcane need to have a well. This is the case because canal water, even if given for both the Kharif and Rabi seasons, is allowed for only 8 months in an agricultural year, whereas sugarcane needs water for 12 months. In order to irrigate sugarcane during canal closure periods one therefore needs an additional source of irrigation.

As mentioned above, well irrigation became popular after the introduction of RWS. While farmers appreciate RWS in terms of dependable water supply, they complain about inadequacy of water and lengthy rotation cycles (once in 21 days in the study area). If rotation cycles were shorter, (8 or 10 days), an additional source of irrigation would not be necessary for crops other than sugarcane. Can we therefore argue that the introduction of lower frequency RWS in the rest of the command area will encourage the conjunctive use of water? Apart from encouraging well irrigation, RWS has enforced night irrigation which is very uncommon in South Indian irrigation systems. Let us illustrate this with an example from the region under study. The frequency of rotation in the rabi season is 21 days in the Gokak canal areas. If a farmer does not irrigate his crops on the day water is released in the outlet, he will not get water again until after 21 days. The gap between two waterings would then be 42 days, which crops cannot tolerate. Thus, the farmer would use water on the scheduled rotation day irrespective of day or night.

Tail-enders' motivation to invest in an irrigation well is clear. It is interesting, however, that almost one-third of the farmers investing in wells are aware of their positive rôle in reducing or arresting the rise in the water table and the dangers of waterlogging. Tube wells, are thus consciously utilised to provide the sub-surface drainage which should accompany canal irrigation (Rogers and Smith, 1970).

4. PROBLEMS AND CONSTRAINTS

Problems related to well construction may have both technical and institutional components. In this section, some of the major problems encountered by the sample farmers for constructing wells are examined, followed by an overview of the constraints that were responsible for non-construction of wells by willing but disadvantaged farmers. Well-owning farmers were asked to give an account of the problems faced while constructing wells. The results are presented in Table 3.

The table reveals that institutional finance and power supply are the two major problems faced by the sample farmers, closely followed by lack of technical advice on ground water aquifers (46.3%). Some farmers (31.5%) faced the problem of a hard-rock bottom, which adds to the cost of well construction. The inadequate institutional finance which was reported by a majority of farmers (64.8%) gives rise to some queries. Farmers in the study region depend more on institutional support for investment, even after enjoying the benefits of irrigation for a long time (for at least 50 years, on average). This raises doubts about the nature and magnitude of benefits from irrigation and its impact on rural savings. A discussion on this may be out of context here. Further, a positive relation observed between farm size and the reporting of inadequate finance compounds the magnitude of the problem. It may indicate that large farmers are more hard pressed for money to invest in wells. This needs further probing, for example, into repayment rates. It is generally held that big farmers, and also maybe smaller ones, obtain institutional finance at a cheaper rate of interest to use it for other purposes.

The next important day-to-day problem (61.1%) is the supply of power for lifting water. Electric pumpset owners complain about erratic power supplies, which prevent optimum use of well irrigation. Some farmers failed to get power connected have to depend on diesel pumpsets. Diesel pump owners use well water sparingly owing to the high cost of diesel. Under these conditions farmers lack the economic incentive for conjunctive use of ground and canal water (Bowonder and Ravi, 1984). Thus, despite several wells in the command area, the demand for canal irrigation has not been substantially reduced. The possibilities of safe withdrawal of ground water to supplement canal water should be worked out for a given cropping pattern. If this kind of planning is considered from the beginning and institutionalised either by promoting tubewell use or by integrating ground water into the project, the possibilities of water logging would be eliminated from the beginning (Alagh, 1987).

Farmers who do not own wells were asked to report constraints on well construction. These are presented below in Table 4.

Tables 4 and 3 reveal lack of capital, lack of technical advice, power shortage and hard-rock strata as problems common to all farmers. A distinctive feature of well owners, however, lies in their capacity to overcome these problems. Those who were unable to overcome problems on their own tried for institutional support, without which they were restricted to available canal irrigation.

The main hurdles to well ownership, as observed from Table 4, were brackish ground water aquifers (67.7%), uneconomic land holdings (70.6%) and restrictions from the irrigation department (52.9%). While brackish aquifers may be difficult to alter, the other factors need closer examination. The consolidation of holdings is one of the objectives of Command Area Development Authorities (CADAs). Due to a number of socio-economic constraints, CADAs were less than successful. Table 4 shows that all small farmers (first size class) reported uneconomic holding as a reason for not owning a well. It may thus be concluded that community wells are needed to service small and marginal farmers and those with fragmented landholdings. The Irrigation Act in Karnataka contains norms for well construction in canal commands which stipulate the distance to be maintained between canals (main canal, branch canals, distributaries, etc) and proposed wells (The Karnataka Irrigation Act, 1965). Farmers are expected to obtain permission for well construction from the Irrigation Department. According to farmers, this is a major obstacle. Non-observance of stipulated norms leads to a proliferation of wells and gives rise to a number of other problems: farmers complain about the inadequacy of well water during canal closure periods. This arises from a high density of wells in the affected areas. Those who use well irrigation tend to refuse to pay water tax on the grounds that they do not use canal water. It is thus clear that, in the interest of overall project efficiency, the

Table 3: Problems encountered by the farmers in constructing wells by size class of holding

Items	Farm size class (ha) up to 2.00	2.01-4.00	4.01-6.00	6.01+	Total
1. Number of well owners	13	18	15	8	54
2. Problems (figures in %)					
a) Inadequate institutional finance	53.8	55.5	73.3	87.5	64.8
b) Lack of technical advice on quality and yield of groundwater aquifers	15.4	55.5	40.0	87.5	46.3
c) Shortage of skilled labour	-	16.6	6.6	50.0	14.8
d) Electric power shortage	53.8	72.2	53.3	62.5	61.1
e) Hard-rock bottom	30.8	33.3	40.0	12.5	31.5

Table 4: Constraints to ownership of wells

Items	Farm size class (ha)				
	up to 2.00	2.01- 4.00	4.01- 6.00	6.01+	Total
1. Number of farmers not owning a well	20	9	1	4	34
2. Constraints (figures in %)					
a) Brackish ground water aquifers	70.0	44.4	100.0	100.0	67.7
b) Lack of capital	100.0	66.7	-	-	76.5
c) Uneconomic land holding	100.0	44.4	-	-	70.6
d) Lack of technical advice on tapping ground water aquifers	55.0	55.6	-	50.0	52.9
e) Lack of power	10.0	22.2	-	50.0	14.7
f) Hard-rock strata	15.0	22.2	100.0	-	17.7
g) Restrictions from irrigation department	50.0	66.7	-	50.0	52.9

unorganised proliferation of wells in canal commands needs to be regulated. Unless it is impressed upon farmers that the irrigation department norms are to their own advantage in the long term, unnecessary conflicts between farmers and irrigation departments may arise.

5. THE IMPACT OF WELL IRRIGATION ON CROPPING PATTERNS AND PRODUCTIVITY

As background to the discussion of cropping patterns and productivity below, the cost aspects of wells owned by sample farmers in the canal command area are presented in Table 5.

The table reveals that dug wells in the study region are shallow (average depth 20 feet) and that some farmers in landholding size classes 3 and 4 have more than one well. Fragmentation of holdings and, in one shallow well, inadequate water have forced farmers to invest in more than one well in order to expand irrigated area. According to farmers, the slippery nature of the region's deep black soils makes the installation of deep wells risky without stone embedding to a considerable depth. Even then the farmers report that embankments cave in and increase the cost of the well. Deep tubewells are also not possible as deep aquifers are brackish in the region. The yield from shallow wells, on the other hand, depends upon water flow in canals. However, some farmers have experimented with shallow tubewells in the command area and results appear to be encouraging.

The cost of a well is directly related to depth and diameter. The average cost of a dug well works out to about Rs 9000. The per hectare cost of potential created and size of landholding are negatively related. The cost per hectare of potential created is more at Rs 5500 in the first size class when compared to that of only Rs 1288 in the fourth size class. As observed earlier, separate wells are often unviable for small farmers. However, as security against possible fluctuations in canal supplies even some of the small farmers have invested in wells. By constructing a well (even a shallow one) a farmer derives additional benefit through using well water during periods of low canal supply. He can confidently grow high-

Table 5: Depth, cost and area commanded by sample wells, by size of land holding

Farm size class (ha)	Number of well owners	Number of wells	Average depth of well (ft)	Average cost of well (Rs)	Average area commanded by well (ha)	Cost per ha (Rs)
1. Up to 2.00	13	713	19.6	7.7	1.4	5500
2. 2.01-4.00	18	18	21.7	9.6	2.9	3310
3. 4.01-6.00	15	16	21.7	10.6	3.6	3000
4. 6.01+	8	11	18.2	5.8	4.5	1288
5. Total	54	58	20.8	8.8	3.1	2838

yielding and better quality crops, which other irrigators on the canal may not be able to grow owing to inadequate water supplies (Irrigation Commission, 1972).

Cropping patterns

It is clear, then, that farmers have invested in wells to grow the crops of their choice. Table 6, however, does not show great differences in cropping pattern between well and non-well owners per se. The impact of wells is more visible in terms of area under perennial and heavily irrigated crops such as sugarcane and paddy for which well owners allocate more area than non-well owners. Some non-well owners also grew sugarcane although canal irrigation without a well should not be possible, since canal water is available for only 8 months of the year. Non-well owners who wanted to grow sugarcane entered into informal agreements with neighbouring well owners to supply water on payment of cash per watering, when canals were closed. Farmers who do not own a well thus obtain some access to well water. However, access to well water depends largely on the availability of surplus water in the well and inter-personal relations.

Productivity of crops

Table 6 reveal that for most crops, the yield rates of well owners are higher than those of non-well owners. The few crops for which non-well owners have obtained higher yields occupy only a small acreage. When farmers grow crops on an experimental basis on small plots, the yield rates tend to be high owing to better management practices. On the other hand, yield differentials obtained by well owners do not look significant enough to warrant investment in well irrigation. However, the desirability of well irrigation also depends on the adequacy of water supplied from the canals. Since water supply during the reference year (1985-86) of the study was relatively good this might have enabled non-well owners to provide adequate water for the crops, so that yield differentials were marginal. On the whole, farmers appear to have invested in wells to grow high value crops and as an insurance against erratic and inadequate supply of canal water.

Well owners were able to achieve higher cropping intensity (145.7%) than non-well owners (112.7%). If the area under perennial crops like sugarcane

Table 6: Cropping patterns, cropping intensity and yields

Crops	Well owners		Non-well owners	
	Area (ha)	Yield (qts)	Area (ha)	Yield (qts)
1. Maize	86.65 (38.4)	16.16	37.68 (40.1)	14.88
2. Sugarcane	39.63 (17.6)	76.28*	5.67 (6.0)	63.36*
3. Jowar	29.75 (13.2)	14.13	22.16 (23.6)	13.76
4. Wheat	23.97 (10.6)	12.63	22.16 (15.6)	12.73
5. Cotton	8.09 (3.6)	17.67	3.84 (4.1)	10.16
6. Groundnut	8.45 (3.8)	10.30	2.33 (2.5)	11.61
7. Pulses	16.63 (7.4)	4.94	2.33 (2.5)	8.60
8. Paddy	8.30 (3.7)	13.32	0.81 (0.9)	25.95
9. Others	3.89 (1.73)	5.41	4.55 (4.8)	4.40
Total cropped area (Gross)	225.36 (100.00)		94.00 (100.00)	
Net cropped area	154.63		83.42	
Crop intensity (%)	145.70		112.07	
Areas affected by waterlogging	30.04 (16.3)		8.34 (9.1)	
Net sown area	154.63		83.49	

Note: Figures in parentheses are percentages of gross sown area.
Sugarcane yields are expressed in terms of tons of cane.

is treated as equivalent to three seasonal crops, then the crop intensity of well owners rises to over 200%. The general feeling among farmers is that higher cropping intensity adversely affects soil productivity in the long run. Farmers in the study region have been experiencing a downward trend in crop yields. For example, the yield rate of sugarcane which was reported to have been around 120–140 tonnes per hectare fell to 70–80 tonnes in the 1980s. Farmers attribute this decline to high cropping intensity combined with the substitution of higher doses of chemical fertilisers for traditional farmyard and green manure. The continuous cultivation of crops on the same piece of land does not allow enough time to build micro-nutrients which are essential for soil health and can also increase the possibility of waterlogging. This could be counteracted through crop rotation, use of organic manure and keeping land fallow for a season periodically.

Well irrigation in command areas is an anti waterlogging measure. Even after 100 years of irrigation in the study region, only 14% of the area is affected by waterlogging. A higher percentage of waterlogged area under well conditions is somewhat disturbing. As mentioned earlier, well irrigation is used very sparingly when canals are open. As a result, wells overflow when canals are open, and flood the surrounding fields. This happens in terrain where canals run on a ridge or higher contour and wells are located in a valley portion. However, more waterlogged areas under well irrigation are essentially a location-specific problem, the cause of which is mainly ill-advised well use rather than the presence of wells as such.

6. CONCLUSIONS

The benefits from conjunctive use of surface and ground water are unquestionable. Their extent depends to a great deal on scientific planning and the proper adaptation of canal operation procedures to soil conditions in the command area. The introduction of a rotational water supply system was found to lead to conjunctive use of water. Lack of integration between dug-well and canal irrigation is likely to affect adversely soil condition. Community tubewells may solve a number of problems such as the non-viability of separate wells for smallholdings, financial constraints to digging wells and the overflow of wells during canal operation periods. It appears that the advantages of restrictions on well construction in the canal command area are not entirely understood by farmers, although the adverse effects of unplanned growth of wells in the study region are being felt already. Farmers should therefore be informed on these aspects.

Well owners are able to grow the crops of their choice and obtain relatively high yields. Conjunctive use also promoted higher cropping intensity. It could be argued that if farmers should be motivated to use well irrigation not only when canals are closed, but also when canal water is available, since well use reduces adverse effects on soil. Systematic water distribution plans with a built-in provision for the introduction of rotational water supply would help to promote the conjunctive use of surface and ground water. Finally, it is necessary to investigate the downward trend in crop yields attributed to high cropping intensity.

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ENVIRONMENTAL ASPECTS OF GROUNDWATER DEVELOPMENT IN BANGLADESH: AN OVERVIEW

L R Khan

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ENVIRONMENTAL ASPECTS OF GROUNDWATER DEVELOPMENT IN BANGLADESH: AN OVERVIEW

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ENVIRONMENTAL ASPECTS OF GROUNDWATER DEVELOPMENT IN BANGLADESH: AN OVERVIEW

L R Khan

1. ABSTRACT

Groundwater is an important source of water for irrigation and public supplies in Bangladesh. It is the major dry season source of water in many parts of the country. In recent years the increased demand for water for agricultural and domestic uses has been met by abstracting more groundwater. Heavy abstraction of groundwater has had environmental consequences in many areas of the country. This paper describes some environmental impacts of groundwater abstraction from heavily exploited zones in Bangladesh.

2. INTRODUCTION

Groundwater is an important source of water for irrigation, domestic and industrial uses throughout Bangladesh. Although average annual rainfall is very high (232 cm as per report of MPO, 1987) irrigation is of critical importance during half of the year ie October to May. During these months irrigation from surface source is not practically available in many areas as water in the rivers is scarce. Therefore, the use of groundwater has become increasingly important source of irrigation during the dry season. In addition, over 90% of the population of Bangladesh relies upon groundwater for drinking water. Based upon a recent study of MPO (1987) the national estimate of net groundwater abstraction for irrigation is 5227 Mm^3/year. Potable water supplies and industrial consumption is estimated to be about 908 Mm^3. Groundwater use is not evenly distributed over the country. Groundwater development has been made in the regions where good aquifers ie, water bearing geologic formations are located and where a demand for agricultural and industrial supplies exists. Unfortunately, the development of groundwater resource in this country during the last decade did not proceed according to rules or procedures to ensure optimum use. Different methodologies and engineering concepts for the development of groundwater through various pumping technologies such as deep tubewells (DTWs), shallow tubewells (STW), hand tubewell (HTW) and manually operated shallow tubewell for irrigation (MOSTI) have been practised without detailed investigation of the resource and its management policy. Little attention has been given to the after effects of heavy groundwater withdrawal for both agricultural and domestic uses. In many cases effects of groundwater development such as decline in water levels, reduction in river flows, quality problems, and subsidence were not anticipated. As a result, many environmental consequences e.g. preservation of amenity and public health, fisheries, navigation, salinity, etc. have been encountered and maximum benefit by development of groundwater resource could not be harnessed.

The aim of this paper is to describe the possible environmental problems which are encountered as a result of the abstraction of groundwater from major regional aquifers of Bangladesh. The conceptual or theoretical background of these problems under prevailing conditions have also been outlined here.

3. GROUNDWATER AVAILABILITY

Bangladesh is a vast alluvial plain which covers an area of 143,998 km^2 of which about 65% is a composite of ancient deltaic plains, 10% is the alluvial plain of the modern Ganges-Brahmaputra river system and 25% is hilly terrain (Jones Inc, 1987). Beneath the alluvial plain there are thick deposits of sediment infilling the Bengal basin. This huge territory-quaternary sedimentary infill is a complex mix of deltaic deposits from a vast continuous aquifer with local clayey sediments. There is a regionally extensive mostly unconsolidated, aquifer system throughout the country. This aquifer system is divided into two parts: an upper aquifer composed primarily of quaternary to recent sediments which may exceed 300 metres in thickness; and a lower aquifer sequence possibly extending to 1600 metres depth. Based on MPO's study (1987) the upper aquifer system has a three-fold sequence: an upper silty clay (2 to 100m thick) overlaying a fine sand and silt aquifer, known as the composite aquifer (3 to 60m thick); and the main aquifer composed of moderate to well sorted medium to coarse sands (30 to more than 100m thick). This aquifer extends from a depth of about 150m to more than 300m and has excellent water transmission properties.

The aquifers underneath the major parts of the country are fed annually from natural recharge. In Bangladesh, recharge occurs primarily through direct infiltration and percolation from relatively large amounts of rainfall and flood water. Annual flood peaks of the major rivers recharge laterally into the adjacent groundwater reservoir where they effectively become bank storage. During the dry season (October to January) a certain amount of groundwater discharges horizontally into streams and contributes to the baseflow while part of recharge is lost vertically through evapotranspiration. Therefore, the potential recharge ie, the amount of water which initially percolates (both vertically and laterally) to the groundwater reservoir, does not contribute fully to aquifer storage. Essentially all annual replenishment of the aquifer occurs during the monsoon season beginning in June and ending in October.

Many reports have been published on the availability of groundwater reserve throughout the country. It has become cumbersome on the part of the Water Development Authorities to rely on these information in order to extend groundwater development programme with full confidence. According to the study of BWDB and UNDP (1982) available groundwater is 19640 Mm^3. On the basis of the report of Groundwater Circle of BWDB (Karim, 1984), the available recharge varies from 30 mm to 300 mm per unit area throughout the country based on soil strata and physiographic conditions. The total available recharge is about 14800 Mm^3 over an area of about 93000 km^2. In the Hand Tubewell-II Project Report which has been prepared jointly by FAO and UNDP, the total amount of available groundwater is estimated at 36565 Mm^3 or 29.64 M acre-ft (Mirza, 1986). In the draft final report of MPO (1985) it was mentioned that the total usable groundwater recharge within this country is 42543 Mm^3. The usable groundwater is considered to be 75 per cent of mean annual potential recharge leaving 25 per cent for some uncertain factors as calibration error, future land use and flood control development. But in the recent

MPO report (1987) it is mentioned that the available recharge is 24,414 Mm^3. This was estimated by reducing usable recharge for geographic and physical limitations on groundwater use; eliminating areas where water needs are already met by surface water development; and deducting outflow to rivers (baseflow, seepage) and evapotranspiration losses. There is wide variation in the above mentioned data of groundwater available within the country. The relative reliability of these data has become a matter of concern. Estimates of groundwater availability by various organisations as mentioned above rely on different methodologies and concepts. Some are based on general topographic and hydrologic conditions and many make simple assumptions about aquifer behaviour. However, recently MPO (1987) carried out a detailed groundwater study based on sophisticated mathematical models considering regional variations in soils, geology, land use and local hydrological conditions. Regional estimates of groundwater availability by MPO are summarized below.

Table 1. Regional Summary of Groundwater Availability in Bangladesh.

Region	Potential and Usable GW. Mm^3			Available GW, Mm^3	
	Area (Km^2)	Potential (Mm^3)	Usable (Mm^3)	Area (Km^2)	Volume, Mm^3
North-West	30161	17834	13391	29191	9480
North-East	34755	23748	17811	22133	9615
South-East	30068	11956	8967	3644	1538
South-Central	14264	4814	3611	5031	1801
South-West	25616	5250	3958	11813	1980
Regional total	134864	63622	47718	71812	24414

* Source: MPO Technical Report No 51, 1987.

4. EXTENT OF GROUNDWATER UTILISATION

In Bangladesh groundwater has been being used for irrigation and public supplies for about two decades. Until 1980 the major element of irrigation growth in this country have been the low-lift pumps (LLPs). The development of groundwater utilization through deep, shallow and hand tubewells started after 1972. During 1979-80, about 76% ie, 1.071 M hectare of total irrigated area was covered by surface water irrigation and the remaining 24% ie, 0.34 M hectares were irrigated with groundwater. Due to acute shortages in surface water during the major cropping season and also in response to the availability of the groundwater resources throughout the major parts of the country, the national water utilization plan has been changed. In recent years, increased irrigation facilities have tremendously increased groundwater utilization. During the Second Five Year Plan (Planning Commission, 1985), the area irrigated by groundwater increased to 1.23 Mha. During 1985 19,815 DTWs, 156,249 STWs and 285, 367 MOSTIs (MPO, 1987) extracted groundwater throughout the country. The area irrigated by groundwater by this time was nearly half of the total irrigated land, ie, about 2.5 Mha.

Based on the reports of the Third Five Year Plan of the Government of Bangladesh (Planning Commission, 1985) total irrigable area is estimated to be about 4.45 M hectare. Area irrigated by the end of 1984-85 was estimated to 2.50 M hectare which is about 56% of the potential area. The remaining 1.97 M hectare are yet to be brought under irrigation. It is planned to expand irrigated area to about 88% of potentially irrigable area by 1990 (Planning Commission, 1985). Demand for urban and rural water supplies throughout the country has increased so that allocation for public water supplies have been updated in the Third Five Year Plan. This recognises the need for more groundwater due to irrigated agriculture and public water supplies incorporating additional deep, shallow and hand tubewells throughout the country.

5. ENVIRONMENTAL ASPECTS OF GROUNDWATER ABSTRACTION

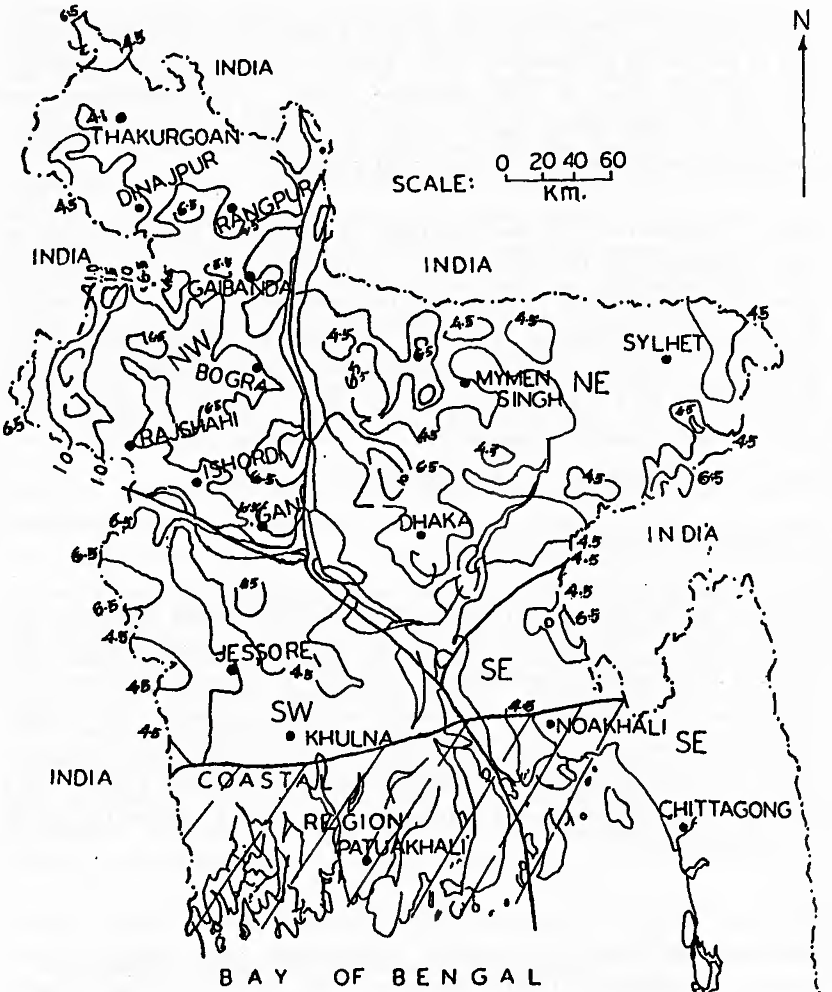
Groundwater is generally regarded as a renewable natural resource. It is extracted from the aquifer like other minerals such as oil, gas or coal. The Development of water supplies from a groundwater system begins typically with a few production wells. Over time more tubewells are drilled and the rate of abstraction increases. As numbers of tubewells increase the aquifer system starts to exceed its natural recharge capability and a mining or overdraft condition occurs. Extensive abstraction of groundwater may entail a number of undesirable results such as decline in groundwater level, salinity or water quality problems, reduction of flow in the connected rivers, land subsidence, and interference with prior water right of others. Thus groundwater abstraction can cause many environmental problems.

Although groundwater has been developed in Bangladesh for irrigation and public supplies over the last decade, little attention has so far been given to after-effects of groundwater withdrawal. In many areas the development of groundwater has led to alarming environmental crisis situations. Awareness of the important role that groundwater can play when developed as a major resource is now increasing as a result. The possible environmental consequences of groundwater abstraction in this country are discussed in the next section of the paper.

5.1 Decline of Groundwater Levels

Except in the Chittagong Hill Tracts, Rajshahi high Barind Tract and the Madhupur Tract, groundwater exists at shallow depths in Bangladesh. Except in these areas groundwater levels are at or near surface level from August to October. The lowest groundwater levels usually occur between April and May. These range from 3m below land surface to more than 8m in areas of extensive groundwater abstraction (MPO, 1985). Fig 1 shows the depth to groundwater throughout the country during the period of lowest level.

In several areas of Bangladesh such as Rajshahi, Bogra, Pabna, Comilla, Mymensingh and Dhaka, groundwater abstractions are causing a large decline in groundwater levels during the dry season. Typical examples are shown in Fig 2. Other than in the Dhaka and Comilla areas, groundwater levels re-obtain their normal static water level if sufficient recharge occurs during the wet season. Temporary overdraft conditions which are evident in some areas, particularly in Rajshahi, Rangpur, Bogra and Jessore districts are due to hydrological droughts and the extensive utilization of groundwater. It has been observed recently (Mirza, 1986; Bhoumik, 1986) that in the northern districts of Rajshahi and Bogra, groundwater levels have been depleted to a level of 9-13 metres below the static water table. As a result of this decline in



LEGEND

DEPTH TO GROUNDWATER LEVEL IN METRES
BELOW GROUND SURFACE ······ 4.5

FIG. 1 DEPTH TO GROUNDWATER LEVEL THROUGHOUT BANGLADESH IN THE MONTH OF APRIL, 1983.
SOURCE: MPO, 1985.

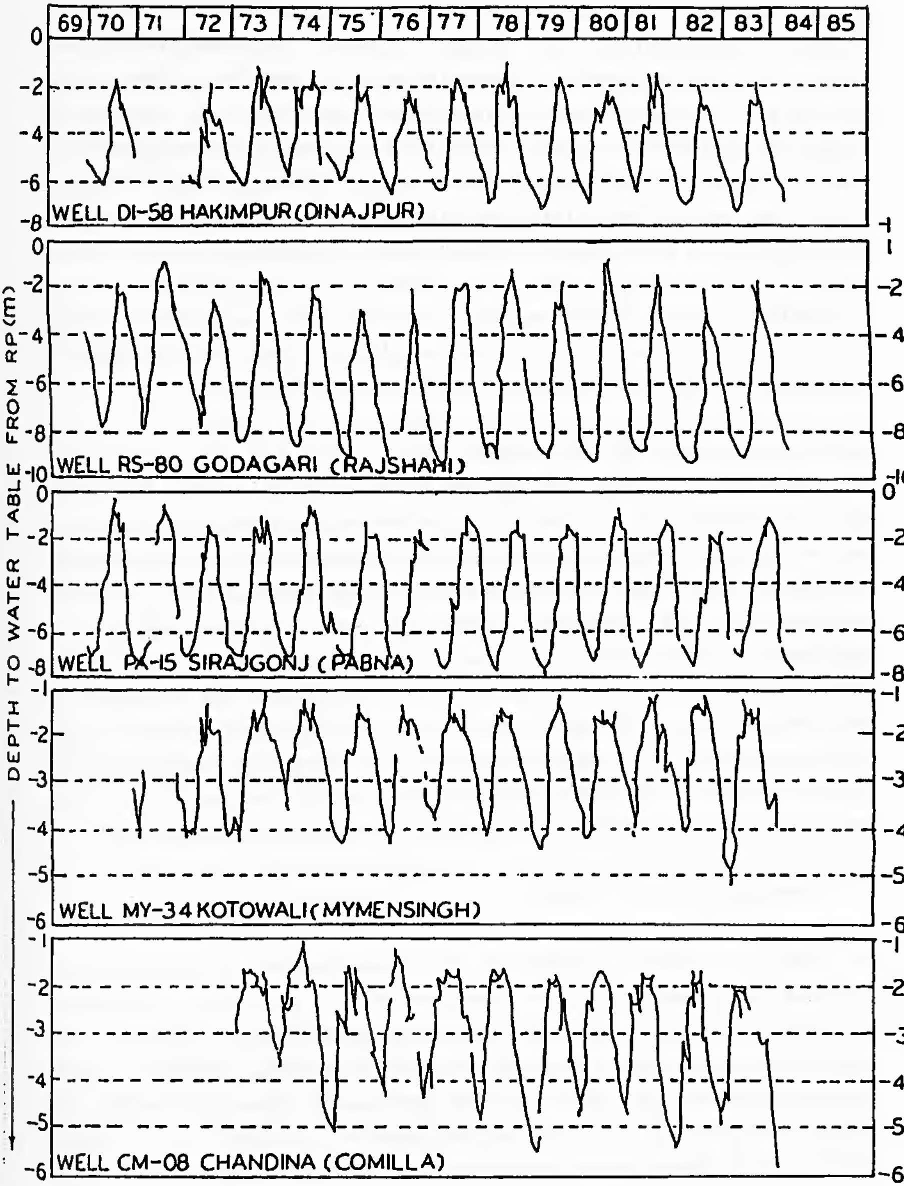


FIG. 2 WELL HYDROGRAPHS SHOWING GROUNDWATER LEVEL FLUCTUATIONS (SOURCE MPO, 1985)

groundwater levels most of the shallow and hand tubewells which have been installed for irrigation and drinking purposes in these areas, have failed. This occurs because the pumping head has gone beyond the maximum suction lift limit (maximum theoretical suction lift limit is about 10 metres) of centrifugal pumps, installed for running shallow tubewells. Furthermore, about 50,000 ponds, tanks and ditches in the Barind areas within the northern districts have almost dried up (Bhoumik, 1986). The draft decline in water levels in these local water bodies is due to the pumping of groundwater from the adjacent shallow aquifers and to evaporation losses. Therefore, this particular region is facing an acute shortage of water for surface irrigation, drinking and fish culture which ultimately has emerged as a threat to the environment.

Usually the rainfall in the northern part is less than in other regions of the country. During the last few years rainfall was much lower than ever recorded before. Agricultural production did not reach expected levels due to limited availability of irrigation water under drought conditions. Heavy pumping of underground water using shallow tubewells has exhausted soil moisture within the upper shallow aquifer. In addition to agricultural crops, many fruit and deep rooted trees within this northern region of the country have been affected due to decline in groundwater levels. The most important issue in this region is the reduced amount of soil moisture available to vegetation, particularly to crops and trees. This has focussed attention on the possibility that groundwater development projects upset the natural ecological balance.

5.2 Groundwater quality issues

In order to assess groundwater development potential, its quality in relation to various uses is as important as its quantity. In general, groundwater quality in most areas of Bangladesh is suitable for agricultural, domestic, municipal and industrial uses. However, in the coastal regions e.g. south-western parts and also in Patuakhali and Barisal districts of the south, this quality criterion is a severe constraint of groundwater development. In Khulna, Jessore and Satkhira districts of the south-west region, northward movement of salinity has increased in the recent past due to a reduction in dry season flows (low-flow) in the river Ganges. This is attributed to the Farrakka barrage located immediately upstream of Bangladesh. Since concurrently, heavy pumping of groundwater from the aquifer is also undertaken in this region, the salt water interface is also moving inwards and the aquifers (reservoirs) are contaminated with saline water. Saline water is of limited use for irrigation, domestic and industrial uses and ultimately causes many environmental hazards. When the horizontal movement of water in the aquifers is fully encroached with salt-water from the Bay of Bengal many of the production wells in the South-west of Bangladesh will have to be abandoned. Salinity is also becoming a constraint in many parts of South-east region of Bangladesh such as in Brahmanbaria, Chandpur and Noakhali districts. Increased use of groundwater for irrigation may degrade soil properties and ultimately hamper the growth and yield of crops. Khan et al (1977) and Khan & Basak (1986) found that an excess amount of iron content was present in the groundwater in some places of Dinajpur district in the north end at Madhupur, Mymensingh Sadar and Trishal Upazilas of the central region of Bangladesh. The precipitation of iron cemented together a continuous layer of soil which formed a hard, water-impermeable reddish-brown layer known as hardpan. This hardpan restricts usual penetration by plant roots. Plant growth and yield are also depressed because of decreased soil aeration, permeability and drainage. The effects of excess amounts of harmful minerals due to ground water extraction have already been encountered in Bogra, Dinajpur, Satkhira and other northern areas of Bangladesh. Once agricultural soils are being affected by harmful mineral components in the groundwater, further groundwater utilization can make the agricultural lands non-productive and create the need for complex soil and water management practices.

5.3 Pollution and health hazard

Much of the drinking water (about 90%) and nearly half the irrigation water in Bangladesh is obtained from groundwater. Therefore, the influence of groundwater and its quality on the environment cannot be ignored. The water in streams, lakes, oceans and soils naturally contains a variety of dissolved substances. In Bangladesh where land is relatively flat, the saturated zone is often by less than a metre below the soil surface. During the wet season, rainfall flushes the soluble substances from soils and may transport them to groundwater. Crop production in low rainfall areas is supplemented by irrigation from rivers, local water bodies (haors, beels) and groundwater. The dissolved substances from these sources are thus added to the soils. If the content of dissolved salts in the irrigation water is high, repetition of this process over a period of few years may make the soil too saline to support plants. On the other hand, if enough irrigation water is added to flush the excess salts out of the soil, the salinity of groundwater in the shallow aquifers may be increased. Excessive salinity of groundwater is undesirable for agriculture as well as for drinking purposes.

Application of fertilizers, especially of nitrogen to agricultural lands can add nitrate to the groundwater through leaching or direct percolation. When nitrate-polluted groundwater is utilized it may cause health problems. When nitrate is ingested in excess, the resulting nitrate causes meta-haemoglobinemia - a fatal disease, and several other human health problems such as birth defects, cancer and nervous system impairment (CAST, 1985). Although nitrate pollution problems as a result of groundwater utilization have not yet been identified in Bangladesh, the possibility of their occurrence cannot be ignored. Bacterial contamination of groundwater in rural as well as in urban areas from organic residues, including crop residues, homestead wastes, animal manures and sewage sludges may also cause health problems. If groundwater is polluted with chemical pesticides it can degrade drinking water. Extensive use of groundwater for irrigation can encourage the growth of mosquitoes in wet paddy fields, which may cause the spread of malarial diseases.

5.4 Reduction in river flows

Generally a groundwater system is hydraulically connected with a river system. Bangladesh is a riverine country. Therefore, most of the shallow aquifers have hydraulic continuity with the neighbouring rivers. Where a stream channel is in direct contact with an unconfined aquifer, the stream may recharge groundwater or receive discharge as base flow from the aquifer storage, depending on the relative water level gradient.

The sources of streamflow in the major rivers within the northern region of the country during the dry period are inflows from the upstream catchment area (India), the groundwater run-off from the aquifer storage, and also rainfall if there is any. During recent years, streamflows in dry seasons in the major rivers e.g. the Ganges and the Brahmaputra have declined drastically due to withdrawal of water in the upstream regions. It has been reported that the streamflows in the Ganges have reduced to nearly 736 cumec between 1983-1984 (Alam, 1985). Therefore, during dry periods the observed streamflows in the rivers are mostly contributed by the aquifer storage as baseflow. Groundwater abstraction from tubewells, particularly shallow tubewells near the river is directly at the expense of river flow. Due to excess pumping of groundwater in the dry season, water levels in many rivers fall below normal dry weather flow. Due to reductions in dry season streamflows and also to heavy groundwater abstractions, a new hydrologic equilibrium has been attained in the northern region and the groundwater levels have declined up to 9-13 metre from the static water level in many places of this region.

Fig 3 illustrates schematically the hydraulic behaviour of an unconfined aquifer with a river system, which is very common in many areas of the country. Continuous abstraction of groundwater using tubewells under such circumstances (as shown in Fig 3) is limited to the difference between the dry weather flow and minimum acceptable flow. The maintenance of minimum acceptable river flows is necessary for fisheries development, inland transport and navigational purposes; and also to contain problems such as salinity and pollution by sewage effluents. Reduction in streamflows can have a negative effect on fish, population, growth rates and migratory patterns, resulting a complex impact upon the aquatic ecosystem.

5.5 Conflict among trade-offs

In this country, the development of groundwater resource through various technologies (DTWs and STWs) is usually undertaken in isolation. The STW programme has been the major groundwater development mode in this country. This programme has become much popular due to socio-economic conditions of people and the choice of private ownership. STWs are installed in the upper shallow aquifer, whereas DTWs are sunk in the main aquifer within the same area which is hydraulically connected with the overlying composite aquifer. Extensive withdrawal of ground water from

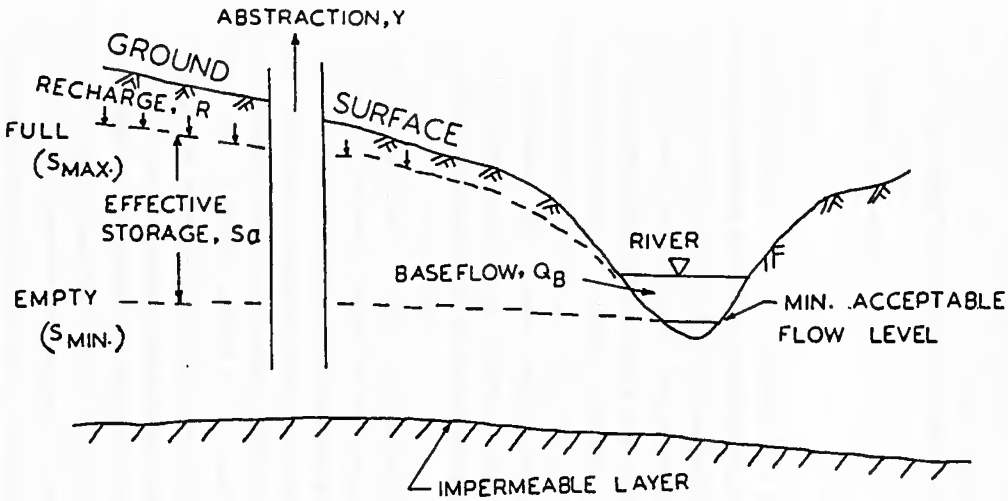
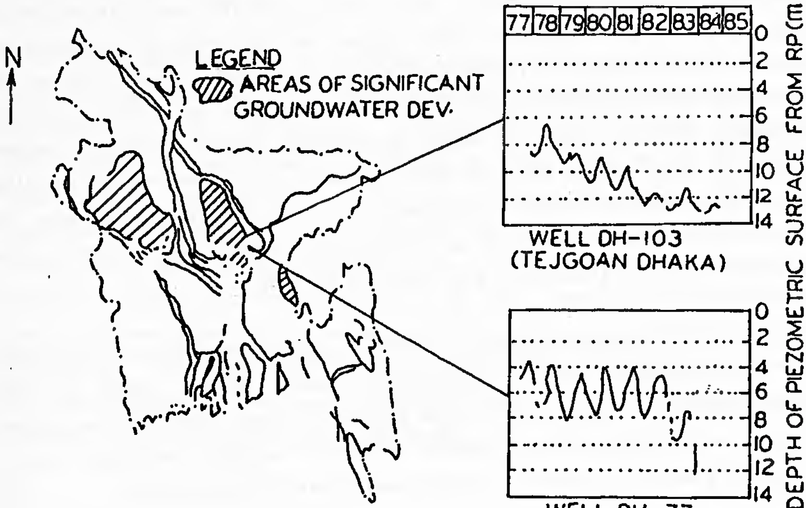


FIG.3 SKETCH OF AN UNCONFINED AQUIFER CONNECTED WITH
A RIVER SYSTEM.



SOURCE: MPO, 1985

FIG. 4 THE EFFECTS OF GROUNDWATER ABSTRACTION ON GROUNDWATER LEVELS.

the main aquifer will lower water level in the upper aquifer, thereby increasing the suction lift limit for the STWs, and also HTWs and MOSTIs in many places of the country. As a result, the STWs and HTWs run dry in many areas. The continued exploitation of groundwater resources for agricultural purposes will decrease water supply for private STWs and for HTWs for drinking water. The interaction of deep and shallow tubewell pumpings creates conflicts among groundwater usages. Conflicts between domestic water supply and irrigation demand will require new attention and action such as deepening the boreholes, construction of new ones, the lowering of pumps, command area development. Some policy choices on the direction of new investment also have to be made.

The use of groundwater for irrigation eventually diminishes the quantity of water available in the neighbouring ponds, beels, haors and other water bodies. Reduction of water levels in these water sources can have impact on spawning areas, feeding grounds, nursery habitats, etc. of aquatic species and result in decreased aquatic productivity.

5.6 Land subsidence

Changes in groundwater levels or subsurface moisture conditions may cause subsidence or settlement of the land surface. This can damage buildings, particularly in urban or metropolitan cities and can create special problems in the design and operation of structures for drainage, flood protection and water conveyance.

Land subsidence has been observed to accompany extensive lowering of the piezometric surface in regions of heavy pumping from aquifers, particularly confined ones. Many areas of subsidence due to groundwater pumping are known in the USA as well as in Japan, Mexico, Taipei, Italy and England. The most spectacular subsidence areas due to groundwater abstraction are the Southern Great Valley of California and Mexico city where maximum land settlement has exceeded about 4.57m (Walton, 1970). The Bangkok city area has also experienced a subsidence of about 1 metre due to groundwater abstraction (Brand, 1974). Todd (1980) reported that the average subsidence ratio at San Jose, California, equalled 1/13 indicating that the land surface subsided 1m for every 13m of lowering of the piezometric surface of the aquifer. Recently, Calcutta has experienced settlement due to groundwater pumping from the aquifer beneath the city.

The above mentioned examples indicate a possible settlement of Dhaka Metropolitan area as a result of heavy groundwater abstraction. The piezometric surface within the city area already declined to about 6m during last 6-7 years period (see Fig 4). The upper 20-30m beneath the city area is composed of a clay layer and the aquifer from where groundwater is withdrawn is more than 40m below the land surface (MPO, 1985). This decline of piezometric levels indicates pumping in excess of the safe yield of the aquifer. As has been shown, pumping under overdraft condition within the Metropolitan area can contribute to land subsidence. Although there is no physical evidence of this up to now and no investigation has yet been made, awareness of and attention to this potential effect on Dhaka city are needed.

6. CONCLUSION

The development of groundwater resources occurs at a time when world-wide interest in environmental matters has increased. There is concern about the possible consequences on the environment. In Bangladesh, groundwater has been developed extensively for irrigation and public supplies without consideration of the possible after-effects. The abstraction of groundwater for agricultural development and public supplies has already brought a degradation of the natural hydrological regime in many areas. As a result, environmental conditions have deteriorated in these areas, particularly the northern regions. In order to get the beneficial use of the important natural resource, groundwater, there is a need for overall management according to rules or procedures for its optimum use. Throughout the country groundwater management practices are either unknown or have become so difficult in terms of time and operation that they are ignored. Different concepts and methodologies for the development of groundwater resources through deep and shallow tubewells have been practised time and time again without detailed assessment of the resource, investigations of aquifer characteristics, economic viability or of operational and management difficulties. As a result, maximum benefits from groundwater use have not been obtained. In future, more careful consideration should be given to water management objectives based on investigations of the local environment and hydrology. The achievement of management objectives, of course, also depends upon geologic and hydrologic considerations, economic, legal, social, political and financial factors.

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IRRIGATION MANAGEMENT NETWORK

IRRIGATION MANAGEMENT IN SOUTH INDIA: THE APPROACH OF THE NATIONAL WATER MANAGEMENT PROJECT

D J W Berkoff

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IRRIGATION MANAGEMENT IN SOUTH INDIA
THE APPROACH OF THE NATIONAL WATER MANAGEMENT PROJECT

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IRRIGATION MANAGEMENT IN SOUTH INDIA
THE APPROACH OF THE NATIONAL WATER MANAGEMENT PROJECT

D J W Berkoff

1. THE NATIONAL WATER MANAGEMENT PROJECT

The National Water Management Project (NWMP) is supported by an IDA credit of $115 K which was declared effective in September 1987. It is initially focussed on three south Indian states (Andhra Pradesh, Karnataka, and Tamil Nadu) but provision is made for pilot programmes in other states. If successful, it is envisaged that the programme could be extended throughout India, possibly under a succession of World Bank-supported operations.

The NWMP's premise is that substantial benefits can be obtained in existing irrigation schemes in India through a more reliable, predictable and equitable water delivery system. This reflects the established consensus, in India and elsewhere, that wherever water is scarce relative to demand, operation of the main system is the key to the management of large irrigation schemes:

> "Only if the main distribution system is well organised can other important management objectives be realised (eg, 'on-farm development' work, improved watercourse and farm level water management, higher water charges); and only then can high returns be obtained from agricultural extension and the application of complementary inputs." (Bottrall, 1981, p 12)

The NWMP provides an instrument for translating this consensus into practical measures at the scheme level. Its essential feature is the preparation of an "Operational Plan" for each scheme to define the principles of water distribution and allocate responsibilities for implementation. Its design was based on a number of pilot operations implemented over the period 1983-87 and it also reflects experience gained in the context of other World Bank-supported projects in India. Limited funds (up to 2,500 Rs/ha at 1986 prices) are provided to upgrade the system in support of improved management, and these and other resources and activities (enhanced Operation and Maintenance (O&M) allocations, Command Area Development (CAD) programmes, supporting agricultural services, delivery of complementary inputs, etc) are to be programmed to complement the proposals contained in the Plan.

Schemes vary widely and the Operational Plan must be adapted to the characteristics of the scheme in question. Nevertheless, a common approach to irrigation management underlies many of the initial proposals for sub-projects in South India. This paper aims to clarify this approach, recognising that its particular application will differ widely in different schemes. It begins by describing how present design practices for mixed paddy/non-paddy originated in traditional design for paddy. It then reviews why it has proved extremely difficult to operate these systems according to design objectives. The design characteristics of the approach proposed under the NWMP are then described, indicating how it aims to respond to practical problems encountered, and the paper ends with a brief assessment of longer term implications.

2. TRADITIONAL DESIGN FOR PADDY

Irrigation management in South India originated with paddy. Typically, traditional schemes include all the land that can be commanded, with paddy covering 100% of the irrigated area during the principal monsoon season. Canal capacities are sized generously though some staggering of transplanting is normally required (the duty - the area irrigated per unit flow - is typically 40-50 acres/cusec or 1.75 l/sec/ha). Main, distributary and minor canals run continuously during irrigation, with discharges at every level adjusted in response to perceived requirements (eg, limited flows for nurseries, full supply and staggering of canals during transplanting, reduced discharges and/or canal closures when it rains or as the crop matures, etc). Distribution below the outlet is by farmers who normally employ field-to-field irrigation supplemented by rudimentary field channels where these prove necessary. The farmers and/or their employees (neergatties) become very adept at distributing flows given their detailed knowledge of the local micro-topography. Typically, they relax if it rains or discharges are in excess of requirements: tighten but co-operate well if supplies are adequate but limited: and compete if shortages go beyond a point that threatens their crops. When co-operation breaks down, head-end farmers typically take what they can to save their crops and shortages and crop losses are concentrated at the tail.

If water is short, and during the second season, the irrigated area is cut back to reflect availability, with head-enders normally the principal beneficiaries. Over time, the irrigated area typically expands as farmers exploit run-off through ad hoc extensions to the canal system, construction of diversion structures (anicuts) on drains, utilisation of tanks for temporary storage, etc. Traditional schemes are therefore often complex in detail. Nevertheless, they can also be relatively efficient, especially on a basin or sub-basin as each anicut or tank in a series utilises return flows from the scheme above.

3. MODIFICATIONS TO TRADITIONAL DESIGN FOR OTHER CROPS

Traditional paddy schemes are typically located in valleys below tanks, along streams and in deltas where flooding, inadequate drainage and/or perched water tables make paddy the main practical alternative, at least during the rainy season, and where water supplies are concentrated. Increasingly, however, large scale upstream development has extended irrigation to lands less suited to paddy while it has become generally recognised that water and not land is the limiting factor. Traditional design has therefore been modified in four main ways so as to increase the area receiving irrigation: first, water allowances per unit area have been reduced, secondly, less water-demanding , non-paddy crops have been promoted, though paddy normally remains the preferred crops, thirdly, new land is in principle increasingly limited to one irrigated crop per year, and fourthly, lands that can be physically served may be excluded so as to take water to more distant areas.

Design of these new style projects has built on traditional practice for paddy, in particular by serving 100% of the approved command with continuous flow to the outlet at duties dependent on the approved cropping pattern. Initially, it was assumed that farmers would follow this cropping pattern of their own accord. When this failed to take place, areas under different crops were increasingly separated or "localised". There is no formal definition of "localisation". It is an administrative process which has undergone several changes over time, being essentially a procedure to delimit compact areas within the command of a public system so as to avoid haphazard development of irrigated agriculture. It reflects the fact that, from the earliest times, the conservation and control of river systems has been in the hands of the ruling power which can thus apply, regulate or deny water to any area within a command. The farmers on their part had the right to opt out of the irrigation which made them liable to pay compulsory water charges or higher land tax. The entire process of notifying the areas to receive water, the sources of irrigation supply, the seasons of supply and the cropping pattern (indirectly reflecting the quantum of water) has come to be known as "localisation". The major characteristics of such localisation systems can be summarised as follows:

a) Localised areas: To facilitate irrigation, crops with differing requirements are in principle "localised" and irrigation is authorised only for that purpose. The localised areas are identified by survey numbers, the source by specific government outlet (sluice) and the quantum of water by specifying broadly the crops to be grown for which the net irrigation requirement from sowing to harvest would be fully met from the government sluice. The crops to be grown were generally classified as paddy (also called wet crop), upland crops (also called irrigated dry (ID) or semi-dry crops, including maize sorghum, millets, etc) two-seasonals (cotton, turmeric, etc, also referred to as ID crops and not often separately differentiated) and perennials (notably sugarcane but also garden crops, banana, etc). Areas for seasonal crops were further localised by season (eg, kharif wet, rabi

ID, summer ID, etc) while if paddy was to be grown in two successive season it was classified as double wet.

b) The full localised area to be irrigated: "Localised" areas are authorised for a full crop over 100% of the land, with the system in principle designed to supply water for the specified purpose. This is in contrast to the warabundi schemes of North West India and Pakistan where farmers are allocated water in proportion to their holding size but normally in quantities that are much less than would be needed to irrigate the whole farm. Areas localised for kharif area are closed during rabi and summer, those for rabi during kharif and summer, etc. Two seasonal areas are closed during summer. Perennials are supplied throughout the year, except during closures for canal maintenance. If an area is closed for surface irrigation, the farmer is still free to cultivate a crop of his choice utilising rainfall, well water, etc. In the case of shortages, contiguous areas within the localised command are notified with regard to their eligibility to receive water for the notified cropping pattern, with such areas in principle rotated from year to year to secure equal access to water to all the localised areas over a period of time.

c) Design duties: Water requirements for paddy are greater than for ID crops and - to minimise capital costs and, in theory, to simplify operations - canal capacities are sized accordingly for continuous flow to the outlet. To spread benefits widely, and assuming higher technical standards for new projects, the duties adopted have often been high, for paddy typically being 50-60 acres/cusec (1.15-1.40 l/sec/ha) at the distributary head, for ID crops 100-160 acres.cusec (0.40-0.70 l/sec/ha), and for perennials, 90-120 acres/cusec (0.55-0.75 l/sec/ha). Duties for kharif may be higher than for rabi/summer due to lower evapotranspiration and an assumed contribution of rainfall. If a canal serves areas of mixed localisation, its capacity is a weighted average sufficient to carry the peak discharge for the season with the maximum requirement. In other seasons and at off-peak periods, it is operated at a reduced discharge.

d) Continuous flow to the outlet: Canals normally run continuously to the government outlet at the specified discharge (if full supply is not required, at reduced discharge) though ad hoc rotational practices are often also adopted. As for traditional schemes, farmers distribute water below the outlet but this is facilitated by improved design (eg, smaller and standard sized chaks), CAD works (eg, field channels, field drains, land levelling, etc) and rotational schedules and farmer groups (eg, those encouraged through the centrally sponsored "warabundi" programme).

e) Variable supply and flexibility: Since variable discharge may be required at any level (to serve different localised areas in different seasons, to meet differing crop requirements within a season) all offtakes/outlets are gated and designed to take full discharge with, say, 50% supply in the parent channel. Outlets at the head of the field channel are normally standard sized pipes (3", 6", 9", etc) which in principle are throttled back to the authorised discharge. Offtakes/outlets can therefore often draw potentially much more than their design discharge, and gates must be adjusted accordingly depending on the flow/level in the parent canal.

Localisation is a formal administrative process completed by a joint team from the Revenue, Irrigation and Agricultural Departments prior to project construction. As previously mentioned, the concepts have evolved over time. In early projects, (eg, Bhadra, Tungabhadra) there was no attempt to separate the areas under different crops, and localisation was based on survey numbers or simply represented the approved cropping pattern with no specific area identified for a particular crop. When it became evident that it was impracticable to serve mixed cropping patterns below the government outlet, localisation was increasingly based on "blocks" so as to separate areas under different crops, (in particular paddy from other crops). Blocks can be based on the field channel, minor, distributary or main canal (eg, where a command is wholly localised for a particular purpose). An attempt is usually made to take physical criteria into account (eg, localising paddy on heavy soils in valley area, ID corps on upland soils, etc) but, in practice, many factors have influenced localisation and there is often little correlation between soil type and the corp proposed. Factors that have had an influence include inconsistencies between the mix of soils and general cropping objectives: political pressures, eg for paddy or sugar: a wish to give each village some paddy land irrespective of soil type: acceptance of

ID cropping by farmers as a condition for obtaining an extension to the canal system, etc.

4. THE MODIFIED DESIGN IN PRACTICE

The design that evolved out of traditional paddy schemes requires that water be sufficient to serve the localised areas to a specified level for the authorised purpose (the promise to the farmers inherent in localisation), and that there is adequate control to prevent unauthorised diversions and deliver the water as planned. Since the design is flexible (variable flows can in theory be distributed down to outlet), this requires that gates at every level are adjusted to respond to variable flows in the parent channels, that the gate operators perform their duties correctly and on time, and that there is no interference in the gate setting or in the flow regime of the parent canal. In practice, it has proved extremely difficult to satisfy these conditions. Reasons include:

a) The discrimination inherent in localisation. In most cases, localisation discriminates between farmers/areas within the same scheme. Farmers whose lands are localised for paddy or sugarcane are supplied more water than those localised for ID. Further, in many schemes, blocks of areas in a village are excluded from localisation in order to extend the benefits of irrigation to more villages. Farmers in a position to do something about this (ie, if they are at the head) see no reason for accepting such limitations if they prefer an alternative (eg, paddy rather than ID). Discrimination is particularly hard to accept where land is excluded from any right to irrigation (non-localised) even though it can be commanded. Land was excluded not only to extend the command to more distant villages but also to provide for special purposes, eg, to provide an unirrigated zone round the village as a malaria control measure.

b) Canal losses and design duties: Canal losses have often proved greater than expected, despite improved standards (eg, lining) and design duties have therefore often been higher than can be achieved in practice. Even if everything else works according to plan, it may thus not be possible to serve the full localised area. Furthermore, little account is taken of canal losses in design of canals down the system (the duty at the head of the distributary, for instance, may be the same as at the head of the minor or at the outlet). It has been implicitly assumed that, while setting discharges (which in any case are variable - see e) below), gates will be adjusted to ensure that losses are distributed equitably down the system. If this cannot be achieved, then losses will be concentrated at the tail even if head-enders are confined to the authorised discharge (in practice they may take more).

c) Crop needs and design duties: Separate from whether the design duty can in practice be achieved (see b)) is the question of whether it meets crop water requirements. Optimistic duties have been adopted to help justify extending the command. Farmers are thus in principle required to accept protective-type irrigation (that is, supplies which do not meet full crop water requirements) while being authorised for a crop over the whole area. For paddy, the peak is usually during puddling/transplanting: whatever the duty, staggering is normally required both along the supply channel and within the outlet command, with capacity thereafter usually more than sufficient. For ID crops, the peak is normally late in the growing period at which time evapotranspiration needs may be only 10-15% lower than for paddy. Even allowing for deep percolation, an ID duty that is half that for paddy (say 120 acres/cusec rather than 60 acres/cusec) can therefore place a severe constraint on deliveries. This is a particular problem for rabi crops delayed until March/April when evapotranspiration rises steeply. In other words, the duties adopted for continuous flow to the outlet have not only been optimistic but have tended to reflect average water needs rather than peak requirements ("the trap of averages"). As in the case of the cropping pattern (see a)), farmers who are at the head and can do something about it see no reason to accept insufficiency of supplies and therefore tail-end farmers suffer, especially during the peak.

d) Continuous flow and farmer interference: Continuous flow at the outlet allows farmers in a favoured position to obtain additional water at any time through interference at the head of the field channel, the lowest control level in the system. Flows can be increased through the simple expedient of fully opening the pipe (since potential capacity is normally greater than authorised discharge), by opening the pipe when it is closed (mixed localisation may require that parent channels be run even when a particular field channel is closed) or, more drastically, by enlarging/bypassing the official opening or removing the gate completely.

e) Variable flow and farmer interference: variable flow also provides opportunities for interference by encouraging farmers to construct cross bunds in parent channels to head up water so as to divert additional supplies. If the gate has been adjusted to reflect reduced discharge in the parent canal, the outlet will take more than its authorised share. If the outlet has been modified (see c)), then it will take that much more.

f) The number of gates to be controlled: In a continuous, variable flow system, the setting of each gate should in principle be adjusted each time that discharges are varied. For instance, if farmers at the tail complain of insufficient water and discharges are increased then, unless all openings further up the system are reduced, all upper offtakes will receive additional supplies whether they need them or not. The number of gates has, if anything, increased as a result of a reduction in average chak size. Given other pressures, it has proved virtually impossible to control large numbers of gates in the system. The gate operator is often the only permanent employee and sees his role as satisfying the farmers with whom he has to live rather than as controlling water on behalf of an impersonal Irrigation Department in which senior staff often change.

g) The long gestation period for large schemes: the long time taken to complete major construction works allows early surpluses to be used to support practices inconsistent with ultimate localisation patters (eg, provision of excessive water, cultivation of paddy rather than ID crops, authorisation of a second crop out of season, etc). It has proved politically difficult not only to resist pressures to use surpluses in these ways, but also to withdraw privileges once they have become established.

h) Year-to-year variations in water supply: Flows in many Indian rivers vary radically from year-to-year, a ratio of ten to one between a good and a bad year being not uncommon. Systems are designed for, say, a 75% year but the farmer may feel he has a right to a full authorised crop each year since this is the premise on which localisation is seen to be based (but see pages 14 to 15). No doubt farmers recognise the need to tighten up in a poor year, but there is no established mechanism requiring a farmer to plant only part of his farm. Though efforts are made to distribute allocations fairly (eg, by closing sub-commands in rotation), in practice shortages are concentrated at the tail.

i) Declining water availability: Not only is there great variability from year-to-year but initial estimates of water availability may be over-optimistic and supplies may decline over time owing to extractions upstream and/or catchment degradation. In surplus rivers, reservoir construction will of course greatly improve security of supply but in the long term, as full development is approached and exceeded, the failure to control and manage the river basin as a whole can become a major problem.

With all these problems, it is not surprising that localisation systems have often proved impossible to operate as designed. The result has been concentration of cropping towards the head: extensive unauthorised cultivation; farmer interference and damage to the physical infrastructure; extensive tail areas that never receive supplies; and a general breakdown of control.

Rotational and ad hoc measures to distribute water are often adopted and in some cases these have been institutionalised (eg, the practice of "systematic canal operation" in Andhra Pradesh. Under systematic canal operation, canals are closed in rotation for one or two days a week (in paddy areas, only after transplanting has been completed) so as to push water to the tail. Such measures may be particularly successful during drought years since during a drought, everyone, from irrigation officials to farmers, recognises the need for restraint. Even if scheme operators make no attempt to manage scarce supplies, the value of water is such that a free for all can still result in considerable agricultural production: head-enders may achieve higher production levels than is their due, tail-enders may make surprisingly productive use of limited supplies, re-use of drainage offsets inefficiencies further up the system, etc.

But this is not really the point. Such systems still often operate at well below their productive potential, are inequitable and unreliable in their impact, often require expensive periodic rehabilitation, and may lead to long term environmental damage. The issue is not how well they can perform under pressure but how they should be operated under all conditions. The traditional design requires a degree of control that has in practice been impossible to achieve. The main requirement is therefore to adopt a management plan that has a realistic chance of being implemented and then to make the necessary infrastructural improvements to support the revised management plan. Only if it has a realistic chance of implementation can scheme operators hope to establish control and only if they establish control can they hope to maintain the physical infrastructure in good order.

5. LOCALISATION AND THE PROPOSED APPROACH

The approach proposed in the initial NWMP sub-projects is based on principles which build on, but in some important respects differ from, past practice. The concept of localisation by blocks is retained but the emphasis is on the irrigation service to be provided rather than the crop areas to be served. In other words, the promise to the farmer is an irrigation schedule to which he must respond rather than supplies to satisfy a specified cropped area. The schedule reflects a notional cropping pattern, but if farmers wish to vary this in response to the irrigation service that is their affair. The schedule and its supporting infrastructure are designed to be manageable under prevailing conditions.

In essence, this approach returns to the original objectives of localisation and attempts to ensure that they can be achieved in practice. Localisation was an administrative measure adopted by the irrigation and revenue authorities to facilitate water distribution. Formal notification is given to the farmers so that they know what to expect but, in its original intention, localisation was legally binding neither on the irrigation authorities nor on the farmers. The authorities had the right to regulate water distribution and the farmers to utilise their land as they thought fit. Localisation was intended therefore as a basis for the design of the physical infrastructure and as a clarification to the farmer of how the authorities intended to distribute water.

Governments retain the right to regulate water distribution. However, they have also increasingly assumed powers to control farmer activity, notably under the CAD acts of Andhra Pradesh and Karnataka, with these powers assumed in part to ensure farmers abide by their localisation status. Even prior to the CAD acts, the perception that localisation was legally enforceable had become widespread, not only among outside observers but also at the scheme level. However, if farmers are required to grow specified crops, the corollary is that the authorities must provide the water necessary to support these crops. Increasingly, therefore, localisation has been perceived as demand-based designed to meet the requirements of specified crop areas rather than as supply-based to distribute available supplies in an orderly manner. Farmers have thus come to believe they had a right to certain water irrespective of the overall situation, and headenders felt justified in securing this 'right'.

The distinction between the initial intention lying behind localisation and how it has come to be perceived is an important one. Both approaches assume a certain cropping pattern (eg paddy or ID crops), but one seeks to control what the farmer does while meeting his requirements (ie is demand-based) while the other promises a pattern of water delivery based on a notional cropping pattern without requiring a specific response and without seeking to meet the requirements of each and every farmer (ie is supply-based). In practice, they will result in similar cropping patterns but the former approach tends to be rigid and difficult to manage while the latter can readily respond to water availability and evolve over time.

6. MAJOR CHARACTERISTICS OF THE PROPOSED APPROACH

The approach proposed under the NWMP aims to return to the original intentions lying behind localisation. It can be summarised as providing a demand-scheduled supply by means of an irrigation system which is structured in a manner which is manageable under present conditions. Its main characteristics are as follows:

a) *Irrigation Service* Operations are in principle to be based on providing a defined irrigation service rather than meeting the requirements of specified crop areas. The irrigation service for an area would reflect a notional cropping pattern (ie the localisation pattern) but if farmers wish to vary their cropping in response to the irrigation service that is their affair.

b) *Characteristics of the Irrigation Service* To the extent possible, the irrigation service would define when, where and in what amounts water is to be provided. Criteria for responding to rainfall would be established. If water availability is not known with certainty in advance (eg for run-of-the-river schemes), rules for responding to variability would be explicit so that the farmer is clear as to the risks he faces. The provisions of the service would only be modified during the season in response to *force majeure* and in consultation with the farmers.

c) *Consolidation of Areas Receiving a Common Service* Different areas in the same command may receive a different irrigation service (ie have different localisation patterns) but such areas would, to the extent possible, be consolidated at least at the minor level and preferably at the distributary or branch level. The notional cropping pattern assumes that 100% of each irrigation service area is irrigated although not necessarily receiving full crop water requirements (that is there may be some stress built into the design - see (d).

d) *Provision of Canal Capacity* As for the traditional design, sufficient capacity would be provided in the canal system to satisfy either full peak requirements of the notional cropping pattern or a specified proportion of peak requirements, that is allowing for some degree of stress. The degree of stress would, however, be limited to ensure that the system is manageable after allowing for realistic loss assumptions.

e) *Time and Not Flow to Control the Quantity of Water Supplied* Wherever possible, the number of control points would be reduced and simple automatic distribution devices would be provided to simplify operations. Canal capacities would reflect the notional cropping pattern and be proportional to the area served. Below the level at which the system is structured, this would allow the introduction of proportional dividers and ungated outlets (eg APMs), with free flow distribution at full supply discharge. Above this level, additional control structures would be provided (eg long crested weirs and modular outlets) to ensure that the system runs with a minimum of adjustment despite variable flow. In addition to investments in support of the structured design, provision may be made for accumulated maintenance, additional escapes, improved communications, measuring and monitoring devices, and other priority items specific to the scheme in question.

The approach therefore has two main elements: the re-assessment of the irrigation service to be provided, and the introduction of a structured design which allows for variable and controlled discharge down to a specified level (at least the head of the minor) below which distribution is proportional and free flowing.

7. REASSESSMENT OF THE SERVICE TO BE PROVIDED

Based on the concept of an irrigation service area, irrigation schedules must be prepared specifying the timing of cropping, the frequency of irrigation, the period of each irrigation and the discharge to be provided (variable above the point at which the system is structured, constant below this point). The details must be adapted to each scheme but certain general principles can be outlined.

Consolidation of service areas must build on the present pattern of localisation but also reflect present realities. For instance, non-localised areas with *de facto* rights in localised areas with long-established unauthorised cropping would both normally be recognised. However, any change which affects access to water will be controversial and a careful balance must be struck. Discussions with farmers may have to be prolonged to ensure that the changed proposed are generally accepted as fair and realistic. Since the aim is to emphasise the provision of an irrigation service rather than meeting the requirements of a fixed cropping pattern, it may be possible to avoid formal relocalisation. In such cases, seasonal schedules would increasingly aim to make best use of available water irrespective of localisation without requiring any farmer to forego what is perceived as his right. In other cases, consolidation by blocks will be necessary as a basis for design and in these cases formal relocalisation will be required.

Timing is of crucial importance, given the interdependence of cropping patterns and sequences. In particular, advancing the kharif opening date (eg by carryover from the previous year) may have major advantages even if rabi cropping is reduced since: i) the crop is established prior to the rains with beneficial effects on plant populations, disease resistance and yields (paddy in particular benefits but all crops are less vulnerable to damage from heavy rainfall), ii) rainfall is utilised more fully and hence demands on stored water are reduced (paddy can make fuller use of rainfall for puddling/transplanting, crop maintenance for all crops coincides more closely with rainfall), iii) the subsequent rabi crop can be planted early thus reducing water demands late in the season – March/April – when evapo-transpiration rises rapidly (early planting may also have beneficial impact on yields eg of wheat), and iv) if no rabi is foreseen, there may be increased opportunities for a crop on residual moisture (the residual moisture crop can be harvested before temperatures build up in March/April). Even if advancing the kharif crop is not desirable option, timing, and opening and closing dates for canals, need to be reassessed.

Scheduling for *non-paddy crops* is normally straightforward, in particular if rainfall is not a consideration. If pre-soaking is required, then water would be supplied continuously at full supply discharge, with areas staggered to complete pre-soaking as expeditiously as possible. During rabi when little account need be taken of rainfall, supply to the outlet would be according to an intermittent schedule following the water requirements of the notional cropping pattern. For instance, if groundnut is the reference crop, a typical sequence might involve an initial (pre-soaking) issue end-November/early-December depending on soil moisture levels to establish the crop: a three-to-four week gap to encourage root development and discourage paddy: five or six further issues on, say, a weekly intermittent schedule from early/mid-January to early/mid-March (with back-to-back issues at the peak): and a final issue for harvesting. The total number of irrigations would vary depending on water availability and, if water is very short, the command might be zoned (ie areas cut off in rotation) or a less water demanding reference crop adopted (eg pulses rather than groundnut). During kharif, and if rain is significant, the main determinant is response to rainfall. A target schedule might be prepared to guide operations but irrigation during a dry spell must normally start in advance of the requirements of the schedule to ensure that, if the spell continues, supply to the last farmer does not deviate too greatly from the target.

Scheduling for paddy may be more problematic. The original design was adapted to paddy and modifications for other crops must avoid the danger that the new design is in turn inappropriate for paddy. A promising approach is to design systems serving paddy for proportionality at two specified discharges, one for puddling/transplanting and one for crop maintenance. Other options include provision of on/off gates at the outlet together with additional escapes in the minor to enable farmers to reject supplies in the event of rainfall or variable stages in harvesting etc. Irrespective of whether these are done, however, scheduling for paddy is likely to have the following characteristics:

- nursery establishment: adequate flow - if necessary on/off at full discharge - to supply all farmers who want water even if this results in apparent 'waste[1]';

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[1] It is important to monitor flows to tail farmers to ensure they initiate nurseries on schedule. This may result in flows that are in excess of nursery requirements, in which case they should either be diverted onto fields for pre-soaking, into tanks or to the escapes, with run-off accepted as the cost of ensuring expeditious nursery establishment (water can often be utilised further down in the basin). Provided all farmers are satisfied, and interference in the system is avoided, partial flows to the outlet may exceptionally be provided so as to avoid over-topping of canal banks if farmers reject supplies. A preferable alternative is to concentrate nurseries under tanks, on wells or in limited defined areas so as to avoid the problem of serving them through the main system.

- puddling/transplanting: continuous flow at full discharge (enhanced discharge if the system is proportional at two levels) with puddling/transplanting staggered both along the parent channel and within the outlet command so as to complete these operations in as short a time as feasible (this period will vary from year-to-year depending on rainfall);

- crop maintenance: intermittent supply at full discharge either with a short rotational period if capacity is available (eg three and a half days) or utilising techniques such as 'Systematic Canal Operation' (SCO) which involves closure of distributaries/minors for one or two days per week.

In schemes with mixed paddy/non-paddy localisation, priority should normally be given to paddy since it is more sensitive to stress and if it suffers farmers are more liable to take matters into their own hands. This does not of course preclude limiting or abolishing the paddy services area in the first place.

8. THE STRUCTURED DESIGN

The other main element in the proposed approach is the introduction of structured design which allows for variable and controlled discharge down to a specified level (at least the head of the minor) below which distribution is proportional and free flowing to outlet with canals run full or not at all. This reduces flexibility in meeting differential requirements at the field level but is much easier to manage since control only needs to be exercised down to the head of, say, the minor below which distribution is automatic and proportional. This substantially reduces the number of gates to be controlled (gates below the head of the minor are eliminated which normally reduces the number to be operated by a factor of at least 5). It also simplifies measurement and monitoring and substantially reduces the incentives for farmer interference. Measurement need only record whether canals are running at full discharge. Similarly, if the parent canal runs full and outlets are ungated and proportional, there is no way for the farmer to increase the discharge he receives without major interference (eg, enlarging the outlet - there are no gates to adjust or remove and a cross weir is ineffective at full discharge) while if the parent canal is closed, there is no point in farmer interference at this level.

The critical decision is to define the level at which the system is to be structured. Above this level, full control by the authorities is absolutely essential since otherwise they cannot guarantee delivery of the service in accordance with the agreed operational plan. It can be assisted by automatic distribution devices. These can be relatively simple, for instance long-crested weirs which ensure that discharges through offtakes that are commanded are relatively insensitive to varying discharges in the parent canal. Below this level, the premise is that neither the authorities nor the farmers are sufficiently organised to control the variable flows and numerous gates associated with the traditional design. Hence a proportional, free-flowing distribution system to the outlet is proposed. Below the outlet, farmers will still need to distribute flows to ensure an adequate delivery to the fields. For ID crops, this will normally require each farmer to take the full flow in the field channel in turn. For paddy, flows may be sub-divided in response to local micro-geography and other factors. In either case, the assumption is that, if supplies can be guaranteed at the outlet, farmers will be sufficiently organised to distribute water effectively below the outlet. However, they may also be assisted in this process, and once adequate control has been established over the main system, emphasis can increasingly be placed upon farmer organisations at this level as well as on programmes through the extension service designed to improve irrigation practices on-farm.

In the longer-term, farmer organisation and management may extend above the outlet to the full service area. If this proves possible, the service provided to each area could reflect negotiations between the irrigation authorities and the farmer organisation rather than the assumed notional cropping pattern (localisation). In other words, the authorities would-subject to constraints on availability and equity between service areas-ultimately "wholesale" water to the farmer organisation (possibly at a price) and the organisation would in turn "retail" available supplies to individual farmers. If this proves feasible, then the rationale for the free flowing design is less compelling. Modifications to increase flexibility and control within a service area, fully controlled by the farmer organisation, could then be envisaged. It may also be possible to distribute scarcity more equitably (and efficiently) by requiring the individual farmer to cultivate only a part of his farm as under the "warabundi" systems of North West India. In this sense, the particular solution to be introduced under the NWMP is an interim one, but one that is considered manageable under present conditions and consistent with longer term trends.

9. IMPLICATIONS FOR CROPPING AND FARMER INVESTMENTS

The approach described above is in principle applicable irrespective of the cropping pattern of a particular scheme. Nevertheless, given the scarcity of water and the history of most schemes, there are usually similar general cropping objectives. These can be summarised as follows: i) to limit as far as possible the paddy service area (especially during the dry season), taking into account the historic situation and localisation rights, ii) to limit and if possible preclude high water demanding perennials such as sugar except on well (eg, by canal closures during summer), iii) to allow for less water demanding perennials such as coconuts if farmers are willing and able to bear the investment costs, preferably still meeting summer requirements from wells, iv) to limit and if possible preclude irrigation of short-term summer crops, v) to guarantee supplemental irrigation during the monsoon season to make best use of rainfall, and vi) to maximise use of stored water for rabi ID crops, subject to the need for carryover (eg, to secure an early and successful kharif crop, to supply perennials, to satisfy other users).

As already emphasised the aim is to define the irrigation service to be provided, and not to control the crops a farmer grows. The irrigation service inevitably places constraints on what is possible, nevertheless, farmers should be permitted to grow crops that differ from the notional cropping pattern. This could occur in response to the irrigation schedule provided (eg, paddy in low lying areas which receive an intermittent ID schedule but are supplemented by seepage, or ID crops in elevated, well drained areas which receive supplies for paddy) or because they have supplementary water supplies (eg, from wells). Furthermore, cropping patterns are never static and evolve in response to a wide range of socio-economic and physical developments. If farmers are increasingly growing crops inconsistent with the notional cropping pattern, this may have implications for the irrigation service to be provided. Thus, in contrast to the perception of a fixed localisation pattern, the objective is to respond each season not only to water availability but also to the evolving environment. Subject to the constraints of water availability, and the existing physical infrastructure, the irrigation service would thus evolve from year to year.

In addition to influencing cropping, the irrigation service strongly influences a farmer's willingness to invest on-farm. This reflects both cropping patters (directly in his willingness to invest, eg, in tree crops, and indirectly in its effect on land formation) and water scarcity. In particular, willingness to invest in groundwater is very largely a response to the adequacy of surface supplies. If he is virtually guaranteed two paddy crops a year - as in many old paddy systems - then there is no incentive to incur the high costs of groundwater development. On the other hand, if the irrigation service is confined to one season or to a limited intermittent supply, then the incentives can be substantial. In the hard rock areas of South India, access to groundwater is highly variable and the costs can be substantial (usually precluding investment by small and marginal farmers). It is not therefore possible to depend on groundwater, in particular since the alternative of public groundwater development has proved unsatisfactory and problematic. Nevertheless, in deciding on the irrigation service, it is important to take account of how it will affect incentives for groundwater development since if these incentives are inadequate, it will not be possible to develop the full potential of the region's water resources.

10. CONCLUSIONS

The approach to water management under the NWMP has been summarised as "providing a demand scheduled supply by means of an irrigation system which is structured in a manner which is manageable under present conditions". In a sense it is an interim solution, but one that is consistent with longer term trends, for instance towards increased control by farmers and greater flexibility within the service area. Initial experience is promising and suggests that, provided sufficient attention is paid to discussions with farmers, significant change is possible even in the short-term. The approach thus provides hope for a manageable management system which responds to evolving conditions and which makes relatively efficient use of the highly variable and limited water supplies available to many of the schemes of South India. Close monitoring of implementation will be essential to ensure that the proposed approach proves successful and is manageable in practice. Guidelines for monitoring have been prepared and will be tested in NWMP sub-projects.

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IRRIGATION MANAGEMENT NETWORK

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MAINTENANCE BEFORE MANAGEMENT: A NEW STRATEGY FOR SMALL SCALE IRRIGATION TANKS IN SRI LANKA?

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MAINTENANCE BEFORE MANAGEMENT: A NEW STRATEGY FOR SMALL SCALE IRRIGATION TANKS IN SRI LANKA?[1]

Mick Moore

1. INTRODUCTION

It is almost a decade since Sri Lanka embarked on a new policy towards its small scale irrigation systems. This policy has two major components. One is an ambitious programme for the physical and managerial upgrading of a large proportion of these systems. This programme has been supported through a number of foreign aid channels, and has focused mainly on very small scale storage reservoirs ('tanks') feeding rice fields through gravity flow in the less wet parts of the country – the so-called Dry Zone. The second component of the new policy has been the creation of an institutional capacity within the government machinery to manage the upgrading programme and generally develop the small scale irrigation sector. No such capacity existed previously. The task was allocated to the Agrarian Services Department, an agency under the Ministry of Agriculture which is responsible for a range of agriculture-related functions and has its own field staff at the level of the administrative village.

2. THE UPGRADING PROGRAMME

Because the implementation of the upgrading programme and the creation of institutional capacity went hand-in-hand, there was unusually wide scope for making mistakes and learning from experience. The Agrarian Services Department started with scarcely any qualified engineering staff. Only as these have slowly been recruited and trained has it been possible to think of developing and systematising a body of engineering and management knowledge relevant to the special circumstances of small-scale tanks. Most of the engineering work in the upgrading programme has been performed by other agencies - the Irrigation Department, private firms, and the project offices of district-level integrated rural development projects.

That considerable learning has taken place is beyond doubt. The lesson which I have learned is that the tank upgrading programme was based on an inadequate understanding of the functions that need to be performed to achieve improved irrigation management. The programme has so far comprised two main elements: physical rehabilitation and water management planning. It has skipped the crucial intermediate function - maintenance - and will for this reason face great difficulties in making real progress in water management planning.

As one might predict in the circumstances, the programme of physical rehabilitation has in practice taken priority over water management planning and has achieved more evident success. Physical rehabilitation has typically involved the restoration or expansion of the earthen tank bund, the installation of a new sluice, and, more recently, downstream work in re-modelling water distribution and drainage channels. The inclusion of downstream work in the programme was one of the significant lessons of experience, as was the evolution of more effective means of consulting farmers about details of design and implementation. While in part the result of being overshadowed by the physical rehabilitation programme, the rather meagre success of the water management programme is also the product of two other factors.

The first factor is the prevalence, until recently, of a high level of ignorance about small scale irrigation systems on the part of virtually all outsiders and experts. We have come a long way in the last few years in understanding the problems. It is unfortunate that ignorance did not breed caution. It led instead to the firm endorsement of a radical, innovative water management plan for small scale tanks which has generated few positive results. This so-called 'Walagambahuwa model' required all farmers under a tank to simultaneously adopt a new, different and costly package of cultivation practices: early land preparation and dry sowing before the onset of the main monsoon rains to make the best use of rainfall and conserve tank water for a second crop; use of short duration rice varieties; mechanised land preparation for speed; higher levels of fertilizer use; and greater inputs into weed control.

2.1 Limitations of the Walagambahuwa model

Although heavily promoted, the Walagambahuwa model was rejected by the farmers. The particular mix of reasons varied according to local circumstances, but generally included (a) the high recurrent investment requirement; (b) the difficulties in achieving a common cultivation calendar among all farmers; (c) the high risk of delayed monsoon rains, leading to the loss of seeds and young plants through dehydration or competition from drought-resistant weeds; and (d) priority given to other activities in the total farming system. The latter point requires a little elaboration. Small scale irrigation tanks are part of a farming system in which labour is typically a constraint at the time of the monsoon rains and in which risk of monsoon failure is high. Labour is allocated so as to seek protection against risk. In a typical sequence, Dry Zone farmers first pay attention to sowing rainfed highland crops. They then sow rice irrigated from very small and shallow tanks, for these both fill first and are most vulnerable to loss of water through evaporation if left unused for any time. Finally - and here it is important to bear in mind that individual farmers frequently cultivate rice under two or more tanks - the 'larger' tanks, irrigating perhaps 10-100 hectares, receive attention.

The Walagambahuwa model of tank water management was simply inappropriate. To promote it was to ask farmers to adopt a dangerously irrational strategy. The fact that water management planning started with a vigorous propaganda campaign for the model was in itself a substantial set-back.

There is, however, another, related factor, operative even after the Walagambahuwa mistake had been recognised, which helps account for the disappointing results of the water management planning component of the tank upgrading programme. This is that the decision-making process relating to tank water use is so complex that it is extremely difficult for any kind of external intervention to have any (positive) effect. There are perhaps three main dimensions to this complexity:

1. The position of each individual tank in the local agro-economic environment varies considerably. As has been mentioned above, the timing of cultivation depends in part on the extent to which agricultural operations under one tank interact with those under other tanks and with other types of cultivation in a single local farming system or, more accurately, a set of overlapping individual farming systems. Some tanks interact with one another in a very direct physical sense. Drainage water from one may flow to another; there may indeed be a whole cascade of small tanks along a valley. The achievement of an adequate water level in one may depend on the receipt of drainage water and thus the commencement of cultivation water in the tank above it in the cascade. Conversely, part of the bed of one tank may comprise the command area of the tank above it in the cascade. Cultivation under the higher tank is feasible only when cultivation operations in the lower tank are far advanced, considerable tank water has been used, and some of the tank bed is dry. In addition, all tanks exhibit particular individual characteristics: varying types of soil in the tank bed and in the command area which affect both the tank's capacity to hold water and per hectare irrigation water requirements; or awkwardly-located land that can only be irrigated, for example, via the tank spillway, or when the tank water-level is high. For all these reasons, a sensible water management plan for each tank requires a high degree of sensitivity to, and understanding of, the local agricultural system.

2. Even when this sensitivity is achieved, a sensible plan - a cultivation calendar, rules of water allocation, agreed enforcement and adjudication procedures - must be flexible because of the high degree of unpredictability about the arrival of production inputs - notably rain but also seed and agro-chemicals. There is a need for a degree of responsiveness to very localised circumstances of a kind which is rarely found among government agencies.

3. The decision-making procedure for water use on small tanks is extremely elusive and informal. It is very difficult to map the

process. Four main elements, more distinct one from another in conceptual terms than in practice, seem to shape the outcome. One is custom: things are normally done in a certain way. Another is some kind of participatory decision-making forum: some or all farmers meet together to discuss crop calendars and related matters like fencing. They may or may not reach an explicit, agreed 'decision'. The third is the power and influence of particular individuals: certain things may be done because that suits the biggest landowner. The fourth is the fact that most systems can irrigate without any collective action or decision at all, at least once the sluice is opened. Water flows from the tank through the open sluice, and farmers take what they can, in cooperation and/or competition with adjacent farmers. In practice - and partly because only a handful or few dozen farmers are involved in a single tank - each of these elements may enter into a single 'decision'. The sluice may be opened on a certain day because that is when a recognised leader announces it is time to start work. But his 'decision' may be based on, for example, the clear intimation from a couple of influential neighbours that the consensus of an earlier farmers' meeting in favour of an earlier start would be intolerably inconvenient. It is in consequence very difficult to achieve an effective integration between external, official intervention and local, community action in water allocation. It may be unpractical to attempt to (a) dispense with this informal and unexplicit local bargaining by insisting on adherence to an externally generated plan and set of procedures; or (b) to make local procedure explicit and formal by insisting on a properly-constituted and fully authoritative farmers' meeting. There are many reasons why 'the plan' may be ignored.

It is then no surprise that on tanks which have been physically rehabilitated 'water management planning' sometimes begins and ends with a peeling sign board which includes a sketch map of the irrigation system, names of farmers responsible for supervision of demarcated rotation areas and a schedule for allocating water between these rotation areas over the course of a week. Since both the small tank upgrading programme and the Agrarian Services Department's involvement are still fairly new, there is reason to hope that it will in future be possible for the Department to promote local water management planning in a more effective manner. At the same time, the complexities listed above do raise serious questions about the capacity of any external, government agency to intervene effectively to improve the allocation and use of water. The questions remain even if the external agency attempts to work through representative local institutions. By contrast, government agencies have demonstrated a considerable ability to organise civil engineering works to upgrade the physical capacity of tank systems. It is then ironic that one can find tank systems which have recently been rehabilitated but which are partly or completely non-functioning because routine maintenance has not been attended to and some major damage has been caused, usually by heavy rains. The most common form of catastrophic damage is a major breach in the tank bund, originating in a small overspill of water which, because unchecked, rapidly eroded a large hole in the bund. Other results of inadequate maintenance include malfunctioning sluice outlets and erosion of the banks and beds of irrigation channels. As in all hydraulic systems, small damages to (mainly-earthen) physical infrastructure can often multiply very rapidly into major faults.

A very natural reaction to such problems is to blame the farmers. Why indeed, when the government has recently spent so much money on providing them with a much improved system, can they not put in the little effort needed to maintain it and to cure small problems before they become large ones? While very understandable, such a reaction is not very helpful. For research clearly shows that, once the government has invested resources in a small irrigation scheme, there is a distinct change in Sri Lankan farmers' conception of the rights and duties involved. What was previously seen as local village property is now seen as government property. What were previously local responsibilities (for maintenance) are now government responsibilities.[2] One can rail against such an attitude. In the longer run one could try to change it by giving farmers both more say in and more financial responsibility for the rehabilitation process. For the foreseeable future one is still faced with the problem of protecting existing investments by ensuring maintenance. And, it is important to point out, there are certain maintenance functions - notably the repair of sluices - which are beyond the technical capacity of farmers.

3. A NEW STRATEGY

The Sri Lankan small tank upgrading programme, like almost all development programmes funded through foreign aid, makes little provision for operations and maintenance resources. And such recurrent resources as are available have largely been directed at operations, i.e. at water management planning, not at maintenance. The Agrarian Services Department has very meagre resources available for maintenance. Accordingly, it has no real inspection and maintenance procedures.

Yet there are reasons to expect that the returns to an inspection and maintenance programme would be far greater than the rather meagre returns to water management planning. For it is relatively easy for an official to make an assessment of the adequacy of farmers' maintenance activities on the basis of a brief inspection. Such an inspection, conducted, say, twice a year and leading to a brief on-the-spot report counter-signed by a local farmers' leader, could be a rather powerful tool for encouraging farmers to meet their maintenance obligations. It would in the first place provide consistent authoritative encouragement for them to do something which most in some way or another recognise as necessary. In the second place, if it could be established that a satisfactory record of maintenance activity by farmers were a pre-condition for access to limited government maintenance funds, the farmers would be provided with a strong incentive. One can envisage such a mechanism gradually inducing farmers to match government maintenance grants with their own financial contributions.

Experience suggests that the recurrent component of the small tank programme has been unbalanced. Government officials have been asked to focus on an operations programme - water management planning - in which the prospects of their making major progress are doubtful. The chances that they could effectively implement an inspection and maintenance programme are much greater, and the case for such a programme much more compelling.

4. NOTES

1. If this paper merits any credit, then that rightly belongs to my three major sources of stimulus and information: to Saleha Begum for discussion of her current research on small tank management in Sri Lanka; to Upali Dharmaratne and the staff of the Kurunegala Integrated Rural Development Programme for the benefit of their experience in the rehabilitation of small scale irrigation systems and for illuminating field visits; and to A M T Gunawardena for his excellent research paper Water Management Under Small Village Tanks (Occasional Publication 21, Agrarian Research and Training Institute, Colombo, 1981).

2. See, for example, S Abeyratne, "The Village Irrigation Rehabilitation Programme", Paper submitted to the Workshop on Participatory Management in Sri Lanka's Irrigation Schemes, IIMI, May 1986.

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IRRIGATION MANAGEMENT NETWORK

SOME COMMENTS ON MEASURES OF INEQUITY IN IRRIGATION DISTRIBUTION

Rajan K Sampath

ODI/IIMI Irrigation Management Network Paper 88/2f December 1988

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88/2f: Some Comments on Measures of Inequity in Irrigation Distribution by Rajan K Sampath

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

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

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SOME COMMENTS ON MEASURES OF INEQUITY IN IRRIGATION DISTRIBUTION

Rajan K Sampath

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SOME COMMENTS ON MEASURES OF INEQUITY IN IRRIGATION DISTRIBUTION

Rajan K Sampath

1. INTRODUCTION

Recently inequity in irrigation distribution has started receiving serious attention from irrigation professionals (Abernethy, 1986, Lenton, 1984, Malhotra et al, 1984, and Sampath, 1984).

In any study of equity in irrigation distribution, the following questions need to be posed and answered clearly:

(i) What is the purpose or objective of the study?

(ii) Given the purpose of the study, what is the relevant empirical concept of equity to be used?

(iii) Given the first two, how do you derive an index of inequity such that it fulfils the following conditions:

  a) That it is quantifiable, ie, measurable
  b) That it is comparable
  c) That it fulfils certain axioms or norms that have been accepted generally by the government or the irrigation management as reflecting properly the ethical judgments with regard to the equity principles that need to be satisfied by the irrigation distribution policy or mechanism.

2. INEQUITY AND INEQUALITY

The fundamental problem with the empirical studies on irrigation distribution seems to be that they all seem to assume that the concept for equity is something uniquely defined both conceptually and empirically. In a sense it is understandable since they look upon equity as being uniformity in distribution in a statistical sense. Thus they look upon inequity as being non-uniformity in distribution which can be stated and measured in a purely statistical manner. This kind of mechanistic view of the inequity problem not only misrepresents reality and thereby makes the findings and prescriptions of the studies useless, but also in some sense even turns out to be counterproductive in the sense that they generate aversion among the irrigation authorities towards the academic researchers and the tend to shy away from them. The purpose of any study of the inequity problem of an irrigation project should be in line with the objectives and purposes of the project as stated and perceived by the authorities and the beneficiaries. Some times, there could be some conflict between the two groups in terms of how they perceive the ultimate objectives of the project, the resolution of which might require intensive study of the project in detail. The objectives of irrigation are not at all identical, sometimes not even similar across projects and regions within a country. Some irrigation projects are established to provide full irrigation to the whole command areas for the entire year or season or crop. Sometimes they are established to provide only supplemental irrigation for particular times of the season, say for germination or flowering period of the crop. Some are purely established as an insurance against drought. Some projects are multipurpose and some are purely for irrigation. Some are storage dams with more flexibility in operations and others are simply run-off the river schemes without much flexibility. Some will have very well lined canals and distributaries having very little conveyance losses and others may not. Some may serve command areas with no other alternative source of irrigation either farmer or government owned and others may have alternate sources. Some projects may serve low rainfall or arid areas an others may serve higher rainfall or semi-arid or even wet areas. The crops grown in the areas may be drought resistant or extremely susceptible to drought. The project command area as a whole may be a water surplus or adequate or deficit area or even be water surplus in one season, water adequate in the second season and water deficit in the third, say summer season as do some areas in India – northeast and southwest.

Inequity may be a problem in all the above-mentioned scenarios; but its nature, intensity and socio-economic consequences cannot and will not be the same across projects and regions. For example, in an extremely water scarce command area, growing only one crop a year and that too a crop which can not withstand drought much, the consequences of inequity in irrigation distribution in terms of malnutrition and poverty will be much more severe than consequences of inequity in water abundant or adequate regions. In a water scarce command area, one not only wants to look at the production and income consequences of inequity in distribution, but also take a more careful look at who the sufferers from inequity are – marginal or small or large farmers. In this situation 'unequal' distribution may not necessarily mean 'inequitable' if unequal distribution is in favour of the marginal and small farmers; in contrast if it is against small and marginal farmers, it will be extremely 'inequitable'. In a water abundant or water adequate command area, the problem of inequity in distribution may not mean much in terms of social consequences. In fact, the problem may not even be 'inequity'. It may be purely an 'inequality' problem with adverse production and environmental consequences due to excess water use or drainage problems. It will assume 'inequity' problem only if it predominantly affects a particular social or economic class.

Thus it is critical to understand the goals and objectives of the projects and the nature and social structure of the beneficiary groups and their problems before embarking on a study of the problem of inequity in irrigation distribution in a command area. After this, a researcher should properly identify the relevant empirical definition of the concept of equality or equity depending on the nature and consequences of inequality in the distribution of irrigation water. It is often wrongly assumed by researchers that every time there is 'inequality' in irrigation distribution, it has an 'inequity' problem. In fact, depending on the water supply and the crop production functions unequal distribution may have purely inequity consequences or purely inefficiency (production) consequences or both or in some rare situations neither.[1]

3. AN EVALUATION METHODOLOGY

In order properly to classify and study the problem of inequality and inequity in irrigation distribution, we suggest the following hierarchical classificatory framework. This framework will help us in designing and deciding the nature of studies to be conducted to understand the extent and nature of inequality and inequity in various situations.

(i) We will first classify the crops or the cropping pattern served by the irrigation project into three categories.

a) Yields highly sensitive to water scarcity. (Yh)

b) Yields moderately sensitive to water scarcity. (Ym)

c) Yields lowly sensitive to water scarcity (Yl)

(ii) In terms of the supply of water, including sources other than the irrigation project, in the command area we will classify the project as belonging to one of three water regimes:

a) Abundant or rich (W_R)

b) Adequate (W_A)

c) Scarce or poor (W_p)

---

[1] Mathematically it can be easily shown that if the crop production function is continuous and smooth (that is twice differentiable) with the first derivative with respect to water positive, then (1) if the second derivative is positive, then unequal distribution is desirable from an efficiency point of view but undesirable from an equity point of view; (2) if the second derivative is zero, then unequal distribution is neither desirable nor undesirable from an efficiency point of view but undesirable from an equity point of view; (3) if the second derivative is negative, then unequal distribution is undesirable from both efficiency and equity points of view; (4) lastly, if the farmers have adequate buffers available to them in the form of alternate sources such as private and public tubewells to take care of their needs, then unequal distribution of irrigation from surface systems may not have any significant efficiency or equity consequences.

(iii) In terms of demand or importance to farming in the command area, we can classify the publicly supplied water into three categories, namely,

a) Primary (P)

b) Supplemental (S)

c) Buffer - insurance against drought. (B)

(iv) We will classify the Socio-economic farm classes served by the project into

a) Poor farms (F_p)

b) Rich farms (F_R)

(v) In terms of the location of the farms in the command area served by the project into

a) tail-enders (F_t)

b) head-reaches (F_h)

In terms of grouping (i), (ii) and (iii), we can classify the public irrigation project into 27 'mutually exclusive and collectively exhaustive' categories, each of them representing a particular combination of cropping pattern, nature of water supply and water demand. In other words, for each of the three cropping pattern categories, we will have 9 'mutually exclusive and collectively exhaustive' categories to one of which the public irrigation system serving a particular cropping pattern will belong. These nine categories, for each of the three cropping patterns can be represented in the form of a matrix as given below:

TABLE 1

Water Supply Regimes	Water Demand Regimes		
	Primary	Supplemental	Buffer
W_R	W_R,P	W_R,S	W_R,B
W_A	W_A,P	W_A,S	W_A,B
W_P	W_P,P	W_P,S	W_P,B

In terms of the above matrix, study of inequality and inequity assumes primary importance for projects falling in the category ((W_p,P) ie, water poor and primary source, followed in the descending order by (Wp.S), (Wp,B) and then by three categories in row W_A which in turn is followed by the W_R row categories. Similar matrix and ordering can be derived for other two cropping patterns situations.

By categorizing the public irrigation project into one of the 27 categories, we can be able to prioritize the projects in terms of the importance of inequality/inequity problem. It is wrong to presume that problem of inequality or inequity is equally important under all situations, even if it appears numerically that the extend of inequality/inequity is the same across situations.

The above approach can be further generalized on the basis of the distinctions drawn between seasons etc. It will only make the number of categories larger. This approach can be used further to understand when non-uniformity in irrigation distribution is purely an inequality problem having only efficiency consequences and when it is an 'inequity' problem also. For example, if there is non-uniformity in distribution in the category W_R,S, which represents a water rich regime where water is used purely for supplemental purposes such as in Assam, India, during the Kharif season, it will have marginal efficiency consequences and virtually no inequity problems in which case it should be treated purely as an inequality problem. In contrast, inequity will be the number one problem in (Wp,P) situation.

Once the projects are identified as requiring an intensive study for inequality/inequity aspects using the ranking criteria discussed above we can now use categories (iv) and (v) to further prioritize and rank them. For example, if the farmers affected by non-uniformity are poor farmers in the tail-end, then, that should get higher ranking in terms of priority than if they are primarily rich farmers.

After doing all these preliminary analyses only, the researcher will be in a position to pose the right question which is: what is it he is dealing with in this particular project-problem of inequality with only efficiency consequences or only inequity consequences or both. Once he knows for sure that inequality/inequity problems exist and need quantification, he needs to develop an index or measure of inequality/inequity. This brings us to the problem of proper measure of inequality/inequity.

4. SOME METHODOLOGICAL COMMENTS

Any measure of inequality implies a definition of what inequality is. Because they derived their inspiration originally from the discipline of statistics rather than welfare economics, the traditional positive measures of inequality define the phenomenon of inequality as the dispersion of a frequency distribution. The robustness of the measures were accordingly discussed in terms of statistical criteria such as how much use they made of the available information, the properties of the estimates and so on. But, since these so-called positive measures tended to acquire normative significance in irrigation allocation decisions at the policy levels, it is important to understand the value or ethical judgments implicit in them and evaluate their appropriateness in terms of broad and general principles.

As Cowell (1977) says, "Inequality suggests a departure from some idea of equality. This may be nothing more than an unemotive mathematical statement, in which case 'equality' just represents the fact that two or more given quantities are the same size, and 'inequality' merely relates to differences in these quantities". It is in this sense that many of the studies that have recently come out looked at the problem and we have seen the inadequacies of the measures, suggested by these studies, when it comes to explaining or developing policies to combat inequity in the irrigation distribution system. We need to keep in mind several general points in developing and suggesting a measure of inequality/inequity:

1. The basic unit used in studying inequality and inequity. What should it be? Physical unit such as unit area or social unit such as a single person, the farm family, etc. I think it should depend upon the purpose and objectives of the study. If it is to study the effectiveness in distribution in terms of its uniformity, then it is useful to define the basic unit in terms of unit area. In other words, data pertaining to water distribution will not be analyzed in terms of farm-sizes but rather in terms of the amount of water

received per unit area across farms or locations. On the other hand, if the objective is to study how irrigation distribution benefited different farm sizes, then the same data will be analyzed in terms of farm-size groups; or if the objective is to study how different farm income-classes benefitted, then the data will be analyzed in terms of different income groups and so on. In other words, the basic unit for the study of inequality/inequity should not be taken as something uniquely given. In fact, one should be very careful about how one defines the basic unit since the estimates of a measure of inequality/inequity could be different for different definitions and the inferences drawn could be different. What may appear highly unequal under one basic unit may be not at all unequal under some other basic unit. So, the first critical tasks for the researcher is to identify the proper definition of the basic unit of analysis before he even embarks on collecting data; particularly if his interest is in inequity.

2. The description of the attribute, namely irrigation water, the distribution of which we are interested in. Careful attention should be given to the definition of the amount of irrigation water. Simple differences that could exist between the farms in the amount of water actually received may or may not imply actual inequality. If some farmers have access to other cheaper sources of water or simply their needs are different due to differences, however, small, in the cropping patterns of topography or soils, then there could exist benign inequality in distribution. This could be a problem in the proper evaluation of irrigation distribution mechanism in those command areas which depend on publicly supplied irrigation purely for supplemental purposes. To the extent this problem exists, one should be cautious in the way one defines and uses irrigation water quantity received by farms.

3. We want our inequity measure to be a scalar representation of the inter farm or inter-locational differences in irrigation distribution in a command area served by a project. The advantages of a scalar representation of inequity as against a multi-dimensional representation are fairly obvious. For, questions such as, has inequity increased over time? Is inequity in on distributary higher

than another? etc., our answers can be uniquely given with a scalar representation of inequity. In contrast, with a multi-dimensional attribute of inequity, we will not be able to answer the questions uniquely.

4. The measures are derived for a given command area or farms. When we compare changes in inequity over time, we need to make sure that this assumption is valid. If not, then we may be comparing apples and oranges. If the purpose is purely to measure 'inequality' in the non-uniformity sense (not inequity sense) to study the effectiveness of irrigation project management practices over time, then not much harm will be done if we are dealing with different command areas or farms over time. But if the purpose is to study the inequality problem in the inequity sense, then changes in command areas and farms could seriously affect the usefulness of the measures if those changes are not properly taken into account.

5. Finally, we might want our inequity measure, not only to give us a correct idea about what the level of inequity or inequality is in the command area as a whole but also, to be capable of dealing with <u>decomposition</u> analysis so that we can decompose the overall inequality measure into inequality within constituent groups, differentiated locationally into head reaches, middle reaches and tail reaches or into farm size groups such as large, medium, small and marginal farms or at different hierarchical levels such as water course, minor, distributaries, branch canals, canals and the system as a whole. In fact, one might even consider this as one of the most important attributes of a good measure of inequity.

5. CONCLUSION

Thus it appears from the above discussion that the recently proposed measures are highly inadequate and inconsistent. In order to overcome the problems posed by the suggested partial measures, we need to identify the properties that we want satisfied and the value judgments we want incorporated in the measures of inequity. This can be accomplished with the help of the knowledge that already exists in the welfare economics of income distribution literature which has been synthesized for this purpose recently (Sampath 1988).

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IRRIGATION MANAGEMENT NETWORK

NEWSLETTER

ODI/IIMI Irrigation Management Network Paper 89/1a July 1989

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.

NEWSLETTER

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Newsletter and Network Papers edited by:

Mary Tiffen, Irrigation Management Network Research Fellow

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Jyoti Bhardwaj, Irrigation Management Network Secretary

NEWSLETTER

1. NETWORK DEVELOPMENTS

We are happy to report that the result of the ODA evaluation of the AAU Networks was a very positive endorsement of their value. We are very grateful to all members who took time and trouble to return evaluation forms. We also learnt something more about your reactions to the material we send out, and this is also useful. It was pleasing to find you think the Newsletter useful as well as its accompanying papers, and I was flattered to find that the papers I had written on *The dominance of the internal rate of return as a planning criterion and the treatment of O&M costs in feasibility studies* and on *Rehabilitation and participation: The views of the engineers*, were those most frequently mentioned as stimulating - and particularly the first. Other high scorers were those by Berkoff, *Matching crop water requirements in large systems with a variable supply - experiments in India*, Patil on *The economics of farmer participation in irrigation management*, Toulmin and Tiffen on *Groundwater management: Equity, feasibility and efficiency*, and Small on *Irrigation service fees in Asia*. It was good also to see that the papers are regularly passed on to other people, and that the readership is far higher than the membership list. Amongst the suggestions most frequently mentioned for improvement was print quality; this Newsletter should already show a modest improvement. More papers on farmers' participation, and on assisting the reader to understand farmer requirements were also requested. This latter request was confirmed by an analysis of members' interests as shown by the Registration forms. This is shown on page 2.

As a result of the evaluation, ODA is providing a somewhat increased level of support to the Unit in future. In the case of the Irrigation Network this has relieved the uncertainties that had been impeding permanent appointments to strengthen the staffing. In September we shall be joined by Linden Vincent, who will take main charge of the Irrigation Management Network. Mary Tiffen will continue to work in the irrigation area, for half her time, the other half being occupied by duties associated with her chairmanship of the Agricultural Administration Unit. Dr Marion Glaser, who was with us for five months, and to whom we are very

Breakdown of membership by special interests, Irrigation Management Network

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grateful for her work on the last Newsletter and Papers, has returned to Bangladesh to work on the development of water user associations for the Tangail Agricultural Development Project.

Linden Vincent has been a Lecturer in the School of Development Studies, University of East Anglia, since 1974, where she has taught, amongst other subjects, irrigation development and management. Her first degree was in Geography and she has also an MSc in Water Resources Development. She combines an excellent understanding of socio-economic and institutional issues with her knowledge of hydrological factors and statistical methods. Her consultancy and research experience has covered small scale irrigation development from groundwater, crop-water requirements for irrigation, administrative structures for irrigation and water management, drought analysis and the development of drought prone areas, flood risk impact on agricultural options, in countries that include the Yemen Arab Republic, India, Zambia, Nigeria and Tunisia.

We are also pleased to say that in future we shall be able to meet the needs better of networkers in Africa, and networkers who prefer to read in French. Thanks to support from CTA[1], we shall be publishing a third issue every year which is especially concerned with the development of irrigation in Africa. This will be sent only to those Networkers who live in Africa, or to those outside Africa who are professionally concerned with African irrigation, as planners, researchers or teachers. If you come into the latter category, and would like to receive the African issue, please fill in the enclosed form. The African Newsletter and Papers will be published both in English and French. We hope in this way to promote the exchange of useful experience, ideas and information between anglophone and francophone irrigation professionals. In addition, the Newsletter accompanying the two normal issues will be published in French. In this way francophone readers will be kept informed of developments in Asia and Latin America, and will be able to decide when a paper in English is likely to be sufficiently interesting to justify a particular effort to read it. The

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[1] The Technical Centre for Agricultural and Rural Co-operation established under the ACP-EEC Lomé Convention to promote better access in ACP countries to information concerned with the development of the agricultural and rural sectors.

African papers will be listed in the main Network so that those on the main Network will be able to send for papers that are likely to be useful to them.

I apologise for the fact that partly because of the planning and negotiation involved in these and other changes, this Newsletter and its accompanying Papers are arriving later than intended.

2. NETWORK PAPERS AND DISCUSSION

This set of papers continues our recent theme of rehabilitation, but the authors each treat it from a different angle.

The first paper, *89 / 1b Identification of causes of poor performance of a typical large-sized irrigation scheme in South China*, by Mao Zhi, presents performance indices used to quantify the need for rehabilitation, to assist in the diagnosis of problems, and to monitor the impact of the rehabilitation measures on a large scheme in China. The twelve indices cover performance in terms of water supply, crop production, maintenance of structures, economic benefit from crops, and financial viability from scheme revenues. The rehabilitation remedies included both institutional and physical changes. The indices could be used in many other countries; the institutional remedies adopted are only possible to those prepared to adopt the reform of giving financial autonomy to irrigation departments or schemes, as has been accepted in countries such as China and the Philippines.

On the issue of performance indices, Charles Abernethy of IIMI writes that he has always accepted that there are differences between equality and equity. Equity can have several other dimensions besides equality, some of which involve subjective or communal value judgements. Equality of water deliveries is one aspect of equity and quite an important one. However, "if (say) tail-enders get their appropriate share of water, but get it at times ill-matched to crop needs, then we have 'equality' but not 'equity'.... All this is rather theoretical, and the present reality is that most system managements do not now how much inequality or inequity their systems have, and are therefore in no position to assess how changes in management policies can affect these aspects. It is important to begin to change this state of affairs. That will not happen, in practically minded irrigation agencies, if we propose indices that are ... difficult to understand". Abernethy's modified inter-quartile index was intended to be one such practical tool; Mao Zhi has perhaps suggested others which can be used to measure other aspects of performance.

Paper 89/1c by Nasiruddin Ansari, *Rehabilitation of communal irrigation schemes in Nepal*, illustrates another method of introducing financial realism into irrigation projects. He explains how the government has evolved a policy on the principles for funding rehabilitation and for deciding priorities between schemes. Other countries feeling the lack of co-ordinated policy towards irrigation may well wish to study this. One of the issues faced is how to assist farmer-managed schemes (which are responsible for the larger proportion of irrigated hectares in Nepal) without damaging either their incentives or their capacity to be self-reliant. Principles include not only farmer initiation of the request for rehabilitation, but also that farmers must contribute to the capital cost (on a scale varying according to scheme size) and commit themselves to full responsibility for O&M costs. Because it is known that the resources of both the farmers and the government are limited, a ceiling cost per hectare for the rehabilitation works has been established. It would seem to me that this latter is an important step, for it will force both farmers and designers to establish the most essential elements in a rehabilitation programme, and to distinguish these from desirable extras that may not contribute much to overall economic benefit. By concentrating on the essentials, for example, lining <u>only</u> in the areas with the most porous soils, cost benefit ratios are likely to increase.

It is argued by some people that rehabilitation is "deferred maintenance", and that in some cases it may economic sense not to do maintenance on an annual basis, but to put the system right every few years though a rehabilitation. Those who argue this often ignore that during the years in which maintenance is not done, productivity is likely to decline progressively, representing lost output that can never be recovered. In Paper 89/1d by Muhammad A Chaudhry and Mubarik Ali, *Economic returns to operation and maintenance expenditure in different components of the irrigation system in Pakistan*, they have attempted to find a methodology for calculating the economic benefit of regular expenditure on operations and maintenance, basing this on data from Pakistan. They also identify where this expenditure is most beneficial. They find that agricultural production can be markedly improved by increasing O&M expenditure on the canal system. Increases are also marked if there is increased investment in O&M of private tubewells, either by increasing their number or by enhancing their utilization rate. However, the marginal benefits to O&M investments in government tubewells are very low.

In the last paper, 89/1e, *Irrigation and water management for diversified cropping in rice irrigation systems: major issues and concerns*, S I Bhuiyan argues that providing the farmer with flexibility to grow either rice or other crops in the dry season should be one of the goals of rehabilitation programmes on rice systems in the future. However, this requires an understanding of the factors influencing farmers' choice between crops, and an appreciation that his decisions will vary over time. Demand for, and the price of, rice may well increase in future. Bhuiyan argues that what requires upgrading is often the drainage system rather than the water delivery system, and that we should not automatically assume rehabilitation is necessary without examining the potential of improved management practices, and the relationship between management and hardware. IIMI research he quotes has already shown that farmers know methods of cultivating dry foot crops if these are profitable.

Bhuiyan also points out that rice systems are not all that different from non-rice systems, and that rice can benefit from ability to vary water applications at different times. This is confirmed in the paper by Mao Zhi. Chinese research showed a benefit from having a drying out period at the late stage of tillering, and varying depths at other stages. Implementing this not only increased production, but also saved water in a system equipped with many storage ponds.

3. IRRIGATION IN THE PHILIPPINES AND THE REHABILITATION SEMINAR

The rehabilitation seminar

Two of the papers mentioned above, those by Ansari and Mao Zhi, were first presented in February 1989 at the Asian regional symposium on the *Modernization and rehabilitation of irrigation and drainage systems*, which was organised jointly by Hydraulics

Research, Wallingford and the National Irrigation Administration, (NIA), The Philippines. The Symposium brought together a distinguished gathering of scientists, engineers and planners from many parts of Asia, but its Filipino hosts set the tone for much of the discussion because of their commitment to policies of transferring responsibility to the farmer, and to increasing financial viability of the NIA, which in turn necessitated, in their experience, consultation with the farmer on the objectives of rehabilitation. One of the opening speeches by Senator A A Aquino, Chairman of the Committee on Agriculture, Philippines Senate, set rehabilitation firmly in the context of the Government's war against poverty, in which its strategies include land reform, decentralization of power and bottom-up planning, appropriate levels of technology and accountability in public expenditure. Sebastian I Julian of the NIA then summed up its philosophy and experience. It is a semi-autonomous agency within the Bureau of Public Works, having 92 irrigation system offices responsible for one or more national irrigation systems, and 67 provincial offices responsible for communal irrigation works - the management of these being by the farmers concerned. He expressed the pride, which seems to be shared by most NIA staff, in the way they are ahead of most irrigation authorities in the world in having found effective techniques of organising farmers into water users groups which are now playing a major role in system operation and maintenance not only on the small communal systems, but also on the bigger national systems (the latter as described by Ferrer and Lucero in Paper 88/1c). He also expressed pride in the increasing financial viability of NIA, although the proportion of Irrigation Service Fees collected is still not as high as it needs to be, and there are acute difficulties in enforcing a no payment no water policy. The reduction of costs and responsibilities by turning over systems or parts of systems is therefore attractive. The financial situation of the agency has become even more critical since the government has transferred to the NIA responsibility for servicing the debt on official foreign loans for irrigation purposes incurred since 1982.

The grave financial situation of many irrigation agencies, and not a few governments, made me suggest in my special lecture that it is vital in any rehabilitation process to be clear who is to pay the capital and recurrent costs and in what proportions, and to consult with farmers within this context. Farmer requirements for improvements are considerably modified by the knowledge of the share of the costs they would be expected to bear; they do their own prioritising of the problems they most wanted tackled. Dr Miranda of IIMI also drew attention to the financial limitations on rehabilitations, in discussing the net returns anticipated for rice and other crops, and in emphasising the need to plan for crop diversification, while Murray-Rust emphasised the need to take into account the financial and manpower resources likely to be available for management after rehabilitation.

The Symposium closed with a panel discussion of some outstanding questions raised during the symposium. One of these was the relationship between maintenance and rehabilitation and between both and performance monitoring to see that productivity is not lost. The Indonesian classification of activities as

	Cost (US$/ha/year)
- annual maintenance	15
- special maintenance (every 5 years)	125
- improvement works (every 25 years)	600

was felt to be helpful. It would cost the same as periodic rehabilitation every 25 years at a cost of $1600/ha but would provide a sustained level of performance.

The two volumes of conference proceedings are available from the Overseas Development Unit, Hydraulics Research, Wallingford, UK. Volume 1 contains the Papers presented and costs £25. Volume II contains the introductory lectures, including those of Aquino and Julian, the special invited lectures (Tiffen, Khan, Miranda and Murray-Rust) and the reports on the symposium sessions and the closing panel discussion. This costs £15. A limited number of free copies are available, strictly for ldc personnel.

The transformation of the NIA

If you only have time or money for one book on irrigation management this year, the one that could be most highly recommended is likely to be *Transforming a Bureaucracy: The experience of the Philippine National Irrigation System*, edited by Frances F Korten and Robert Y Siy. It is available from the Kumarian Press, West Hartford, Connecticut, 060110-1505 USA, or, in S E Asia, from the Ateneo de Manila University Press, PO Box 154, Manila 1099. It describes the impact on the whole ethos of the NIA of what was, in the late 1970s, an experimental approach to the rehabilitation of a few small communal systems in the Philippines, using community organizers, and how this affected its approach to design, management and financial viability. The initial stages are described by Benjamin U Bagadion, until his retirement in 1985 Administrator for Engineering and Operations in the NIA (his 1980 paper in this Network, No 4c, is still available). Chapter 3 is a case study by Illo of the Taisan Project, showing the methodology in practice, while Chapter 5, by Romana de los Reyes and Sylvia M G Jopillo, gives the quantitative data comparing the benefits from 24 systems in which NIA used the participatory approach with 22 where it had used a more conventional engineering approach. Chapter 6, "From Bureaucratic to Strategic Organization", by David C Korten, and Chapter 7, "Summary and Conclusion", by Frances Korten and Robert Siy, are particularly important. Chapter 6 deals with the original "Technical-Engineering approach" of a typical bureaucratic organization where irrigation system design is treated as a technical problem, where users are expected to adapt themselves to the technical requirements, where design, construction and operations are the responsibility of different departments, and where design is a somewhat mechanistic matter of applying established engineering standards to site information. In the Philippines the NIA started in this mode and has now become a "strategic organization", characterised by a problem solving approach which involves continuous interaction between farmers, designers, constructors and operations personnel, because a key performance indicator has become the willingness of clients (the farmers) to pay for the services provided by the NIA - (Mao Zhi's 9th and 12th performance indices). One of the means for the transformation was the introduction of a cadre of educated and predominantly female community organizers into an organization staffed primarily by male engineers (a few of the former have now worked their way up to high levels within the NIA). These at the start worked in the Engineering Division, which Korten considers to have been the right place given the importance of getting the design process right. At a later stage, when the engineers were already converted to the new methods, they were moved to the Division concerned with agriculture, institutional development and operation. The change in the design process, in which the design was elaborated in conjunction with farmers who had already been organised, and who were aware that they would become responsible for the repayment of part of the capital costs as well as the operating costs, was at first hampered by such mundane things as the NIA's original funding basis, which depended on annual appropriations from the government, which was in turn linked with a short-term planning cycle of one year, inadequate for the new design methodology. There were also mundane contractual problems in relation to the community organizers, and whether these were casual, permanent or contractual staff. The new methodology also involved a problem solving team approach at provincial and regional level - an approach which made it impossible for designers to blame constructors for shortcomings, and constructors to blame operators, and operators to blame farmers. The provincial engineer became a team leader, and this in turn affected the work and judgement criteria of the staff at the level above, in the region. This necessitated supportive changes in the way of retraining, etc. The change in attitudes and in organisational structures were not achieved quickly but over a period of years, starting with a pilot project in one area. Nor is the change finished; it is ongoing. Since this book was written, there has been much more emphasis within the NIA to applying the new principles to the national systems where it has the management responsibility, and where, therefore, the situation is quite different to the communals where the NIA has been responsible for rehabilitation, but not for operation. The NIA is also now experimenting with training a farmer or other local person to be the community organizer, or to retraining one of its redundant staff for this new function. Frances Korten and Siy identify some of the key features essential to the success of the Philippine transformation. These include the policy framework that demanded farmers pay part of the rehabilitation costs and that the NIA depend for its budget primarily on payments from farmers, and the legal status given to farmer associations. It is not to be expected that the methodology of using community organizers will bring about the transformation of irrigation agencies elsewhere if these underlying fundamentals do not exist.

The concrete value of participation in the larger NIA system is quantified by Nenita Tapay in one of four papers in *Organisation and participation in Southeast Asian irrigation systems*, Wageningse Sociologische Studies 25, Wageningen Agricultural University, 1989, price $11. The book contains a useful review and commentary on 'participation' and irrigation, and three case studies including the one by Tapay. The other two look at Indonesia, where Schrevel provides a critical review of the water user associations in Java, their relationships with staff, and contrasts with the older system of a village water master, in a situation where many farmers are part-time cultivators. Kalshoven gives a review of farmer associations in Muda and Kemubu, Malaysia. Unfortunately, this goes only up to 1982, and contains little about their role in the rehabilitation of Muda, the Muda II programme. However, the discussion of these multipurpose organisations which are more concerned with provision of inputs than with water distribution provides basic background on their relationship to Malay social structure and government administration.

4. GROUNDWATER RESEARCH

Anthony Bottrall writes: A successful workshop on groundwater management was held at the Institute of Rural Management, (IRMA), Anand, India, 30 January to 1 February. The areas where thinking appears to have progressed furthest since the Ford Foundation began supporting research in this field are in the geographic area of the Eastern Gangetic plain in India and Bangladesh and in the thematic area of water markets. For the eastern region, evidence points strongly towards a strategy entailing (a) good hydrological/topographic mapping to differentiate those zones with high immediate potential for groundwater development from those requiring other measures (especially drainage) before they can be easily exploited; (b) intensive development of high-potential areas, largely through private investment and fostering competitive water markets; (c) concurrent efforts to improve energy supply (through better management of available electricity; reduction in diesel costs; improvement of pump installation, maintenance and repairs) and other incentives; and (d) efforts to improve the longer-term prospects of the region by effecting major changes in water resources policy and management and in the allocation of government investment with respect to surface canals, groundwater, rural energy and drainage.

The eastern region is likely to benefit particularly from the development of competitive water markets, but limited and erratic power supplies (and to a lesser degree, land tenure and other social factors) are major constraints to their more rapid expansion. Good work has been done by several economists on the workings of water markets in different parts of the sub-continent (Tushaar Shah, Shashi Kolavalli, Richard Palmer-Jones, M A S Mandal), but more comparative studies are still needed to understand better in what circumstances they are likely to be most effective in promoting greater productivity and improving poor people's access, as well as where they may be less useful or even have negative effects on equity and sustainability.

More detailed, in-depth studies of the performance and management of public tubewells in eastern India are still needed (and are promised by the World Bank later this year); but the evidence from various papers presented at the workshop indicated that they have been much less efficient than private wells; and, though they are officially justified on equity grounds, small and marginal farmers rarely seem to have been the principal beneficiaries. The only strong case for public tubewell management lies in areas where heavy pumping is needed for drainage purposes (as in the head-reaches of many canal commands in eastern India) or where water quality is a problem (as in NW India and Pakistan). In areas with good quality aquifers but deeper water-tables, where private investment in shallow tubewells is impossible, larger capacity wells are indicated; but alternative forms of organisation need to be tried out and developed: either water users' groups, or third-party landless groups or 'Water companies' (such as are being experimented with in Bangladesh and in Gujarat).

The evidence on management by water users' groups, especially in eastern India, and wherever pump capacities and commands are relatively small and subject to competition or encroachment by others, suggested that - unless bolstered by external support, especially at the start - they were often subject to erosion of support and takeover by individuals or a few family members. Some degree of local monopoly, as is likely to occur in more water-scarce ares, may be a desirable (if not necessary) condition for their initial establishment and subsequent sustainability.

Appropriate and implementable policies for water-scarce hard rock areas are much more difficult to identify and advocate with confidence. In this region underground hydrological conditions vary tremendously from small location to small location. Ideally, therefore, policies for promoting productivity, equity and sustainability should be based on as good local hydrological knowledge as possible and be differentiated according to the specifics of each location. This implies decentralised planning, if possible on a community/watershed basis. But is that at all realistic, in terms of available technical knowledge and administrative capacity? The overall scarcity of groundwater in the region also implies the need for a highly co-ordinated approach to surface and groundwater planning and development, at all levels from macro (river basin) to micro (watershed). The region is one where carefully designed legislation, redefining the rights of individuals, local communities, and local and State government bodies, could have an important role to play. To understand the multi-level interaction of the various important physical, technical, economic, social and legal factors better, a more widely encompassing framework of analysis is required than that used in most of the (predominantly single-discipline) micro-studies presented at the IRMA workshop. A regional workshop is being held at Tamil Nadu Agricultural University, 4-6 October to work on such a framework and identify key areas for further research.

The papers relating to the NW region and Pakistan showed there are very serious second-generation management problems to be tackled there (particularly relating to the management of poor-quality groundwater) which need closer study. Professor A C Gangwar of the Agricultural Economics Dept, Haryana Agricultural University, is keen to organise a regional workshop, which would also bring in people from Pakistan.

IRMA is bringing out an overview of the workshop shortly (write to Dr Tushaar Shah, its Director, for information (IRMA, PO Box 60, Anand 388 001, India). There should also be a set of proceedings from a subsequent workshop organised by the World Bank in Washington in May.

5. NEWS FROM IIMI

a. General

On 1 September, IIMI moves its headquarters to Colombo, Sri Lanka. Its new address will be 64 Lotus Road, Colombo 1. Letters should be addressed to PO Box 2075, Colombo, Sri Lanka.
IIMI is currently seeking for research programmes in Asia appropriately qualified civil engineers (Ref 302ML), agricultural economists (Ref 303ML), and an agricultural engineer (ref 304ML). For further information, write to the Director General at the address above. Brief details are held also at ODI.

In January IIMI began a collaborative programme with the Water and Power Consultancy Services, WAPCOS, a Government of India undertaking. The accent will be on research and training innovation. Initially IIMI is providing a half-time non-resident scientist for the exploration and identification of collaborative programmes with India's strong network of irrigation institutions.

The Programme Committee of IIMI's Board met in Kandy in March for one of its regular planning meetings. Concern was expressed over the way irrigation and water projects are branded by some lobbyists as environmentally dangerous. The Chairman of the Board, David Bell, said "The world population will probably double by the middle of the next century and as incomes grow, food demand is likely to more than double...... more and better irrigation will be crucial to food supplies in developing regions." He acknowledged that "There are conspicuous examples ... of irrigation projects that haven't been well designed or managed, where productivity is low, or where large areas have gone out of production altogether because of waterlogging or salinity. And there are some where public health hazards have come in behind irrigation. But these are planning or management shortcomings. With good management, good design, irrigation for sustainable agriculture is entirely feasible." The importance of IIMI's mission in this regard was also expressed by other Board members, including Robert McNamara, formerly World Bank President, Dr Kunio Takase of Japan, and Professor A A Abdalla of Sudan. Anyone who would like a copy of the full press release should write to IIMI at the above address.

IIMI publications

These are sent free to selected audience groups. They can also be ordered. The first price is for developed countries, the second for developing countries; postage is additional.

IIMI has a new Working Paper series that is intended to stimulate discussion and to make the results of recent research available as soon as possible, and to invite comments upon it. One thrust of its research is based on the hypothesis that an inflexible and unreliable supply in the primary or main canal negates the efforts of irrigation staff and of farmers below that level to achieve productive and equitable irrigation. Operational practices are often conditioned by the design features of the structures for water level control in the main canal and discharge control at their off takes. Research on the impact of a design feature, such as a fixed duck-bill weir, cannot easily be carried out in the field, and has to depend on mathematical modelling. Those interested in the methodology and initial results should ask IIMI for:

Mathematical modelling of irrigation canal systems: International Irrigation Management Institute Working Papers No 9, by Daniel Berthery, Hilmy Sally and Jayantha Arumugam, and *Calibration of the Kirindi Oya RBMC mathematical flow simulation model: Description of the field measurement campaign and preliminary results, Working Paper No 10*, by Hilmy Sally, Daniel Berthery, Frederic Certain and Andre Durbec.

Public interventions in farmer managed irrigation systems, by Edward Martin and Robert Yoder (323 pp) presents papers from a conference held in Nepal in 1986. They concentrate on the important issue of how to assist farmer managed systems to become technically more efficient without undermining their management effectiveness. Case studies are mainly from Pakistan, The Philippines, Nepal, and some are already familiar. It is therefore good to see studies originating from Thailand, Morocco, and an interesting tank experiment in India. Also interesting is a paper by Sutaman on the Bali systems, famous as farmer managed, but recently subject to a rehabilitation which in some cases has had to be corrected later. This paper gives the story up to 1985; there is more to be written. The papers include a discussion of future research issues, focussing on the types of government intervention and their effects.

Other publications available from IIMI are:

Irrigation management for crop diversification in Indonesia, the Philippines and Sri Lanka: A synthesis of IIMI's research (124 pp), 1989, by Senen M Miranda, Colombo, Sri Lanka: International Irrigation Management Institute, US$12.50 (US$6 in developing countries).

Professional management in irrigation systems: A case study of performance control in Mahaweli System H, Sri Lanka, (120 pp), 1989, by Namika Raby and Douglas J Merrey, Colombo, Sri Lanka: International Irrigation Management Institute, US$12 (US$5.50 in developing countries).

Financing irrigation services: A literature review and selected case studies from Asia, edited by Edward Martin, (296 pp), 1989, Colombo, Sri Lanka: International Irrigation Management Institute, US$27.50 (US$12.50 in developing countries).

6. NEW PUBLICATIONS

a. Books

B D Dhawan (1988) *Irrigation in India's Agricultural Development: Productivity, Stability, Equity,* Indian Institute of Economic Growth, Studies in Economic Development and Planning No 44. New Delhi/London: Sage Publications.

Dr B D Dhawan examines the impact of irrigation on Indian agricultural production and performance. In the first two chapters, he points to the immense need for irrigation in India, and discusses multiple effects of irrigation, such as being able to use HYV seeds, extra seasons and more intensive methods. In Chapter 3 he presents his methodology for assessing the impact of irrigation. He describes how regression techniques can be used to estimate productivity by source of irrigation and the decomposition of agricultural income. He discusses the methodological problems in using crude agricultural output figures from "before" and "after" the installation of the system and the limitations of statistical data. He proposes an indicator of the stabilization effects of irrigation as a useful tool for evaluation. Chapter 3 is substantial, and contains examples and derived equations for practical consideration.

The rest of the book applies the various techniques discussed in Chapter 3 to examine the impact of irrigation on Indian agricultural development. He looks at issues of groundwater as against canal water, important changes in cropping patterns to enhance the productivity of irrigated lands, the stability impact of irrigation and at the question of access and inequality. He demonstrates the agricultural income increase in India which has been realised through irrigation, and points to further ways to increase production. He acknowledges his methods are least effective in identifying increases of income to the landless, although there is some evidence of downstream impacts of irrigation on generating employment for those who are not farmers.

There is very little overlap between Dr Dhawan's book and Robert Chambers' new book, *Managing Canal Irrigation: Practical Analysis from South Asia*, whose Indian edition was reviewed in the December 1988 issue. It is now also available from Cambridge University Press, UK, price £20 hardback and £6.95 paper back.
Troubled Water by David Kinnersley, Hilary Shipman London 1988. Although primarily about water authorities responsible for domestic and industrial supplies and sewage, and also primarily about the UK, this book raises issues that may be relevant to those considering turning Irrigation Departments into companies supplying irrigation water.

Vector-borne Disease Control in Humans through Rice Agroecosystem Management, IRRI/PEEM, 1988, contains the proceedings of the workshop on *Research and Training Needs in the Field of Integrated Vector-Borne Disease Control in Riceland Agroecosystems of Developing Countries*, held in the Philippines 9-14 March 1987. It asks whether the increased prevalence of diseases such as malaria and Japanese encephalitis a necessary consequence of increased irrigation. The Workshop recommendations provide a framework for the interdisciplinary research needed on this subject and indicate that the concern now shared by both rice scientists and public health personnel may lead to improved rice cultural practices.

b. Reports and Manuals

PEEM III, IV, V, VI, WHO, Geneva 1987. Selected working papers from these meetings have now been published, covering methods of forecasting vector-borne disease implications in developing water projects, incorporating health and environmental safeguards in water projects, the environmental and health impact of population resettlement, and the financial and economic aspects of environmental management and its cost-effectiveness as a vector-control measure.

In a series of three papers, Dolores Koenig makes a comprehensive sociological analysis of the socio-economic, political and organisational aspects of forced population resettlement as a result of the Manantali dam project in Mali. It contains many useful points for similar projects elsewhere. The report argues that resettlement is seen more as a technical problem of rebuilding so the question of sustaining conditions of economic production is overlooked. The hasty timing of resettlement, lack of settler participation in all phases of the project, and lack of land for longterm development of new communities are seen as the main shortcomings of this project. The reports are entitled *After the First Year's Move Trip Report*, February 1987; *The Second Campaign: Manantali Population Resettlement Project*, September 1987, and, co-authored by Michael M Horowitz, *Lessons of Manantali: A Preliminary Assessment of Involuntary Relocation in Mali*, from Clark University International Development Program, 950 Main Street, Worcester MA 01610, USA, or the Institute for Development Anthropology, 99 Collier Street, PO Box 2207, Binghamton NY 13902, USA.

Division Structures is a manual for senior agricultural staff designing or implementing smallholder irrigation schemes. It deals with orifice and weir intakes, giving descriptions of each, criteria for selection and design examples with detailed calculations. Published as part 5 in the Kenyan Ministry of Agriculture's series on small hydraulic structures, it is available from the Ministry of Agriculture, Irrigation and Drainage Branch, PO Box 30028 Nairobi, Kenya. A comprehensive design manual incorporating the whole series is planned.

GTZ has now published the English translation of *Management of Irrigation Systems - Guiding Principles,* by Walter Huppert and Hans H Walker in its Handbooks on Rural Development series. (See ODI-IIMI Newsletter December 1988.) It is available from GTZ-Verlagsgesellschaft mbH, Postfach 1164, D-6101 Rossdorf, West Germany.

Kampuchea: Undoing the Legacy of Pol Pot's Water Control System, by Bert Pijpers, provides a brief historical overview of the disastrous irrigation projects carried out under Pol Pot and the difficulties of repairing the damage today in the absence of western aid. Pol Pot's legacy of canals, dykes and structures unfortunately took little account of topography or soil conditions. This booklet has the merit of covering a little-known country and is available from Trocaire, Catholic Agency for World Development, 169 Booterstown Avenue, Blackrock, Co Dublin, Ireland.

In Operation and Maintenance of Small Irrigation Schemes, Peter H Stern outlines the points to watch out for to avoid problems with operation and maintenance; water supply, conveyance and distribution; drainage; and water-borne disease. This practical booklet is published by Intermediate Technology Publications, 103/105 Southampton Row, London WC1B 4HH, UK, price £4.95.

Estimating the Economic Efficiency of Irrigation - the Case of Brazil (36/89 CP-BRA 37 SR, FAO, 10 March 1989). This working paper describes the methodology used for estimating present and future economic efficiency of irrigation in Brazil. The analysis is based on hectare budgets and farm modelling techniques, and includes a comparison with rainfed production costs. It is the first comparison of all major forms of irrigation in Brazil on a common base and should be of interest to specialists of Brazil as well as others, since it is anticipated that the methods will be replicable.

In *Manpower Planning for Irrigation*, Richard Carter and David Mason suggest a model for determining irrigation manpower levels. The stages of the procedure involve classifying the irrigation system, grouping activities into functions, defining job descriptions and designing an organogram. Typical job descriptions and organograms are presented with quantified examples for Indonesia, Nigeria, Sudan and Zimbabwe. Published by FAO, 1988.

Guidelines for Conducting Training Needs Assessments in Irrigation Management. J Stofkoper and J I Gianchandani argue that training needs assessments should be simple in design and not time-consuming if they are to be used regularly by trainers. The guidelines presented are aimed at staff developing or revising the content of training courses, and the manual concentrates on the questionnaire survey method. Available from Louis Berger International Inc, Water & Power Consultancy Services (India) Ltd, 213 Ansal Chambers-II, 6 Bhikaiji Cama Place, R K Puram, New Delhi 110066, India.

Vanishing Land and Water by Jean-Louis Chleq and Hughes Dupriez explains how erosion occurs and how to fight it, and gives instructions on building runoff barriers and small dams and on sinking wells and boreholes. Amply illustrated with photographs and diagrams, the book is based on experience in Burkina Faso and is aimed at farmers and rural craftsmen in semi-arid regions. This English translation from the French is published by Macmillan, and is also available from Terres et Vie, 13 rue Laurent Delvaux, 1400 Nivelles, Belgium.

The papers presented at the *International Conference on Irrigation System Evaluation and Water Management* (Wuhan University, 12-16 September 1988) have now been published in two volumes. They are available at US$50 plus $40 postage from Prof Lei Shenlong, Vice-Secretary General of ISEWM, Wuhan University of Hydraulic and Electric Engineering, Wuhan, China.

ISRIC: Aims, Programme & Activities. The International Soil Reference and Information Centre has just published an updated description of its activities. It is a useful resource for irrigation planners, serving as a documentation centre on land resources; and carrying out research, consultancies and training in aspects of soil classification and mapping, and agroclimatology. ISRIC, PO Box 353, 6700 AJ Wageningen, The Netherlands.

c. Journals

The Dominican Republic Takes the Lead by Herve Plusquellec in *The Bank's World*, Vol 8 No 3, March 1989. In the Dominican Republic, salinisation and poor canal maintenance have been solved in a pilot project by turning the management of irrigation systems over to Boards of small farmers. While in the Argentinean province of Mendoza, the administrative areas under decentralised small water user organizations have been enlarged to make them even more financially and administratively efficient. The reorganization of water users' associations in Mendoza, Argentina by Jorge Chambouleyron in Irrigation and Drainage Systems Vol 3 No 1, pp 81-94.

The January 1988 issue of the *ICID Bulletin* (Vol 37 No 1) contains two articles of special interest. J S Abbott reviews world wide usage of micro-irrigation comparing the results of the 1982 and 1986/87 ICID surveys (pp 1-12). Figures show the usage of micro-irrigation techniques has doubled in five years, and in addition to the leading Western countries and Israel, significant increases in the area under micro-irrigation are reported in Egypt, Brazil, Mexico, Jordan, China and Taiwan (all over 10,000 ha).

In the same journal, Asit K Biswas argues (pp 13-22) that too much emphasis has been placed in recent years on the use of systems analysis for water management problems. While models may be useful for operational purposes their value for policy making is negligible, and the problems dealt with are often far too theoretical.

For optimum results, systems analysis should be considered along with other approaches.

Wamana Journal. The January 1989 issue contains two articles by Niranjan Pant and Tushaar Shah dealing with ground water development in eastern Uttar Pradesh and in Gujarat respectively, also covering user group management of tubewells. The April 1989 issue features water management in Punjab and Haryana by S P Malhotra and examines implementation of the Warabandi system. It describes Warimetric, an innovative method for assessing water charges on the basis of the number of turns a farmer receives his share of water.

7. CONFERENCES

The papers of a conference on planning to suit the local socio-economic environment, held by DVWK in Berlin in April, are available. They contain both theoretical frameworks and practical observations, the former making them perhaps of most interest to researchers and teachers. The title is *Situation-specific management in irrigation*, published by Paul Parey, Hamburg/Berlin, 1989.

The triennial international conference, World Water 89, will be staged at the Wembley Conference & Exhibition Centre in London from 14-16 November 1989. Details are available from World Water 89, Westrade 89, Westrade Fairs Limited, 28 Church Street, Rickmansworth, Hertfordshire WD3 1DD, UK.

Southampton University will be holding an international conference on *Irrigation: Theory and Practice* on 13-15 September 1989. Details available from Institute of Irrigation Studies, The University, Southampton, SO9 5NH, UK.

There will be a symposium on *Land Drainage for Salinity Control in Arid and Semi-Arid Regions* from 26 February - 3 March 1990, to be held in Cairo, Egypt. Further details from Drainage Research Institute (DRI), Irrigation Building, 13 Giza Street, El Giza, Cairo, Egypt.

8. TRAINING COURSES

The following have been notified to us:

a. Short courses

Dept of Agricultural Engineering, College of Engineering, University of Wyoming, PO Box 3295, Laramie, Wyoming, USA. 14-31 August: *Automatic Operation of Irrigation Canals.*

International Irrigation Centre, Utah State University, Logan, Utah, USA. 20 August-23 September: *Soil and Water Conservation and Management.* 27 August-16 September: *Farmer Participation and Irrigation Organization.* 27 August-30 September: *Design of Wells and Pumps for Irrigation.* 6-23 September: *Soil Conservation & Management Study Tour of US Mid-Western States* (English and Spanish). 1-21 October: *Maintenance of Pumping System Components.* 1 October-11 November: *Operation, Maintenance and Management of Irrigation Delivery Systems.* 19 November-2 December: *Financial Management of Irrigation Systems.* 3-16 December: *Workshop on Policy, Planning and Strategies for Irrigated Agriculture.*

International Rice Research Institute, PO Box 933, Manila, Philippines. 28 August-6 October: *Irrigation Water Management Training Course.*

Iav Hassan II - Centre International de L'Irrigation, BP 6202, Rabats-Instituts, Rabat, Morocco. 3 September-7 October: *Irrigation Systems Management.*

DCTP/UNDP, 5th Floor, Bonifacio Building, University of Life Campus, Meralco Avenue, Pasig, Metro Manila, Philippines. 4-22 September: *Planning and Management of Training Programs.*

Colorado Institute for Irrigation Management, Colorado State University, Fort Collins CO 80523, USA. 4-29 September: *Monitoring, Evaluation, Feedback and Management of Irrigated Agricultural Systems.* 2-27 October: *Remote Sensing, Image Processing and Geographical Information Systems: Applications in Irrigated and Agricultural Farming Systems.* 16 October-3 November: *Training of Trainers for Irrigation Management.* 6-24

November: *Water Users' Associations in Irrigation Management.* 27 November-22 December: *Irrigation Systems Rehabilitation.*

b. Academic courses

International Agricultural Centre, PO Box 88, 6700 AB Wageningen, The Netherlands. 20 August-1 December 1989: *Postgraduate Course on Land Drainage.*

9. ACTIVITIES AT ODI

We have decided to launch a new AAU series of INTER NETWORK PAPERS, which are on topics that we feel may be of interest to members of more than one AAU Network. The first of these is by Gaie Mendelssohn, *The use of micro computers for project planning, monitoring and evaluation*, AAU Inter Network Paper 12, March 1989. It looks at specific tasks in the project cycle that can be performed more efficiently with the use of a computer and standard softwares for word-processing, a spreadsheet, and database management. The author worked in the agricultural planning unit of a small Caribbean island; it concerns the type of planning work which in larger countries would be done at District or Province level, and should be helpful to all those who want to take the first steps in developing computer use.

We have been fortunate in having a series of interesting lunch time meetings this year at ODI:

Wednesday 11 January 1989, a Discussion Meeting on *Irrigation charges in the Barind Integrated Area Development Project: A New Approach*, by Mr M Asaduzzaman of the Bangladesh Agricultural Development Corporation. Mr Asaduzzaman plans to develop this into a Network Paper.

Friday 9 June 1989, a Lunch Time Meeting on *Improvement of operation in Nong Wai Pioneer Agriculture Project, Thailand*, by Mr G N Kathpalia, Consultant. Mr Kathpalia reported on a return visit to this project, which he described in Network Paper 10c, 1984.

Monday 19 June 1989, a Lunch Time Meeting on *Problems and successes in introducing drip irrigation to arid areas with particular reference to Tamil Nadu*, by Prof R K Sivanappan, former Director of the Water Technology Centre at Tamil Nadu Agricultural University, Coimbatore. Although drip irrigation is never likely to extend to more than 1% of India's irrigated area, it is particularly useful for high value crops in water scarce areas. Professor Sivanappan described simple systems that have been developed for small farms. His current address is 14 Bharathi Park, 4th Cross Road, Coimbatore 641 043, India.

Friday 14 July, a Lunch Time Meeting on *Performance evaluation of irrigation tanks in South India*, by Dr K Palanisami, Agricultural Economist at the Water Technology Centre of Tamil Nadu Agricultural University. This may later appear as a Network Paper.

Mary Tiffen July 1989

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IRRIGATION MANAGEMENT NETWORK

IDENTIFICATION OF CAUSES OF POOR PERFORMANCE OF A TYPICAL LARGE-SIZED IRRIGATION SCHEME IN SOUTH CHINA

Mao Zhi

ODI/IIMI Irrigation Management Network Paper 89/1b June 1989

Papers in this set

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

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IDENTIFICATION OF CAUSES OF POOR PERFORMANCE OF A TYPICAL LARGE-SIZED IRRIGATION SCHEME IN SOUTH CHINA

Mao Zhi

Contents

Mao Zhi is Professor in the Department of Irrigation and Drainage at the Wuhan Institute of Hydraulic and Electrical Engineering, Hubei Province, China. This paper was first presented at the Asian Regional Symposium on the modernisation and rehabilitation of irrigation schemes, held at the Development Academy of the Philippines, 13-15 February 1989. The proceedings were published by Hydraulics Research Ltd, Wallingford, OX10 8BA, UK, and their permission to reprint is gratefully acknowledged.

IDENTIFICATION OF CAUSES OF POOR PERFORMANCE OF A TYPICAL LARGE-SIZED IRRIGATION SCHEME IN SOUTH CHINA

Mao Zhi

SUMMARY

In the past, Zhanghe irrigation scheme was well-known for its poor performance. Since its rehabilitation in the last decade, however, it has been considered advanced. It is one of the large-sized irrigation schemes typical in South China, both in terms of its natural and social conditions and its experience of rehabilitation.

In this paper, an index system consisting of twelve techno-economical indices of evaluation of the irrigation and drainage schemes is presented. The performance of the scheme in engineering, economical and social terms can be quantified by these indices. The indices of Zhanghe scheme in the past and the causes of the unsatisfactory values of these indices are discussed. The effects of rehabilitation of this scheme are illustrated by contrasting the indices before and after the rehabilitation. The performance criteria and the main measures and experiences of rehabilitation in Zhanghe scheme are also introduced.

1. INTRODUCTION

Zhanghe Irrigation scheme (ZIS) has an irrigation area of 174 thousand ha and is the largest one in Hubei Province, China. It is situated in the central part of the province, north of the Changyiang (Yangtze) River.

Its irrigation water is mainly supplied by a large-sized reservoir, the Zhanghe reservoir, which is built on a tributary of the Changyiang River-Zuzhang River. The reservoir is designed for the multipurpose uses of irrigation, flood control, water supply, power generation, etc, but in fact it is mainly used for irrigation.

In Zhanghe Irrigation District (ZID), about four fifths of the irrigation area lies in hilly regions, with only one fifth in the plains. The soils of the area are mostly clay and loam. The main crops are rice, wheat and cotton. The multiple cropping index is about two. Rice is planted over 86% of ZID and wheat is planted on 73% of the rice fields after harvest. The average evaporative capacity is 1353.1 mm, and rainfall is 937.7 mm, which is distributed in a highly irregular pattern both within and between years. Irrigation of rice is necessary in both dry and wet years, and the irrigation periods are from May to August.

ZIS was completed in 1965. Besides the water source projects, the canal systems include one main canal, five sub-main canals and 13,984 branch canals at 5 to 7 ranks. The total length of the above mentioned canals are 7,167.6 km.

The construction of ZIS fundamentally changed agricultural production in the area. The annual yield of rice increased from 3.0 t/ha after 1966 to 4.5 and 4.9 t/ha during 1975 and 1976. However, the rice yields remained at the same level, or even declined, during 1977 - 1980 due to poor performance and other causes, including policy, engineering and management aspects.

Since the 1980s, ZIS has been rehabilitated and it has now become one of the famous advanced irrigation schemes in China. Because ZIS is typical of large-sized irrigation schemes in South China both in natural and social conditions, a summary of its experience is of practical interest when investigating the status of policy, engineering and management before and after the rehabilitation. This paper, therefore, introduces and analyses indices of performance before and after rehabilitation and the main rehabilitation measures implemented.

2. INDEX SYSTEM FOR EVALUATION OF IRRIGATION SCHEMES

According to the eight national unified indices and in the light of the specific conditions of ZIS, the following index system is used. It consists of twelve techno-economical indices for analysing the performance of ZIS, organised into three groups. Most indices give the percentage of actual performance in terms of planned performance.

2.1 Group 1: Indices of irrigation water utilisation

The three indices used are

1. Efficiency of utilising irrigation water resource S (%)

$$S = \frac{Wp}{Wd} \times 100$$

where Wd and Wp are the design and actual possible annual quantity of irrigation water diverted from the water source in the same years (m^3/year);

2. Gross annual irrigation water quota M

$$M = \frac{W}{A}$$

where W is the actual gross annual quantity of irrigation water (m^3/year). A is the actual irrigation area (ha); and

3. Irrigation application efficiency E

$$E = \frac{Wf}{Wh}$$

where Wf is the total volume of water delivered to the points of use in field by the irrigation canal system (m^3); Wh is the total volume of water diverted from the headwork for irrigation (m^3).

2.2 Indices of irrigation area and engineering aspects of system

Again, three indices are used:

4. Efficiency of actual irrigated area F (%)

$$F = \frac{A}{Ad} \times 100$$

where A is the actual irrigated area and Ad is the design irrigated area (ha);

5. Percentage of area provided with field irrigation and drainage system D (%)

$$D = \frac{Af.a}{Af.d} \times 100$$

where Af.d and Af.a are the design and actual area provided with the field irrigation and drainage system (ha); and

6. Percentage of facilities in good condition G (%)

$$G = \frac{Ng}{N} \times 100$$

where N is total number of facilities for irrigation or drainage in a particular category; Ng is the number of the facilities in good condition (safe, integrated, functioning normally and attaining the design standard).

2.3 Indices of economic benefit

The six indices used are

7. Yield per unit area y (t/ha/year),

$$y = \frac{Y}{A}$$

where Y is the total annual yield (t/year) of crops in A (ha);

8. Yield per unit quantity of irrigation water y_w (kg/m^3)

$$y_w = \frac{Y}{W}$$

where the unit of Y is kg/year and W volume of water supplied (m^3)

9. Income from irrigation water charges per unit area (yuan[1] ha/year)

$$i = \frac{Iw}{Ad}$$

where Iw is the actual total annual income from irrigation water charges (yuan/year)

10. Irrigation benefit per unit area b (yuan/ha/year)

$$b = (y - y_o)c + (y^1 - y^1_o)c^1 - h$$

where y and y_o are the annual yields of crops per unit area (t/ha/year) with and without irrigation respectively; y^1 and y^1_o are the annual quantities of by-products per unit area with and without irrigation (t/ha/year); c and c^1 are the costs of agricultural product and by-product (yuan/t); h is the annual expenditure per unit area for irrigation (yuan/ha/year).

11. Irrigation benefit per unit quantity of irrigation water b_w (yuan/m^3)

$$b_w = \frac{b}{M}$$

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[1] The Chinese unit of currency. In 1988 yuan = $0.268.

12. Percentage of financial self-sufficiency J (%)

$$J = \frac{I}{H} \times 100$$

where H is the total annual expenditures which includes salaries, administrative expenses and current expenditures (yuan/year); I is the total annual income from water charges and diverse other revenue sources (yuan/year).

3. THE OVERALL STATUS OF THE TWELVE TECHNO-ECONOMICAL INDICES ON ZIS BEFORE REHABILITATION AND ITS EVALUATION

10 to 15 years after putting ZIS into operation, ie during 1976 - 1980, the performance of the scheme began to decline. The poor performance was reflected in the twelve indices discussed above. In order to compare and evaluate the ranges and average values of the indices between 1976 and 1980, the values from ZIS are shown in Table 1, next to a notional normal level, derived from national and provincial figures.

The data table in Table 1 shows that the values of twelve indices on ZIS during 1977-80, especially E, D, G Y_w, i and J, were all unsatisfactory.

The value of index E which mainly characterises the status of water waste is only about three quarters of the designed value. Such a value indicates that the waste of irrigation water was remarkable. The value of D reflects that the area which lacks a field drainage system was four fifths of the area in need of it. Value of G shows that about one fifth of the facilities were damaged. Value of y is only about two thirds of the normal level; that show both the low yield and the high water use. The value of i is only about one third of its normal level, thus the value of J is only about one third of the standard level. The values of y, i, b and J in Table 1 reflect that the economic situation is very poor. Therefore, it was necessary to rehabilitate to improve the performance of ZIS.

Table 1 The values of twelve indices on ZIS before rehabilitation

No	Names, symbols, and units of indices	Values of Indices			
		During 1976-1980 on ZIS		Design	Normal level or Standard Level
		Ranges	Average		
1	Efficiency of utilising irrigation water resource S (%)	75-93	88	100	95
2	Gross annual irrigation water quota M (m^3/ha/year)	6,400 -7,300	6,900	4,620 -5,700	5,000 -6,000
3	Irrigation application efficiency E	0.43 -0.53	0.48	0.65	0.60
4	Efficiency of actual irrigation area F (%)	55-98	91	100	100
5	Percentage of area provided with field irrigation & drainage system D (%)	10-30	20	100	100
6	Efficiency of facilities in good conditions G (%)	75-90	82	100	98
7	Yield per unit area y (t/ha/year	4.68 -5.76	5.16	6.00	6.00
8	Yield per unit quantity of irrigation water y_w (kg/m^3)	0.65 -0.82	0.75		1.15
9	Income from irrigation water charges per unit area i(yuan/ha/year)	7.2 -12.5	10.1		30
10	Irrigation benefit per unit area b (yuan/ha/year)	371 -477	420		600
11	Irrigation benefit per unit quantity of irrigation water b_w (yuan/m^3)	0.053 -0.065		0.061	0.85
12	Percentage of financial self-sufficiency J (%)	25-38	33		100

4. THE MAIN CAUSES OF UNSATISFACTORY STATE OF THE TECHNO-ECONOMIC INDICES

The causes of the unsatisfactory state of the techno-economic indices are many. The main causes were as follows:

4.1 Irrational regimes, organisations, policies and regulations for engineering and water management

4.1.1 Management organisations lack financial rights Although there was a professional management organisation, the ZIS Bureau of Management was set up by the government. There are five controlling stations under this Bureau, but they all lacked the right to make decisions by themselves on financial matters and on improvements to the project construction and management. Because the main income of the controlling stations was from the water charge, which was low, the main costs of projects were provided by the government. Investment plans and the organisation of the main projects were also decided by the government. Therefore, the projects often were not planned well.

4.1.2 Lack of a water code for water rights The ZIS Bureau of Management and its subordinate units did not have the right to allocate water. Local government, other administrative units and administrative officials usually interfered in the work of water allocation for their own partial and immediate benefit. Rational allocation and effective implementation are difficult in these circumstances.

4.1.3 Lack of policies and regulations for motivating staff to work hard. Besides the professional management organisations, there were many grass-roots management organisations of farmers. The staff of the professional organisations and the farmers who worked in the grass-roots organisations received a fixed salary which had almost no connection with the results of their work.

4.1.4 Irrational policy, form and rate of water charge In the past, as in many other regions in China, there was an irrational policy, form and rate of irrigation water charges in ZIS. The irrigation water charge rate was not based on the quantity of water used by farmers but on the irrigated area. The rate was very low, at about only 10 yuan/ha/year. For some years the farmers did not pay any irrigation water charges at all. As a direct consequence, there was a tendency to over-irrigation and wastage of water. This led not only to the loss of irrigation water but also to a decrease in rice yields. Therefore, in this area the value of index M is high, y and i are low. Moreover, the income of the irrigation management unit has decreased, which results in J being less than 100%; meaning the irrigation management unit was operating at a loss.

4.2 Imperfect irrigation and drainage schemes

4.2.1 Imperfect water-capture project and irrigation distribution schemes The water-capture project was imperfect. There were two spillways of the Zhanghe Reservoir in the design but only one of them had been completed. Thus, the normal water level in this reservoir had been lowered and the beneficial capacity had been decreased by 16% of the design value. The actual possible quantity of irrigation water and irrigation area and the corresponding indices (S and F) were all decreased.

The distribution systems, especially canal appurtenances, were imperfect. There were no bifurcation gates and control gates on the last distribution canals, and no water measuring devices on distribution canals. It was impossible to distribute the irrigation water in a planned manner and impose the water charge fairly.

4.2.2 Imperfect field irrigation and drainage systems In ZID, there are 71,000 ha of irrigation area of rice on the bottoms of hilly lands and plains. As a result of rice planting over a long time and diverting a large amount of water from water sources into the rice fields, the groundwater table in the rice fields has been raised year after year. Based on the local experimental data on the plains, (especially on the bottoms of hilly lands), if the groundwater table cannot be controlled by the field drainage systems, the yields of rice will decrease by 10 - 15% and the yields of wheat after rice 20 - 25% due to the high level of groundwater table. Ten years ago, in the bottoms of hilly lands and plains, there were only 22,000 ha of irrigated area of rice provided with the field drainage systems. Lack of field drainage systems were one of the main causes of low yields of crops in the bottoms of hilly lands and plains.

In the past, most of the rice fields in hilly lands also had low yields because the field irrigation and drainage systems were not sound. Irrigation and drainage was carried out not by field canals, but with water flowing from 'plot-to-plot'; the loss of water and fertiliser was serious and the water temperature in the rice field was low. This caused the low values of indices of yields and economic benefits.

4.3 Poor maintenance of canal systems

As a result of poor maintenance for many years, the capacity of some distribution canals was reduced due to the heavy siltation, more weeds or termitaria. There were ten dangerous sections on the main and secondary canals due to erosion and scouring. The transmission line and communication line for the work of management were usually out of order.

4.4 The ponds were abandoned

Ponds are an important supplementary water source in ZID. Formerly the average long-term quantity of water which has been supplied by ponds was about 1,200 m^3/ha/year. After 1976, it was only about 600 m^3/ha/year because the farmers abandoned the ponds and transformed them into paddy fields. This practice further worsened the problem of water shortage in ZID and caused the decrease of irrigation area and yields of rice and the values of corresponding indices F and y.

4.5 Irrational water-management method and rice-irrigation method

As mentioned above, in the past it was impossible to apply advanced methods of management of water use because of the artificially imposed obstacles and the imperfection of canal systems. In fact, only a simple method was used in which the distribution of water to the secondary canals was based on the relative size of the irrigated area. It was a problematic method and usually led to over-irrigation in the early stage, water shortage in the later stage, over-irrigation in the upper zones and water shortage in the lower zones of the irrigation district.

Sometimes the rice fields could not be irrigated in time. The old rice irrigation method with a deep layer of ponded water of 80 - 150 mm on the surface of rice fields from the transplanting of rice shoots to the 'milky ripening' stage was widely applied by farmers. The data from the local experimental station, and the other places, had proved that by using this old method the rice yields were 12 - 20% less and the water requirement on rice fields were 20 - 35% higher than with a more advanced method which will be described later.

The irrational water-management method and rice-irrigation method were therefore also important causes of the unsatisfactory values of many indices.

5. THE PRINCIPAL MEASURES FOR REHABILITATION

The principal measures for rehabilitation of ZIS and improving its poor performance are as follows:

5.1 Reforming the administrative regimes

In 1979, an economic reform was started in China and the reform of regimes, policies and regulations of projects and water management also began to keep pace with it in every region. Under this situation, the following reforms have been enforced in ZIS after 1981.

5.1.1 <u>Giving rights to the professional management units</u> The ZIS Bureau of Management was given the responsibility (especially financially) for the rehabilitation and management of projects and water use. Interference by other administrative units and officials was prohibited. Therefore, the work on the rehabilitation and scientific management could be fully realised.

5.1.2 <u>Economic contract and personal responsibility</u> 'Systems of Economic Contract' and 'Systems of Personal Responsibility' have been implemented not only in the professional management units but also in the grass-roots management units organised by farmers. The income of each unit or person working for the rehabilitation and management is closely linked up with the results of their work.

5.1.3 <u>Reforming the water charge</u> The water charge rates were changed from the irrigation area only, to a dual system, one part based on the quantity of water used and the other on the irrigation area. Rates were raised to a realistic level. The rates for a quantity of water are 0.01 yuan/m^3 for irrigation and 0.03 yuan/m^3 for industrial use and the rate for the irrigated area is 12 yuan/ha/year.

After the water charge reforms, not only has the gross annual irrigation water quota (M) been decreased, but the yields per unit area (y), especially per unit quantity of irrigation water (y_w), have been increased. The income of the Bureau of Management of ZIS from the water charge (i) has also been raised to about six times that before reform. Thus, the financial ability of the Bureau for rehabilitation and scientific management was greatly strengthened.

5.2 Strengthening the construction and maintenance of the canal system and management of water use

As mentioned above, an imperfect canal system and poor management of water use are the main causes of irrigation water wastage and declining irrigated area and rice yields in ZID. In the process of rehabilitation, through clearing away the silt and weeds, treating the termitaria and reinforcing the dykes in the dangerous sections, the canals have recovered their design capacity. 430 water measuring devices have been installed on distribution canals, and all the sections on the main and secondary canals with heavy seepage loss have been lined with concrete, clay or plastic film. In order to eliminate plot-to-plot irrigation and drainage, the irrigation and drainage field ditch systems have been constructed on almost the whole area of rice fields. All the above-mentioned measures have provided favourable conditions for planning the use of irrigation water and using the advanced rice-irrigation method.

Through rehabilitation, the principle measure in water use management was the implementation of the 'water use plans'. These were formulated for ZIS as annual and periodic plans. The annual plan outlines the amount of irrigation water and irrigated area for the entire year. The periodic plan formulates the quantity of irrigation water, irrigation area, water diversion and water allocation for each irrigation. Practice has demonstrated that the irrigation water can be delivered on schedule and then the quantity of irrigation water can be gradually decreased and the rice yield can be remarkably increased by implementing these two kinds of water use plans.

5.3 Using small reservoirs and ponds to increase water source

One of the main causes of decline of the irrigated area and rice yields in ZID is the shortage of water sources. Building small and middle-sized reservoirs and restoring ponds are important measures for expanding water sources. Through the process of rehabilitation, to date in ZID, 195 Type II (the total capacity is 100,000 to 1 million m^3) small reservoirs, 100 Type I (1 - 10 million m^3) small reservoirs, and 22 middle-sized (10-100 million m^3) reservoirs have been constructed. The total beneficial capacity of these reservoirs are 819 million m^3, equivalent to 87% of the beneficial capacity of Zhanghe Reservoir.

The characteristics of ponds are that they are widely distributed, provide timely irrigation, are easy to manage, and have a high water temperature. Irrigation with pond water aids rice growth. For a period after the construction of the Zhanghe Reservoir, people neglected the role of the ponds and many even filled in their ponds to make rice fields. Through this process of rehabilitation, at present, there are

85,969 ponds storing 249 million m^3 in ZID. Practice has demonstrated that ponds play an important role in the prevention of drought.

An irrigation system centred around the Zhanghe Reservoir and based on the ponds, and small and middle-sized reservoirs has gradually been formed. In this irrigation system, the water may be allocated to each other. At present, the average long-term total amount of stored water reaches over 1,200 million m^3. The problem of water shortage is nearing a solution.

5.4 Strengthening the work of research and experimentation

In 1968, an irrigation experimental station was established in the central part of ZID. In 1979, the work of experimentation and research at this station was strengthened and rice-irrigation methods have been included in the main research subjects. Based on the experimental results from 1979 to 1982, an advanced rice-irrigation method in the locality has been developed. In the past several years, this method has been gradually popularised on the greater part of the irrigated rice fields in ZID.

This advanced method uses the field irrigation and drainage systems to keep alternately a shallow ponded water layer, and damp and dry situations of soil on the rice fields at different growing stages of the rice. The water regimes on rice fields for this method are shown in Table 2. In all the growing stages, except the periods of drying the field in the sun and the yellow ripe stage, the water depth of the above-mentioned standards can be doubled after a rainfall, in order to make effective use of rainwater.

Based on the plot experiments at the station and the practices on the larger acreages, the yield of rice can be increased by 12 - 20%, and 20-35% of the irrigation water can be saved by using the aforesaid method in comparison to the old methods.

Table 2: General standards of water regimes on rice field in ZID

Growing stages	Depth of water layer on rice field (mm)
Transplanting of rice shoots	10 - 20
Revival of green	0 - 30
Early and middle stages of tillering	0 - 40
Late stage of tillering	Drain, dry the field in sun for 5 - 7 days
Booting to flowering	0 - 60
Milk ripening	0 - 40
Yellow ripe	Drain, dry the field.

6. THE EFFECTS OF REHABILITATION

The effects of rehabilitation on ZIS can be illustrated by the contrast between the twelve indices before and after the rehabilitation (Table 3).

The data in Table 3 shows that all indices have been improved through rehabilitation. Especially, the values of indices M, y and b show that the irrigation water has been saved by 15%, the rice yield and economic benefit has been increased by 48% and 40%. It is thus clear that, through rehabilitation, saving water has effected remarkable increases in crops yield and economic benefits.

Therefore, now, ZIS is one of the famous advanced large-sized irrigation schemes in China.

Table 3: The comparison of the values of twelve indices on ZIS between before and after rehabilitation

No	Names, symbols and units of indices	The average values of indices on ZIS		The values of the ratio of (A)/(B)
		Before rehab -ilitation 1976/80 (B)	After rehab -ilitation 1985/87 (A)	
1	Efficiency of utilising irrigation water resource S (%)	88	100	1.14
2	Gross annual irrigation water quota M (m^3/ha/year)	6,900	5,850	0.85
3	Irrigation application efficiency E	0.48	0.60	1.25
4.	Efficiency of actual irrigation area F (%)	91	100	1.10
5	Percentage of area provided with field irrigation & drainage system D (%)	20	95	4.75
6	Efficiency of facilities in good conditions G (%)	82	100	1.22
7	Yield per unit area y (t/ha/year)	5.16	7.65	1.48
8	Yield per unit quantity irrigation water y (kg/m^3)	0.75	1.31	1.75
9	Income from irrigation water charge per unit area i (yuan/ha/year)	10.1	55.6	5.50
10	Irrigation benefit per unit area b (yuan/ha/year)	420	588	1.40
11	Irrigation benefit per unit quantity irrigation water b (yuan/m^3)	0.061	0.101	1.66
12	Percentage of financial self-sufficiency J (%)	33	105	3.18

7. CONCLUSIONS

Many old irrigation and drainage schemes in China need to be rehabilitated due to their poor performance. This performance can be identified by an index system which consists of three kinds of techno-economical indices: 1) Indices of utilising irrigation water, 2) Indices of irrigation area and engineering aspects of the system, and 3) Indices of economic benefit.

The main causes of poor performance on irrigation and drainage schemes are from not only technical but also social aspects. The principal measures for rehabilitation may be to resolve both the technical and social problems.

The effects of rehabilitation can be illustrated by the contrast between the values of the techno-economic indices before and after rehabilitation. Based on the analysis of the data of these indices from a typical irrigation scheme in South China, the irrigation water can be saved by 15%, and the rice yield and economic benefit can be increased by 48% and 40% respectively through rehabilitation. It is thus clear that the effects of rehabilitation of irrigation and drainage schemes are remarkable.

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IRRIGATION MANAGEMENT NETWORK

REHABILITATION OF COMMUNAL IRRIGATION SCHEMES IN NEPAL

Nasiruddin Ansari

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REHABILITATION OF COMMUNAL IRRIGATION SCHEMES IN NEPAL

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REHABILITATION OF COMMUNAL IRRIGATION SCHEMES IN NEPAL

Nasiruddin Ansari

SUMMARY

Nepal is a landlocked country lying between Tibet (China) and India, and the terrain is mostly hilly and mountainous except for a narrow strip of plain area (the Terai) in the south along the Indian border. About 90% of the present population of 17.5 million depend upon agriculture. Therefore, since time immemorial farmers of Nepal have developed thousands of irrigation schemes mostly on their own initiative. These systems have been functioning in different ecological settings. Some systems in the hills are several centuries old. These are being improved to the extent possible by farmers themselves, but most of them need rehabilitation and improvements to increase their performance. Irrigation systems built and operated by farmers in the Terai are thought to be among the largest communal systems in the world. The use of these communal systems is diminishing due to environmental degradation in the catchment area.

Out of a total land area of 14.72 million ha, only 3.0 million are cultivated. Out of this, only 1.979 million ha are potentially irrigable. During the last three decades, the Government-developed irrigation basic infrastructures command 434,000 ha, whereas the age-old communal schemes command about 650,000 ha. Government agencies have been implementing schemes without farmers' participation at any stage resulting in problems in O & M, allocation and distribution of water. In

general, government operated schemes have performed at a low efficiency, whereas communal schemes perform more efficiently

Seeing the potentiality of intensifying irrigated agriculture in a short time through rehabilitation and improvements to farmer-operated systems, a Government agency, the Department of Agriculture, launched such a programme. During the last five years, several small communal systems have been renovated, rehabilitated, and even enlarged, through a participatory approach where costs have been shared 75% and 25% by the Government and the farmers' group. Such completed projects have shown increasing performance and use. Recently His Majesty's Government of Nepal has launched a programme of fulfilment of basic needs of the population by 2000 AD in which increased stress is laid on intensifying irrigated agriculture. Hence, the Government has adopted a new participatory approach and a strategy of improving the existing communal schemes to extract benefits in a short while.

1. REHABILITATION NEED OF COMMUNAL IRRIGATION SCHEMES

1.1 Need for rehabilitation and improvement

It has been mentioned above in the summary that in Nepal, traditional farmer-managed irrigation systems have existed for centuries. In the absence of a Government agency responsible for creating irrigation facilities, three types of initiatives developed in Nepal viz: a) religious trusts, b) individual or groups of farmers, and c) community as a whole. It is noteworthy that even in the wake of irrigation developments by Government agencies over the last 35 years, more than 60% of the irrigated area of the country is being served by these farmer-managed systems. Therefore, these systems play an important role in the irrigation subsector for agricultural intensification.

It has been stated that in Terai about 526,000 ha of area is under the command of surface irrigation schemes managed by 1,925 farmers' groups or communities. In the hills, about 166,000 ha are under gravity irrigation. Each such scheme serves areas between 5 and 15,000 ha. Most schemes fall in the range of 5 to 5,000 ha and divert water from rivers by making diversions of brush wood, boulders, and soil. During the monsoon, they have to be reconstructed several times after each flood. The canal system is generally earthen with a few simple rudimentary structures. In the hills, with the help of district budgets, some retaining walls and pucca linings have been constructed. Some FMIS have permanent weirs financed by District Panchayats (elected Councils) or other Government institutions.

About 41% of the FMIS in Terai draw water from perennial sources and the rest from seasonal rivers. The perennial rivers have decreasing water up to March and so cannot irrigate for year round cropping. The seasonal rivers provide only one supplementary irrigation. Therefore, augmentation from other sources or from groundwater is essential to improve their function and performance.

The farmers' investment in time in rebuilding the diversion bunds is considerable and most farmers' committees would prefer permanent diversions as an improvement to their systems. They would need head regulators to control floods entering into the canals. Farmers usually contribute land and also kind to the maintenance of their systems. The contribution is usually based on the area of land a household irrigates from the system. In an emergency, all the available labour force is required to go to repair. The considerable labour used in maintenance is estimated to be between 30 to 75 farmer-days per hectare, depending upon the number of times the diversion bund has to be rebuilt , and on the terrain and length of the canals, etc. Assuming the value of labour is Rs 18/- per day, the average cost of O & M comes to Rs 900/- per annum per hectare. In difficult hill canals, this cost is still higher. The lack of technical skills in the original construction of these canal systems has the effect of increasing the maintenance cost. (In 1988 US $ 1 = Rs 23.29.)

Where the main canal is shared by more than one village, then the water is bifurcated into two or more village canals by means of a Saacho (a rectangular notched log where the width of notches are proportional to the areas of the villages). Although many FMIS have strong beneficiary organisations which can ensure proper management and the required resource mobilisation, in the country there are still several in a poor state of affairs due to ineffective organisation. Some of them are totally inoperative due to serious technical problems or a financial inability to keep them operative. With the increase of command area due to new land being brought under cultivation, and a decrease in dry season discharge due to environmental degradation, many of the schemes fail to supply sufficient water for optimum cropping intensities for the total area. In such schemes, augmentation of water has to be done from other sources or conjunctive use of groundwater will be required.

It is evident from the above situation that there is a great potential for improvement in the FMIS where rehabilitation and upgrading can greatly help in agriculture intensification and thereby contribute to the national goal of self sufficiency in food by 2000 AD.

1.2 Rehabilitation with the participatory approach

1.2.1 General

From the beginning of the 1980s, emphasis has been given in developing countries to the necessity of involving beneficiaries of irrigation development in decision making from inception to the completion of schemes. In 1978 in Nepal, a high level seminar-cum-workshop was organised on People's Participation in Rural Development. It was concluded that there was a greater need for people's participation in development works, but the question as to how people could be activated was not resolved. With the enactment of the Decentralisation Act 2039 (in 1982), the policy has been to motivate the beneficiaries to initiate their own development works. Village and district level projects have been implemented with the beneficiary groups sharing certain portions of the cost involved. Since that time, users' involvement has gained momentum.

A seminar was held in Nepal in 1983 on 'Water Management Issues' which, among other issues, revealed that farmer irrigation organisations had a tendency to turn more to the Government for resources for the improvement of their systems. As a matter of fact, they have been getting some finance for such improvements. A serious result of Government help in the remodelling and upgrading of the FMIS was the erosion of the self-help attitude among the farmers. They wanted the Government not only to rehabilitate their existing systems but also to take up the maintenance. This tendency had developed during the last decade when Government had taken up such schemes of upgrading and remodelling as new projects, and after completion had taken O & M responsibility as well. In this approach, the people's initiative that existed before had ceased and it was assumed by the people that the Government is there to provide the services.

1.2.2 Farmer irrigation projects implementation

In Nepal, the Government has to transport food grain to the food-short hilly and mountainous areas (even by plane) when the transport cost is borne by the exchequer as a subsidy. On the other hand, a lot of small streams in those areas could be utilised for irrigating the farm lands, and the existing or abandoned farmers' schemes could also be improved to give a better performance.

Hence, in 1981 the Government decided on a policy to take up small irrigation schemes under a participatory approach in which the Government would provide 75% of the cost as a subsidy and the balance was to be borne by the beneficiaries as their equity. The schemes were implemented by the Farm Irrigation and Water Utilisation Division (FIWUD) of the Department of Agriculture (DoA). In the beginning, this programme was to be applied in a few food-short hill districts and if the result was found to be encouraging, then the programme could be spread to other districts. The anticipated benefits from this programme were as follows:

- The schemes were implemented with beneficiaries participation where only 75% of the capital cost was borne by the Government.

- Large and medium projects would take a long time and huge investments, whereas new minor schemes and rehabilitation schemes could be completed in a short time with less cost.

- The construction by beneficiary participation would mostly use local material, labour and skills.

- As the beneficiaries would expect benefits to flow as soon as possible, the works generally could be done fast in a participatory approach.

- Such projects after completion would be operated and maintained by the beneficiaries themselves, thereby there would be no O & M burden to the Government.

- Overhead cost and the administrative burden was minimised.

To implement these schemes, simple procedures, and rules and requisitions were adopted as narrated below:

1 The Government provided, as a subsidy, 75% of the cost estimate prepared by FIWUD technicians.

2 Before the actual implementation of the scheme, the beneficiaries had to deposit, in cash, 5% of the cost estimate in a bank account in the project's name.

3 The Agricultural Development Bank of Nepal (ADBN) had to provide a loan to the beneficiary group up to 20% of the cost of the scheme; alternatively, the beneficiaries had to provide labour works amounting to 20% of the cost.

4 The total fund consisting of 75% of Government subsidy, 20% of the ADBN loan, and 5% cash contribution by the beneficiaries was deposited in a nearby bank. The expenses for work were paid from the account, which was jointly operated by the project technician and the representative of the beneficiaries' committee.

5 The technical supervision and control of the work was the responsibility of the FIWUD technical personnel.

6 Before the start of the scheme, the beneficiaries had to make a written commitment to carry out by their share of financial and labour resources.

1.2.3 Evaluation of farm irrigation projects

Before the take up of a rehabilitation scheme, the base line data, like total area cultivated, different crops grown and yields, farm inputs and net incomes are assessed. After completion, during the O & M phase, the above data are again collected on a sample survey basis.

Some 14 rehabilitation and upgrading of farmers' irrigation schemes were implemented in the initial years starting 1981 in the districts of Ramechhap and Sindhuli. In these schemes, the Government provided Rs 2,011,000/- as subsidy, and the beneficiaries spent Rs 670,000/- as their equity. Before completion of these schemes totalling 783 ha, maize was grown in 430 ha, wheat in 62 ha, millet in 193 ha, paddy in 271 ha, and potato in 16 ha, thereby having a cropping intensity of 125%.

After receiving irrigation facilities in a proper and organised manner, most of the cropping pattern was changed. Now farmers cultivated paddy in 563 ha, wheat in 500 ha, maize in 200 ha, millet in 100 ha, and potato in 183 ha, thereby attaining a cropping intensity of 200%. The yield also increased a little bit. The main benefit was due to an increase of cropping intensity and pattern. The net income increased from Rs 2,312,000/- to Rs 6,346,000/-.

2. NEW STRATEGY FOR EXTENSIVE REHABILITATION

2.1 Background

His Majesty the King has given directives to fulfil the minimum basic need of the country by 2000 AD. Accordingly, a programme is formulated to increase the present food grain production from 4,312,000 tons to 8,651,000 tons by the end of the century. Irrigation, being the prime contributing factor, has been given priority and long term targets have been fixed.

To meet the objectives of the Basic Needs Programme, a total of 1,250,000 ha must be provided with irrigation facilities by the end of 2000 AD. By the end of 1986/87, some 434,000 ha of land was to be provided with irrigation infrastructure by the combined efforts of Government agencies and the ADBN. Hence, during the next 13 years, an additional 816,000 ha area has to be brought under irrigation. This target needs greater efforts to achieve.

2.2 Previous policy for irrigation development

Although great importance has been given to irrigation, the achievements from new irrigation projects and rehabilitation of old schemes has not been encouraging. Out of the 434,000 ha areas developed for irrigation by Government agencies, the actual irrigation has been about 40% of the commanded land during the kharif season, and only about 20% get year round irrigation.

The Department of Irrigation (DOI), being the main Government agency responsible for irrigation development, has concentrated on the execution of permanent types of large, medium and minor irrigation schemes with a consideration to long term benefits. Other agencies like DOA, MPLD, and ADBN, have given importance to shorter term objectives and have implemented simple, less expensive projects in which farmers' participation was possible to be arranged. Also traditional farmer-managed irrigation schemes which were sick or inoperative due to technical or financial problems, were rehabilitated. Both of these policies had positive and negative aspects.

In Nepal, the different agencies involved in irrigation works here so far each followed their own policy and there was an inconsistency in cost sharing and Government subsidy. The DOI projects were taken up with the full cost and responsibility of the development, so much so that O & M has been the full responsibility of the Department. The other agencies followed a system where the beneficiaries have to share a part of the cost as well as the full responsibility of O & M. In the ADBN schemes has been fully borne by the beneficiaries as the loan has to be returned in due course of time.

2.3 New working policy

Under the new policy, all the different Government agencies involved in irrigation development have been merged into one Irrigation Department and all irrigation work will be carried out with a unified approach and the same policy. The main principles for the new policy are as follows:

- Beneficiary initiation and participation is made compulsory for project identification, selection, layout and construction. Also, a commitment for participation in the O & M phase is required.

- Irrespective of which agency is executing a project, the contribution of equity by the Government for the different types of project is fixed and ADBN will provide loans to the beneficiary groups based on a fixed proportion of beneficiaries shares of the total cost. The working procedures of this policy are narrated in the following paragraph.

2.3.1 Classification of projects scale

i Surface Irrigation Schemes are categorised as small, medium and large depending on the size of command area the project serves. This also depends on whether they are in the hills or plains.

Table 1: Classification of Irrigation Schemes in Nepal

Class of irrigation systems	Command Area (ha)	
	Hills	Terai (plain)
Small	less than 50	less than 500
Medium	50 - 500	500 - 5,000
Large	greater than 500	greater than 5,000

Lift irrigation project from rivers and sprinklet systems will also be classified as above.

ii All type of small and large diameter shallow and deep tubewells and open dug wells are categorised as groundwater irrigation projects.

iii It is realised that sprinklet or drip irrigation could be of great benefit for the hilly areas where water is scarce. In areas where such potentiality exists, farmers will be encouraged to use such a system and an appropriate grant will be made available.

iv Renewal, repairs and rehabilitation works of non-Governmental or communal schemes are also categorised as in (i) above.

2.3.2 Selection of rehabilitation projects

i Project feasibility studies will be initiated only after a genuine demand from the beneficiaries is made to the irrigation authorities. Studies will be made on the basis of design manuals being prepared for nation-wide use. Those projects having greater IRR, less expensive and with a chance of completing in a short time, as well as those projects which have a chance of receiving foreign aid, will be given higher priority.

ii Any project which gives an IRR of more than 10% will be considered feasible. The project will be started only after the total fund for completion is ascertained beforehand.

iii Rehabilitation, upgrading or remodelling of traditional or non-governmental projects will be identified and proceeded for execution with the joint efforts of the concerned member of District Panchaat, Member of Peasants' Organisation, beneficiaries groups, DOI and ADBN. Surveying, designs and cost estimates will be made with the close cooperation of the beneficiaries groups. Priority for approval will be given to projects which are less expensive and have a chance of greater users' participation.

iv The farmers' group is ready to enter into a written agreement regarding the terms and conditions of assistance to be given by the Government, and the farmers' responsibility for establishment and/or maintenance of a Water Users' Group which would participate in planning and construction, contribution to the capital costs and resumption of full responsibility to O & M of the scheme after completion. This agreement will be a pre-requisite for processing the project for Government involvement.

v On the technical feasibility of the scheme, the suitability of soil for irrigation and problem of soil erosion and land slides will be given due consideration.

vi The cost per hectare of rehabilitation should not be more than Rs 30,000 ($1,300) in hills and Rs 20,000 ($800) for the Terai schemes.[1]

2.3.3 Criteria for prioritisation

At present, in the sectoral lending programme, the following priority in selection is going to be adopted.

i The scheme should have a high economic rate of return.

ii The per hectare cost should be low but within the limit given above.

iii A beneficiary's organisation already exists in the project area or, if not operational at present, there is a good chance for its revival without delay.

2.3.4 Basis of cost sharing

In determining the farmers' share of the capital cost of the scheme, due consideration has to be given such that:

i The sense of ownership among farmers is enhanced. Also the government contribution should not be high enough to undermine the

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[1] Note by Mary Tiffen. Fixing an upper limit for rehabilitation costs in this manner is a very important principle. It will help to focus the attention of both designers and farmers on what are the essential priorities for rehabilitation, and to differentiate those from desirable extras.

farmers' participation for the development or upgrading of the scheme.

ii The proportion of the farmers' share will remain flexible in order to permit revision after a trial period. The estimate of repayment capability of farmers is subject to actual experience in the field.

iii Farmers' contribution should mainly be in the form of labour, but a small proportion of it must be in cash in order to prove the farmers' commitment. In the rehabilitation of the scheme, certain farmers may make their contribution entirely by cash or from loan.

iv The beneficiaries' group have to provide land free of cost for tertiary and field channels to improve the water distribution.

v Farmers' share of the cost of the schemes should be based on their capability to pay and the per hectare cost.

On the basis of location of the schemes, the unit cost of rehabilitation and the past experience of FIWUD and MPLD where beneficiaries were required to contribute 15 to 25 per cent of the total cost of the scheme, the following formula is to be applied for the Government's and farmers' contribution to capital costs.

Table 2: Proportion of Government and Farmers' Shares towards the Capital Cost of Rehabilitation

Rehabilitation Cost (Rs/ha)	Government contribution (% of total cost)	Farmers' Contribution (% of total cost)	
		Cash/loan	Labour
1 Less than 10,000	75	5	20
2 10,000 - 20,000	85	2.5	12.5
3 20,000 - 40,000	91	1.75	7.25

2.3.5 Organisational arrangement for irrigation development

i In order to formulate a national policy and programme for irrigation development in a coordinated way, a high level committee has been set up under the Chairmanship of the Water Minister, where heads of other allied ministries will be members. This committee will fix priorities, fix the targets, decide the working procedure, and provide coordination between working units.

ii The Department of Irrigation and the ADBN will be the main working units for irrigation development. To have closer coordination at each stage between these two units and the Department of Agriculture and to assist in each others' technical efforts, and to have a complete record of irrigation facilities in the country, a central coordination committee will be established.

iii The organisation of the DOI and the ADBN, from the centre to the districts, will work as per newly created organisational setups. The work would be implemented in a coordinated manner at all levels, including field units.

3. CONCLUSION

In Nepal, farmer-managed irrigation systems are claimed to give a better performance than the Government sector irrigation schemes. In Government schemes, farmer initiative and involvement during construction and O & M has not been considered, resulting in difficulty in water management and finally resulting in poor performance. In Nepal even now, about two thirds of the irrigated area is under traditional, communal, irrigation systems. All of them are not functioning well, and many need upgrading and rehabilitation whereby their utility can be greatly enhanced. In irrigation sector strategy, the rehabilitation of farmers' systems is given priority due to the fact that intensification of irrigation is possible in a shorter period and in a cost effective manner. All such work will be done on a demand basis and under a participatory approach, with the full involvement of actual beneficiaries.

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IRRIGATION MANAGEMENT NETWORK

ECONOMIC RETURNS TO OPERATION AND MAINTENANCE EXPENDITURE IN DIFFERENT COMPONENTS OF THE IRRIGATION SYSTEM IN PAKISTAN

Muhammad A Chaudhry and Mubarik Ali

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ECONOMIC RETURNS TO OPERATION AND MAINTENANCE EXPENDITURE IN DIFFERENT COMPONENTS OF THE IRRIGATION SYSTEM IN PAKISTAN

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ECONOMIC RETURNS TO OPERATION AND MAINTENANCE EXPENDITURE IN DIFFERENT COMPONENTS OF THE IRRIGATION SYSTEM IN PAKISTAN

Muhammad A Chaudhry and Mubarik Ali

1. INTRODUCTION

Pakistan's agricultural sector is presently confronted with a major challenge: how to increase production to the levels required to feed a population growing at an annual rate of more than 3 per cent. In general, agricultural production can be increased by either expanding the irrigated cropped area or by raising the crop yields. The possibilities of developing more land and new surface water supplies in the short run are remote as it would require huge capital investments and strong soil protection measures. Therefore, the most reliable way to increase irrigated cropped area and yield is to generate additional water supplies through groundwater development schemes, better management, and efficient operation and maintenance (O&M)[1] of various components of the existing irrigation system.

The national average yield of major crops is at present far below their production potential (Muhammad, 1982). Overall scarcity of water, non-availability of water at the right time, and inefficient utilisation of available water appear to be the leading factors restricting expansion in irrigated acreage and causing the gap between actual and potential yield levels.

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[1] Operation and maintenance includes the management of water supplies and upkeep of system facilities from the water source to the farmer's fields. Operation means the allocation and delivery of water supplies, including the management of any storage facilities, and the handling of drainage runoff. Maintenance is the upkeep of irrigation and drainage structures, embankments, dams, outlets and channels and the removal of silt and vegetation from canal and storage facilities (Easter, 1985).

The Government of Pakistan (GOP) has attempted to improve the performance of the irrigation system by implementing a series of irrigation development programmes. Consequently, the situation with respect to overall water availability has improved. However, the system is still confronted with the twin problems of low operational efficiencies and high distributional inequities (Chaudhry, 1986).

2. THE PROBLEM

Once an irrigation system is working, its O&M play a critical role in determining the growth of the agricultural sector. In agriculture, poor O&M will result in

- below capacity working and/or to erratic water supplies which in turn lower the area cultivated and depress yields

- a shift to lower value crops

- lower investment in yield enhancing variable inputs such as fertiliser

- reduced on-farm investments (Carruthers, 1981).

In Pakistan, many of these negative consequences of inefficient O&M are already in evidence. Therefore, substantial investments are being made to rehabilitate badly deteriorated segments of the irrigation system.

The public irrigation infrastructure is rapidly deteriorating because of continuous deferred maintenance. Inadequate maintenance of the canals results in frequent breaches and consequent interruptions in water supplies. The ability to carry out maintenance is inhibited, to a major degree, by financial constraints. Financial constraints appear to be more binding because the revenues generated by the system have not kept pace with rising O&M costs; the latter have increased due to the positive relationship between system's deterioration rate and the age of the system (Chaudhry, 1986). Existing investments are therefore becoming unproductive, and future investments are likely to suffer from the same set of problems. The constantly increasing demand for irrigation water, properly distributed in time and space, underscores the need to reform economic policies that tend to result in allocation of less funds for O&M activities.

Tight budgetary constraints and the very high opportunity cost of capital policy mean choices need to be made regarding the relative amounts to allocated for O&M of different components of the irrigation system. Investment in all components of the system may not be equally productive. Moreover, since O&M of a large irrigation system, as in the case of Pakistan, is an expensive activity, it is important to ascertain the social productivity of such investments. Research related to such policy choices would not only be useful to those making O&M allocation decisions at government level, but also to those international agencies providing financial and technical assistance to Pakistan in improving its irrigation system's performance.

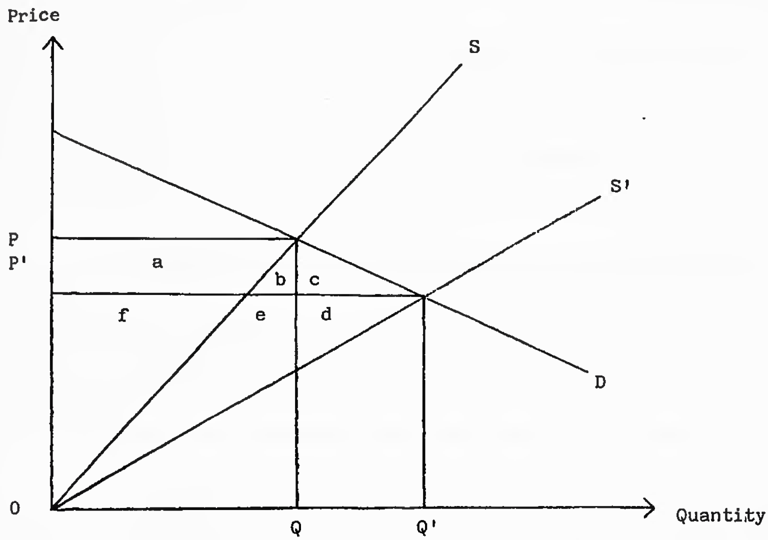
An econometric model has been developed in this paper to estimate the contributions of recurring investments, made for O&M of the irrigation system, to agricultural productivity. The estimated parameters have been used to simulate the effects of various O&M investment scenarios on agricultural output, farm prices, and gross income. The study is restricted to the irrigated areas of Punjab province because of its dominance in Pakistan's agriculture.

3. ANALYTICAL FRAMEWORK

3.1 Theoretical framework

The contribution of various conventional and non-conventional inputs to agricultural production can be measured by using the production function. However, the production function approach is confronted with a possible simultaneous equation bias problem (Hoch 1958; Lau and Yotopoulos, 1971). Also, problems of data and multicollinearity limits the usefulness of

Fig 1: Hypothetical impact of an increase in O&M spending on agricultural production



this approach (Binswanger, 1975; Braha and Tweeten, 1986). These problems can be avoided if indirect functions such as profit, cost, or supply are employed to estimate the contribution of various inputs in output.

The productivity model employed in this study is analogous to a supply function and is expressed as a function of the prices paid for variable inputs and received for agricultural output and the quantities of the fixed inputs of production. Instead of irrigated land, we have treated irrigation infrastructure as the fixed input because we were interested in estimating returns to investment in O&M activities. Expressing fixed inputs in their flow values generally yield statistically superior results (Yotopoulos, 1967). As such, the flow value of the irrigation infrastructure is defined in terms of the amount spent for O&M of the system.

It is hypothesised that an increase in O&M spending would increase the agricultural production through increases in both irrigated area and per acre yield. This would shift the supply curve rom S to S' in Figure 1, lowering the equilibrium prices from P to P' and raising output from Q to

Q'. Net social benefits of this shift in the supply curve can be estimated as follows:

gain to consumers would equal the difference between consumer surpluses at prices P and P': {a+b+c}

losses to producers would equal the difference between producer surpluses at prices P and P': a-{d+e}

losses to taxpayers (farmers) would equal: O&M budget

net gains to society would equal the difference between gain to consumers and loss to producers and taxpayers: {b+c+d+e}-{O&M}.

It is assumed that funds for O&M activities would come mainly from farmers in the form of water charges. The producers will be better off as long as the cost savings from productivity gains, measured by area {d+e}, exceed losses in total receipts which would be equivalent to area {a} in Figure 1.

3.2 The productivity model

The following model was used to estimate the contribution of various inputs to total agricultural production.

1. $\ln PIND_t = \ln A + b_1 \ln OMC_t + b_2 \ln OMGTW_t + b_3 \ln OMPTW_t + b_4 \ln PR_t + \ln U_t$

where

$PIND_t$ = Agricultural index in year t with 1971=100. This is computed through Laspeyre's formula: {sum $(q_1 * p)$/sum $(q_0 * p_0)$}*100;

OMC_t = Operation and maintenance expenditure on canal system (million rupees). The expenditures are deflated by GDP deflator, with 1971=100;

$OMGTW_t$ = Operation and maintenance expenditure on government tubewells (million rupees). The expenditures are deflated by GDP deflator, with 1971=100;

$OMPTW_t$ = Operation and maintenance expenditure on private tubewells (million rupees), expressed in 1971 prices;

PR_t = Parity price ratio (prices paid/prices received);

ln = natural logarithm;

U_t = Disturbance term.

The subscript $_t$ refers to time period, while A (conglomeration of shifters) and b_i's are parameters to be estimated.

The data with respect to operation and maintenance costs of the canal system and government tubewells in Punjab Province were obtained from the provincial irrigation department (PID) files and various issues of the non-development budget (NDB) documents. O&M cost of private tubewells for each year were calculated by multiplying the total number of tubewells in that year with the average O&M cost of a tubewell in the year 1971. In order to account for O&M cost variations in electric and diesel tubewells, proper weights were assigned while calculating average O&M cost for the year 1971. Data regarding prices paid and received by the farmers for inputs and outputs, respectively, were taken from Tweeten (1985) and Qureshi et al, (1985).

3.3 The simulation model

A simulation model is employed to trace the effects of an exogenous increase in O&M spending on agricultural output, farm prices, and gross income. In order to portray market equilibrium conditions, both supply and demand functions have been incorporated in the model. Similar models with varying assumptions have been used by Tweeten and Quance (1972), Yeh (1976), White and Havelicek (1982) to evaluate the impact of public expenditure in different non-conventional inputs on agricultural productivity. Economic outcomes are simulated in response to changes both in demand and supply parameters to reflect different possible market conditions.

The reduced form of the demand and supply equations can be written in double log form as follows:

$$[2] \quad \ln Qd_t = \ln Ad + bd \ln PPt + (1 - rd)\ln Qd_{t-1} + rd_i \sum_{i=to}^{t} gd_i$$

$$[3] \quad \ln Qs = \ln As + bs \ln PR_t + (1 - rs)\ln Qs_{t-1} + rs_i \sum_{i=to}^{t} gs_i$$

where:

Qd, Qs = Quantities demanded and supplied, respectively;

PP, PR = Prices paid by customers and received by producers, respectively; these are equilibrium prices and are net of inflation;

gd, gs = Rates of shift of demand and supply in the ith year;

bd, bs = Short-run price elasticities of demand and supply, respectively;

rd, rs = Co-efficients of adjustments towards equilibrium in demand and supply, respectively;

Ad, As = Constant terms in Ordinary Least Squares demand and supply equations, respectively.

A number of economic parameters can cause a shift in demand and supply curves. The demand curve can shift due to an increase in population growth rate, per capita income, export demand and similar other parameters, During the last ten years, population, per capita income, and agricultural exports grew at an average annual rate of 3.13, 3.15, and 2.02 per cent, respectively. On the other hand, agricultural imports also grew at an average annual rate of 4.7 per cent during the same period. If this trend persisted, it would offset some of the effects of parameters causing an outward shift in demand curve. Moreover, increased emphasis on education is also expected to slow down population growth a bit. Since various economic parameters can cause a simultaneous shift (upward or down ward) in the demand curve, three demand scenarios (low, moderate or high) were exogenously applied to the model. Low, moderate and high demand scenarios assumes an annual shift of 1.5, 3.0 and 4.5 per cent in the demand curve, respectively.

Similarly, a supply curve can shift due to a variety of reasons. However, O&M spending on the irrigation system is the only component of gs considered in this study. Three scenarios of O&M spending considered in the simulation are: annual growth rates of 5 per cent, 10 per cent, and 15 per cent. However, it is assumed that O&M spending would increase simultaneously on all components of the irrigation system. Annual growth rate in the productivity index between two time periods emerging from an increase in O&M spending on different components of the irrigation system can be written as:

$$[4] \quad \ln (PIND_t/PIND_{t-1}) = B_i \ \ln(O\&Mi_t/O\&Mi_{t-1})$$

Replacing gs_t in equation [3] by RHS of equation [4], the following supply function is obtained:

$$[5] \quad \ln Qs_t = \ln As + bs \ln Ps_t + (1-rs) \ln Qs_{t-1} + rs \sum_{i=t_0}^{t} bi \ \ln(O\&Mi_t/O\&Mi_{t-1})$$

It is evident from equation [5] that supply shift is the cumulative effect of O&M spending on different components of the irrigation system over time. Equations [2] and [5] are used to simulate equilibrium output, farm prices, and gross income under alternative demand and supply scenarios.

4. RESULTS AND DISCUSSION

The model in equation [1] was used to measure the contributions of funds spent for operation and maintenance of different components of the irrigation system to agricultural productivity. The model was fitted by OLS to data for 1966-1986. The Durbin-Watson statistics of 1.94 suggests no serial correlation in the model. The correlations between independent variables were low and insignificant, except between OMGTW and OMPTW where r = 0.93. According to Hu (1973) "if economic theory suggests that a variable should be included in the function, then one may have to leave the variable in the equation, although it contributes to multicollinearity problem.."

Results of the model are reported in Table 1. The constant term and co-efficient of OMPTW were significant at 1 per cent probability level; whereas co-efficients of OMC and PRATIO were significant at 5 per cent probability level. The co-efficient of determination (R^2) was 0.91; indicating that the model explained the variation in agricultural productivity extremely well.

Table 1: Regression results indicating contribution of O&M spending in different components of the irrigation system to agricultural productivity in Punjab province

lnA	lnOMC	lnOMGTW	lnOMPTW	lnPRATIO	R^2	D.W
.671*	0.308**	0.004	0.358*	-0.40**	0.91	1.94
(0.609)	(0.19)	(0.084)	(0.10)	(0.157)		

Figures in parentheses are standard errors.

* Co-efficient is significant at 0.01 probability level.

** Co-efficient is significant at 0.05 probability level.

The results with respect to O&M investment elasticities indicate that a 10 per cent increase in O&M expenditures on canals, public tubewells, and private tubewells would increase agricultural productivity by 3.08 per cent, 0.04 per cent and 3.58 per cent, respectively. The elasticity of PIND with respect to PRATIO was -0.40.

In order to assess the relative profitability of increased O&M investments in different components of the irrigation system, marginal products (MP) of past O&M investments are estimated by using the following equation.

[6] $$MPi_t = bi(PIND/O\&Mi)_t$$

where bi is the elasticity of PIND with respect to O&M investments, and $(PIND/O\&Mi)_t$ is the average productivity of O&M investments in period t for ith component of the irrigation system. If PIND is expressed in terms of the value of output in equation [6], it would directly yield the value of marginal product (VMP), or the marginal benefit of O&M investments made in different components of the irrigation system.

Historical estimates of marginal benefits to O&M investments in canals, public tubewells and private tubewells are given in Table 2. Marginal benefits to past O&M investments in canal system were highest and were followed by those in private and public tubewells, respectively. In the case of canal system, marginal benefits to past O&M investments were significantly greater than unity, and showed an increasing trend, suggesting the need to allocate more funds for O&M of the canal system.

However, marginal benefits to past O&M investments in public and private tubewells were found to be declining over time; exhibiting the law of diminishing returns from O&M investments[2]. The MVP figures estimated above are high but seem plausible in view of the fact that the irrigation infrastructure is assumed as given, which means that the capital costs are not accounted for.

Higher marginal benefits to past O&M investments in canal system suggest that agricultural production can be increased at a relatively faster rate by increasing O&M investments in this component of the irrigation system.

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[2] Marginal benefits from past investments in different components of the irrigation system were regressed against the time variable to see their trend over time. The co-efficients for canal, public tubewells, and private tubewells were 0.0179, -0.0437 and -0.0644, respectively. All co-efficient were significant at 1 per cent probability level.

Table 2: Historical estimates of marginal benefits to O&M investments in different components of the irrigation system in Punjab province, 1966-86

Year	Marginal benefits per Rupee of O&M investment to		
	Canals	Public tubewells	Private tubewells
1966	11.58	0.59	15.15
1967	14.90	0.76	13.60
1968	15.19	1.15	13.10
1969	16.42	0.84	12.42
1970	20.39	0.69	11.92
1971	17.93	0.40	9.71
1972	18.70	0.57	9.53
1973	19.08	0.43	8.76
1974	22.60	0.40	8.00
1975	18.81	0.44	6.60
1976	20.24	0.36	6.84
1977	20.99	0.41	6.43
1978	21.02	0.47	6.51
1979	23.54	0.35	6.63
1980	24.36	0.29	7.03
1981	26.94	0.27	7.01
1982	20.06	0.27	6.87
1983	21.38	0.28	7.20
1984	15.72	0.19	5.06
1985	19.29	0.26	6.37
1986	20.66	0.29	6.81

(Figures expressed in 1971 Rupees)

Marginal benefits to past O&M investments in private tubewells, although showing a decreasing trend, are significantly greater than unity, indicating that it is still profitable to increase O&M investments in private tubewells. This can be done by increasing the total number of tubewells or enhancing the utilisation rate of existing tubewells. However, benefits of increased O&M spending on private tubewells would be reaped mainly be tubewell owners who are few relative to the size of the whole farming community. Contrarily, increased O&M investments in canal system would yield benefits not only for large number of farmers, but these benefits would be distributed equitably as well. This, however, should not be interpreted as increased O&M investments being directed towards the canal system at the cost of private tubewells. Both systems are independent and have their own unique roles to play in increasing agricultural production.

Marginal benefits to past O&M investments in governments tubewells are very low. One possible explanation for insignificant relationship between agricultural productivity and O&M investments in public tubewells might have been the fact that the dependent variable was developed for the whole province; whereas the benefits of public tubewells are reaped only in certain geographic pockets. In view of the tight budgetary constraints, and continuously increasing O&M requirements for the public tubewells, the government has decided to divest these tubewells to private sector in fresh groundwater zone. The ongoing transition programme should be pursued cautiously - the public tubewells should be shut down only as they are replaced by alternative pumping facilities. Otherwise, waterlogging problems may become more serious.

5. PROJECTED ECONOMIC OUTCOMES

Economic outcomes of alternative shifts in the agricultural supply curve due to assumed annual growth in O&M investments are simulated under low, moderate, and high demand scenarios. In the supply equation [5], a short run elasticity of 0.40, as estimated by equation [1], is used. The long run price elasticity estimated by various studies and reported in Qureshi et al (1985) and Tweeten (1985) has been argued to range from 0.40 to 1.50. In the present study, a long run elasticity of 1.0 and lag parameter of 0.40 are used. On the demand side, price elasticity for major agricultural crops in Pakistan has been reported to range between-0.3 to -0.70 (Hamid et al, 1987). The present study assumes a short run elasticity of -0.29 and lag parameter of -0.20.

The model's projected economic effects follow the outcomes hypothesised in Figure 1: for a given demand scenario, increased O&M spending increases output (supply), which lowers prices. However, the combined effect of lower prices and higher output is higher farm income. Contrarily, when annual growth in O&M investments is held constant, and demand for agricultural output is increased, all of the selected variables tend to move in the same direction (upward).

Simulated economic outcomes under assumed demand and supply conditions are shown in Table 3. The maximum annual growth rates in output (14.10 per cent) and gross income (10.10 per cent) are registered when O&M outlays increases at the rate of 15 per cent annually under high demand

Table 3: Annual growth rates of simulated economic outcomes under alternative demand and O&M investment scenarios in Punjab province, 1988-2000

Demand scenario*	Annual growth in O&M investment**	Variables (% per year)		
		Output	Prices	Gross income
	5%	4.87	-0.12	4.66
Low	10%	7.82	-1.24	5.22
	15%	11.32	-2.14	5.79
	5%	5.74	0.42	6.49
Moderate	10%	8.91	-0.78	7.14
	15%	12.66	-1.75	7.79
	5%	6.68	1.01	8.6
High	10%	10.07	-0.28	9.35
	15%	14.10	-1.33	10.10

* Annual growth rate under low, moderate and high demand scenarios is assumed to be 1.5, 3.0, and 4.5%, respectively.

** Assume annual growth in O&M investment in canals, public tubewells, and private tubewells at the same time.

Table 4: Marginal benefits to increased O&M investments in different components of the irrigation systems under alternative demand scenarios in Punjab province, 1988-2000

Annual growth in O&M investment	Year	Canal system			Government tubewells			Private tubewells		
		Low demand	Moderate demand	High demand	Low demand	Moderate demand	High demand	Low demand	Moderate demand	High demand
	1988	20.09	20.38	20.66	0.29	0.29	0.29	3.94	3.99	4.05
5%	1992	20.50	21.65	22.87	0.29	0.31	0.32	4.02	4.24	4.48
	1996	18.83	20.84	23.07	0.27	0.30	0.33	3.69	4.09	4.52
	2000	16.83	19.55	22.72	0.24	0.28	0.32	3.30	3.83	4.45
	1988	17.81	18.06	18.31	0.25	0.26	0.26	3.49	3.54	3.59
10%	1992	15.20	16.05	16.96	0.22	0.23	0.24	2.98	3.15	3.32
	1996	11.81	13.08	14.47	0.17	0.19	0.21	2.32	2.56	2.84
	2000	8.96	10.41	12.09	0.13	0.15	0.17	1.76	2.04	2.37
	1988	15.86	16.08	16.31	0.23	0.23	0.23	3.11	3.15	3.20
15%	1992	11.42	12.06	12.74	0.16	0.17	0.18	4.24	2.36	2.50
	1996	7.57	8.38	9.27	0.11	0.12	0.13	1.48	1.64	1.82
	2000	4.91	5.70	6.62	0.07	0.08	0.09	0.96	1.12	1.30

* Annual growth rate under low, moderate and high demand scenarios is assumed to be 1.5, 3.0 and 4.5%, respectively.

scenario. Under this situation, prices decline at an annual rate of 1.33 per cent. Maximum depression in prices received (2.14 per cent yearly) would occur when O&M outlays are increased at an annual rate of 15 per cent under the low demand scenario. Our results indicate two ways of meeting increased demand for agricultural output: increased O&M outlays, or let farm prices rise. In the former case, increased O&M would cause the agricultural output to increase through ensured and timely availability of water; whereas in the latter case, agricultural output would increase as a result of a more efficient allocation of available resources by the farmers.

Since there are three scenarios both for demand and supply, there are nine possible market combinations. Perhaps the more realistic scenario is - annual increase of 5 per cent in financial outlays for O&M activities subject to an annual shift of 3 to 4 per cent in demand. This scenario seems plausible because financial outlays for the public irrigation system have increased at an annual rate of about 5 per cent in real terms during the last five years; whereas on the demand side, population and per capita income have grown at an average rate of 3.1 and 3.15 per cent, respectively, during the last ten years. Under this scenario, output, prices and gross income would grow at an annual rate of 5.74, 0.4 and 6.49 per cent, respectively.

During the projected period, marginal benefits to additional O&M investments are highest in the canal system, and are followed by those in private and public tubewells, respectively (Table 4). For a given O&M investment level, marginal benefits exhibit a positive relationship with the demand level because higher demand causes the prices to go up. Contrarily, when the demand is constant, marginal benefits from additional investment show a declining pattern because increased output lowers the prices. Under the most realistic scenario, marginal benefits to O&M investment in canal system would go down from Rs 20.38 in the year 1988 to Rs 19.55 in the year 2000. Projected estimates of marginal benefits indicate that it would be profitable to continue making increased O&M investments in canal system and private tubewells during the projected period. The profitability of additional O&M investments in the canal system not only suggests the need to allocate more funds for O&M activities, but to generate these funds by raising water charges too.

6. CONCLUDING REMARKS

Increases in agricultural production can be realised by increasing O&M investments in the canal system and private tubewells. Increased O&M spending in canals would result in less frequent canal breaches and also savings of water losses occurring as a result of continuous deferred maintenance. The end result, however, will be availability of higher and more reliable water supplies. Increased O&M investments in private tubewells can be made either by increasing the total number of tubewells or enhancing the utilisation rate of existing tubewells - both options eventually translate into increased water availability.

The estimates of marginal benefits to past and prospective O&M investments in canals and private tubewells are significantly greater than unity; suggesting the need to allocated more funds for O&M of these components of the irrigation system. High returns to O&M investments as reflected in increased agricultural production provides a sound basis to the state to enhance water charges, thereby making O&M a self financing activity.

In practice, it is always difficult for the government to enhance water charges on a yearly basis. This underscores the need to develop an automatic mechanism that would minimise administrative costs and discourage political manipulation of the process. Since output prices are reviewed by the government every year and inflation rates are not too high as well, the possibility of indexing the water charges with output prices may be considered.

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IRRIGATION MANAGEMENT NETWORK

IRRIGATION AND WATER MANAGEMENT FOR DIVERSIFIED CROPPING IN RICE IRRIGATION SYSTEMS: MAJOR ISSUES AND CONCERNS

S I Bhuiyan

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IRRIGATION AND WATER MANAGEMENT FOR DIVERSIFIED CROPPING IN RICE IRRIGATION SYSTEMS: MAJOR ISSUES AND CONCERNS

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IRRIGATION AND WATER MANAGEMENT FOR DIVERSIFIED CROPPING IN RICE IRRIGATION SYSTEMS: MAJOR ISSUES AND CONCERNS

S I Bhuiyan

1. INTRODUCTION

1.1 The issue

In recent years there has been a growing concern as to how Asian irrigation systems, which were developed mainly for supporting double-cropping of rice could be effectively utilized for production of irrigated upland crops. The attainment of rice self-sufficiency by a few countries and near self-sufficiency by few others is the major justification for efforts to induce a shift away from rice. The case for such a shift for the Philippines, which is at the threshold of self-sufficiency, has been advanced by Ali(1987). The declining profitability of rice production in recent years is another reason for looking into the production possibilities of irrigated non-rice crops in the dry season. This decline has also spurred a significant slow down of investment in irrigation in the South and Southeast Asian region (Tables 1 and 2), which raises concerns about how future rice production needs of these countries could be satisfactorily met.

Several recent deliberations (for example, Schuh and Barghouti, 1987; Miranda and Panabokke, 1987) have emphasized that the existing irrigation infrastructure is a major constraint to diversification out of rice. Some authors have indicated the importance of rehabilitating or upgrading the irrigation hardware for introducing the flexibility needed to allow large scale crop diversification within the systems.

1.2 Rice irrigation system uniqueness

Rice irrigation systems can be considered unique from a variety of viewpoints: they handle large flows of water per unit of crop land, especially during land preparation periods; their terminal delivery systems are designed for rather a large number of farmers who share one outlet (popularly called turnout or offtake). But perhaps the most unique characteristic common in rice irrigation systems is that they suffer significant design and management inadequacies. Overdesign of the irrigation water supply component and underdesign of the drainage component are the norm, rather than the exception because use of modern high-yielding rice technology evidently requires irrigation water supplies and the rice crop, unlike upland crops, has the inherent capability to withstand limited inundation on the field through the growing season without showing signs of stress. The long-term adverse effects of not adequately draining the soil on soil health and the role of drainage systems in maintaining soil productivity have not been fully recognized.

1.3 Diversified cropping vs farmer's crop choice

As much as it is not desirable to get irrigation systems be technically locked into growing rice only, it is also not desirable that the systems be modified to suit growing one or more upland crop(s) only. Diversified cropping or crop diversification within irrigation systems is often assumed as a necessary goal, but what is important for the farmer is that he is provided with the flexibility of choice to grow a crop or mix of crops that he prefers. Providing the option to grow an alternative crop should therefore be the central focus of irrigation reform of the future. It seems that if the flexibility of farmer's crop choice is given the focus of attention, some of the issues concerning the need for rehabilitation and upgrading of irrigation infrastructure and their management for non-rice crops may appear simpler or at least different.

1.4 Main objective of the paper

This paper represents an effort to examine selected irrigation and water management issues related to farmer's adoption of upland crops in the dry season within rice irrigation systems. It is assumed that rice will have to be the chosen crop in the wet season for all farmers.

2. RICE IRRIGATION SYSTEMS AND CHOICE OF CROPPING

Stated below are a number of common generalizations concerning the adaptability of rice irrigation systems for production of upland crops in the dry season, which reflect popular notions on the subject. Their validity and possible impacts are examined.

1. Rice irrigation requires continuous flow of water and upland crops require intermittent supplies. Therefore, rice irrigation systems are not suitable for the production of irrigated upland crops in the dry season.

The fact is that ricefields do not require, and should not have, a continuous flow of water. Rice plants grow generally well in shallow ponded water on the field and for that irrigation water is applied to the field intermittently ensuring that the soil maintains at least a saturated condition by the time water is reapplied. Upland crops are also irrigated by intermittent supplies. Thus, farm level irrigation water application systems for rice and non-rice crops are not basically different, although the frequency as well as the in-field water distribution system for the two may vary (for example, basin-flooding for rice but furrow method for corn).

At the main system level, irrigation water may be allowed to flow in the canal network continuously or be rotated in the network canals according to a predetermined schedule for both rice and upland crops. Water supply rotation within the canal network, which is sometimes mentioned as a unique requirement of upland crops, is actually a common practice for rice irrigation in the dry season when available water at the source is more limited. There are various forms of such rotation that are found in practice (de la Vina et al, 1986). Therefore, there is no basic difference with respect to the method of canal water flow allocation and delivery for rice and non-rice crops.

However, there are major differences in the manner farmers apply the irrigation water on the farm for rice and upland crops. Fig. 1 exemplifies the various methods used for applying irrigation water to maintain the desired soil-water status for various crops in Indonesia (Johnson and Vermillion, 1987). The water flow differences at the farm level arising from use of different methods can however be supported by the same irrigation system.

2. Rice irrigation systems will need redesigning, upgrading or major rehabilitation to allow widescale adoption of upland crops in the dry season.

If an irrigation system works well for a rice-rice cropping pattern, it can be made to work satisfactorily for a rice-upland crop pattern without major reforms of its facilities. This is because the basic function of the system, which is to deliver controlled amounts of water for needed irrigation and remove the excess water when desired, remains the same regardless of the type of crops grown. Besides, crop-specific modifications are not appropriate when rice must be grown in the wet season. In the dry season farmers may decide to grow several crops within the service area of a single turnout or offtake served by the main irrigation system, and even within the same farm. Therefore the system must remain flexible in terms of its operational method as well as the use of the infrastructure.

A practical way to build-in the desired flexibility in the system's ability to meet the water delivery needs of various crops is to maintain the existing facilities in the main system, and to schedule water deliveries to the turnouts according to a chosen crop (one that is most commonly grown, or recommended by the system authority) in the dry season when mixed cropping is practised. This may require changes in the established practice for water allocation procedures for the selected area. The adjustments of the flow at the farm level for specific crops can be conveniently and effectively done by the farmers, as found in areas where upland crops are grown within canal irrigation systems.

The drainage component of the main irrigation system is one that may require rehabilitation or upgrading to accommodate more upland crop culture in many rice irrigation systems. Drainage provisions are often neglected from the design to operation stages. The consequence of this is often not dramatic in rice culture because of the inherent ability of the rice plant to cope with certain degree of excess water conditions. But, as stated earlier, the riceland that is not well-drained loses its productivity in course of time. Since upland crops can not tolerate excess water conditions without showing signs of stress or yield losses, many rice irrigation systems may require their drainage systems to be improved for promoting adoption of upland crops. As indicated earlier, such improvements will be to the benefit of both rice and upland crops.

The farm level facilities needed for both irrigation and drainage can be well taken care of by the farmers themselves. Additional on-farm facilities are often required to meet the specific irrigation and drainage needs of the upland crops grown after rice and hence these would be seasonal in nature. For examples, in the Upper Talavera River Irrigation System (UTRIS) in Nueva Ecija, Philippines, in the dry season farmers use 10 to 15 percent of the farm land to provide the on-farm internal ditches for irrigation, drainage, and seepage control required for growing onions. These would be erased from the field at the time of land preparation for the wet season rice and the land saved in the process would be used for rice production in which plot to plot irrigation water flow works effectively (Figs. 2 and 3).

3. In rice irrigation systems, upland crops are not grown on a large scale in the dry season because water deliveries are not precise and reliable.

In most cases, facts do not support this contention. Upland crop culture does not have to wait for the development of capacity to deliver precise amounts of water to each farm or turnout for a group of farms within the irrigation system. There are many examples of average irrigation systems with average structural facilities for water control, in which major areas are grown to upland crops in the dry season.

Precision in water deliveries has rarely been achieved in Asian rice irrigation systems. To operate a system for precise water deliveries may not be economically attractive. But to achieve reliability in water deliveries is a highly desirable objective regardless of the choice of crop. Rice farming suffers from lack of reliability as much as, if not more than, upland crop farming because farmers resort to low-risk, low input use strategies when water deliveries are unreliable and therefore forego significant rice yield benefits.

Is the lack of reliability in water delivery one of the most important reasons that currently restricts farmers from growing upland crops in the dry season? Maybe it is in some areas, but certainly not in most. This assertion will be borne out by the fact that the vast majority of irrigation water users who are located favourably within the system service area (eg, headend farms) and enjoying the highest degree of reliability that the system can offer, still grow rice in the dry season. We also see that in many areas where water supply is less reliable, farmers decide not to grow rice and try to grow some upland crops. What then decides whether or not farmers will grow an upland crop or not? This question has been discussed later in the paper.

4. Rice self-sufficiency has been recently achieved or nearly achieved in many Asian countries; therefore a strategy to grow more upland crops in the dry season within the rice irrigation systems should be adopted.

The strategy to grow more dry season upland crops in rice irrigation systems without augmenting the water resources would mean converting rice lands into upland crop areas, leading to reduced rice production. The dry season being more productive for rice than the wet season (due to the higher levels of solar radiation), the proportion of rice production loss would be greater than that of the land converted away from rice. If such area reduction is not compensated by equivalent increases in yield potential for remaining areas, rice production shortfall may result. Therefore such a strategy must be carefully weighed against the total agricultural production system and national rice production targets.
For greater adoption of upland crops within rice irrigation systems, a desirable strategy would be to augment the dry season water resources in areas where this is feasible, especially in areas with lighter soils. In parts of many canal irrigation systems where some upland crops are grown, farmers exploit additional water sources such as groundwater or surface water available in inactive canals or depressions. The groundwater

resource is often substantial and economically exploitable for upland crops in the dry season by using shallow tubewells.

5. Because rice self-sufficiency has been achieved in several Asian countries and nearly achieved in many others, investments in new irrigation development should be substituted by investments in upgrading or rehabilitating existing irrigation systems.

Irrigation water is still the most crucial input needed to increase rice production in the Asian rice-growing countries which have limited land resources. Self-sufficiency in rice production achieved recently in a few Asian countries may be a temporary phenomenon. One bad drought in 1987 eliminated most of the reserve food stock of 30 million tons in India. Within India, the major rice-growing eastern Indian states are still rice-deficit areas mostly because of lack of irrigation facilities. Philippines has not yet achieved sustainable self-sufficiency in rice production. Bangladesh, which has less than 25 percent rice area with irrigation facilities, is far from self-sufficiency. So are Nepal, Vietnam, and Kampuchea. Indonesia has recently achieved self-sufficiency in rice, but by high subsidies for inputs. (The Indonesian model can hardly be duplicated by other countries, most of which are also resource-poor.) All the above countries, except India, receive emergency food assistance through the World Food Programme (FAO, 1988).

The late 1960's and the 1970's were periods of considerable growth of irrigated area in the South and Southeast Asian countries. Starting in the early 1980's the growth has slowed down (Tables 1 and 2), a process which may be associated with the declining profitability of rice production. The crucial concern in this regard is that rice-growing countries of Asia are expected to increase rice production at about the same rate between 1985 and 2000 as they did during the past 15 years (FAO, 1987), but with irrigation growth rates which are likely to be much lower than in the past period. Barker and Herdt (1985) estimated that if per capita incomes grow at about the rates they have over the decade of 1970-80, there will be a 58 percent increase in total rice demand by the year 2000 compared to 1980.

How will the demand be met? Will new breakthroughs in rice technology be available in the near future to have higher yields per hectare than those achieved in the early- or mid-1980's? Many experts have their doubts. Brown (1988) describes the situation as a "dwindling backlog of technology", and concludes that there are no identifiable technologies waiting in the wings that will lead to quantum jumps in wheat or rice output in the third world. On the contrary, there is a growing concern that the current levels of rice yields may not be sustainable in the face of continuing environmental degradation. The unprecedented floods in 1988 in various parts of Asia (for example, Bangladesh, China, India (Punjab), and Thailand), which wiped out ricefields of millions of farmers (about 3 million hectares were destroyed in Bangladesh alone), are believed to have been caused by degradation of the environment in the respective catchments. Schuh (1987) emphasized the importance of recognizing the looming environmental problems on agriculture that are brought about by intensive use of fertilizers and pesticides, and shifts of growing farming population to marginal lands.

Will higher yields be achieved through higher levels of chemical inputs use, or other means? These questions deserve most serious examination in formulating strategies to popularize the growth of upland crops replacing rice in the existing rice irrigation systems.

To what extent can rehabilitation or upgrading of the existing irrigation facilities substitute for development of new irrigated area to meet the increasing rice production needs? Undoubtedly, rehabilitation is, and will remain, a continuing necessity in many rice irrigation systems for restoring their deteriorated functions and production capacities. But the benefits from structural upgrading of these systems, that can realistically be achieved and sustained over a period of, say 5 to 10 years, have not been clearly established. A study of recent irrigation systems' rehabilitation in the Philippines indicates that "upgrading" the tertiary facilities (turnout and farm level irrigation and drainage infrastructure) through a rehabilitation program did not meet farmers' needs and, as a result, the upgraded facilities were either left unused, or physically removed by the farmers (Tabbal et al, 1987). Likewise, a study of rehabilitation in Sri Lanka indicated that the physical solutions to water distribution provided through a rehabilitation scheme did not prove to be effective and did not result in improved management of the irrigation system (Murray-Rust and Rao, 1987). Furthermore, our knowledge of the potential to improve low-performing irrigation systems through improved management to achieve significant, sustainable production benefits is inadequate, and the possible trade-offs between infrastructure and management improvement are not understood sufficiently.

3. FACTORS AFFECTING UPLAND CROP CULTURE IN RICE IRRIGATION SYSTEMS

A growing body of literature on the needs and means for diversifying crop culture in irrigated rice production systems is becoming available. However, many of them have tended to look into the issue from the top, assuming that crop diversification must be pursued, and discussed means to support it. While this approach may be useful in certain situations (eg, where government directives on cropping become binding on the farming community), it seems more important to understand well the farmer's decision-making process regarding the choice of crops. In particular, it is important to clearly identify and analyze the roles of the external forces - socio-institutional and economic - and resident physical features or limitations at the farm level that dominate farmers' decision-making. Few research undertakings have focused integratively on these issues.

Some upland crops are known to give much higher return than rice in the Philippines (Table 3). Yet, rice is the overwhelmingly preferred irrigated crop in the dry season. This implies the complexity of farmer's decision-making process in which his perceptions and experience with risk, market limitations, resource constraints, etc., play vital roles. In some other situations, such as in Indonesia, the profitability of rice is higher than for other food crops (Altemeir et al, 1987) and farmers' choice is mostly guided by the availability of water.
The model in Figure 4 indicates the factors that seem critically important in the farmer's choice of a dry season drop - whether it is rice or an upland crop. The order of priority of these factors will probably vary from farmer to farmer, depending on his knowledge and

perception of how critical a given factor is in relation to the biological performance of and economic returns from the crop under consideration. It can be assumed that as a farmer gathers more experience with the process dealing with a choice among several upland crops, he would have to consider fewer variables. The interactions of these variables, as shown in the figure, render the process quite complicated, and are illustrative of the difficulty faced by farmers in the right choice of crops.

3.1 Farmer's crop choice - physical factors

The choice of crop between rice and upland crops for the dry season may depend on many factors, but the following are considered most important:

1. *Soil texture and drainability* Heavy clay soils, which are mostly chosen for developing rice irrigation systems, are suitable for rice but largely unsuitable for upland crops. Because of low drainable porosity in these soils, upland crops grown in them may suffer from lack of oxygen, especially when the soil is saturated.

Low internal drainage capacities render heavy clay soils difficult to manage: they become too hard when dry and, in the case of montmorillonitic clay, they crack widely when dry. Proper land preparation becomes more difficult because of these properties. Thus presence of heavy clay soils is a decided physical limitation to growing upland crops. Most of these limitations can be more or less overcome by managing irrigation water very carefully and providing drainage ditches (surface or subsurface) to improve the soil's internal drainage capacity, but these measures are not cost-efficient in most situations.

2. *Irrigation status* There is a minimum supply needed to grow a decent upland crop. If such a supply has been lacking in the past, farmers would be reluctant to try to grow upland crops and risk their investments in land preparation and use of initial inputs in seeds and fertilizers. Strangely, as mentioned earlier, the reliability of water supply may also work in the opposite direction, as seen prevalent in most rice irrigation systems. Farmers may decide to grow rice in areas which have a relatively greater degree of water supply reliability. The influence of

strong interactive roles of some other factors are perhaps responsible for such decisions.

If a farmer has access to a supplementary source of irrigation water, such as a shallow tubewell and a pump set to lift groundwater, his risks of yield loss from water stress is minimized and he is better able to make a crop selection to exploit the market opportunities.

3. *Landscape position and surface drainage capacity* If the farm is located at the bottom of the toposequence and has no natural outlets for removing excess water, it suffers from the risk of getting inundated or temporarily waterlogged from heavy rainfall or excess irrigation in upper farms. Such lands may also be close to the groundwater table at the end of the wet season and remain in excess water conditions too long to be suitable for upland crops.

4. *Influence of neighbours' farming status* A farmer usually feels unsafe to try to grow his small area to upland crops if his neighbours are growing rice. (The same concern is there for rice surrounded by fallow lands.) There is the genuine fear of suffering excess water problems due to inflow of seepage water from adjacent rice plots. Although such excess water can be intercepted and drained away from the crop field if the surface drainage system is effective, such a method involves extra cost. Another reason for feeling unsafe is the possibility of finding the crop field out of phase with neighbouring areas and becoming easy, concentrated targets of insects and disease organisms, and of farm animals of the locality. Fear of major rat infestation in isolated plots is often a dominant reason for deciding to go along with neighbours.

5. *Seasonal rainfall* In many instances high rainfall during critical times badly damage the upland crops. For example, in the Philippines, mungbean farmers are afraid of rainfall at the flowering time and onion farmers wary of excess moisture at the bulb formation period. Late-season rains, i.e. rains in the beginning of the dry season, can damage freshly-sown upland crops, or delay the sowing because of lingering excess moisture condition of the soil and consequent lack of soil tilth for land preparation. This problem is greater in heavy-textured soils. For certain upland crops, for example wheat in Bangladesh, the late-sown

crop is adversely affected by higher temperatures at the reproductive and grain-fill time in the month of March or April. These distractors divert farmers' interests from upland crops to rice, for the sake of lower risks and higher stability of production and income.

3.2 Farmers' Crop Choice - Socio-economic Factors

1. *Family needs for rice* Many farmers grow rice in the dry season to be able to meet the family needs. Growing one's own staple food is often considered a wise strategy and a less risky one, even though more incomes might be possible if other crops are grown. Generally, the smaller the farmer's resources base, greater is the security he seeks with respect to choice of a crop. Therefore, farmers who have already produced adequate amount of rice in the wet season to meet the family needs are likely to be more attracted to growing non-rice crops in the dry season.

2. *Economic incentives* Farmers respond quickly to strong and steady economic incentives offered by crops. In most situations, even if the incentive exists, it is erratic. A successful program of replacement of rice with upland crops in a Taiwanese irrigation system aimed at reducing the national rice surplus level had the following major program of incentives for several years: (a) 1.0 ton of rice to be given to the farmer for each hectare of rice area shifted to corn, sorghum, soybean, or sugar cane; (b) 1.5 tons of rice given for each hectare of rice area shifted to vegetables, fruits, aquaculture, or fallow (Wen, 1977).

Factors that hamper the provision of economic incentives to the farmers are: price fluctuations, inadequate infrastructure for marketing, lack of market information, and lack of proper post-harvest processing and storage facilities. Most upland crops have limited markets and their prices are highly sensitive to production levels. Adriano and Cabezon (1987) showed the pattern of relationship between over-production and price decline for several crops in the Philippines. Producers of upland crops with limited markets have to be lucky to do well in consecutive years, because a season of favourable price is often followed by a season of overproduction and lower price. Such a speculative market may prove to be too much for many small farmers.

3. *Production costs and credit availability* Cash input costs of non-rice crops are usually higher than those of rice. For some high-value crops such as tobacco, garlic, onion, etc , the labour and seed costs are very high. Small farmers have difficulty in mobilizing the needed resources without easily-available credit. In most situations institutional credit is either inadequate, or not available to small farmers, and privately borrowed money is too expensive. These factors discourage resource-poor rice farmers to grow diversified crops and encourage them to stick to rice. In northern Bangladesh, which is the most important irrigated wheat-growing area in the country, many farmers have recently abandoned wheat culture in the dry season (many of them have shifted to rice culture) because of various reasons including the unavailability of institutional credit (which compels the farmers to borrow from private money lenders or sell their wet season rice immediately after harvest when the market price is the lowest in the year) and the low wheat price at harvest time.

4. *Agronomic knowledge* A rice monoculture for many years may create a lack of adequate knowledge and skill among farmers that is needed to grow good upland crops in the irrigated conditions. Such a deficiency may interact strongly with some other problems of upland crop production, resulting in continued disinterest in upland crops.

5. *Land tenure* The farmer's crop choice may be affected by his land tenure status. A tenant farmer usually does not make the choice entirely by himself and he may be directed by the land owner to grow a certain crop. A tenant farmer or a lease-holder is often not eligible for institutional credit, where such credit is available. The output sharing system may also discourage him from trying to grow upland crops which will require more labour and other cash inputs. On the other hand, there are examples in certain areas (eg, certain portions of the Upper Talavera River Irrigation System, Philippines, and of the Manuengteung Irrigation System, West Java, Indonesia) where relatively better-off land owners rent out the farm in the dry season in small parcels to the landless or poor farmers to grow high-value crops such as onion, garlic and chilli which require intensive labour inputs. In the Indonesian case, the land-owners are often found to grow rice in a part of the farm for their own domestic consumption.

6. *Farmer organization* In areas where farmers are better organized to share irrigation water supplies, the adoption of upland crops is potentially higher. This is because without farmers' cooperation water sharing among all needy members is difficult to achieve when irrigation water is in short supply. Mutual cooperation among the water users is especially critical in growing high-value upland crops which require high investments. In the UTRIS case, several farmer groups, each representing the service area of one turnout or offtake served directly by the supply canal, have organized a federated association to establish a fair allocation of water to different turnouts when the canal supply is low.

4. CONCLUDING COMMENTS

Providing options to farmers to grow more upland crops in the dry season within rice irrigation systems should be a major strategy to increase farmers' income and avoid overproduction of rice in countries where rice self-sufficiency has already been achieved. To promote wide adoption of upland crops, it may not be necessary to redesign, upgrade or rehabilitate functional rice irrigation systems, on the untested assumption that they are inflexible and unsuitable for the alternative crops. Drainage improvement however may be required in many such systems because upland crops are highly sensitive to excess water and rice systems are known for their inadequate drainage provisions. Additional irrigation facilities that would often be needed on the farm for most upland crops are seasonal and these can be adequately handled by the farmers themselves.

The oft-made proposition that qualitative improvements through redesign and/or rehabilitation of functional rice irrigation systems would yield significant and sustained rice production increases deserves in-depth assessment. Adequate and convincing evidence of the success of this approach is still lacking. Similarly, our knowledge of the appropriate forms of irrigation system management improvement that will (a) be sustainable, and (b) generate high water use efficiency and crop production benefits, is inadequate. Therefore, irrigation investment strategies based on the assumptions that qualitative improvements made in existing irrigation systems could substitute for the need to develop new irrigation infrastructure in South and Southeast Asia, where population growth rates and hence, demand for more food production remain high, need careful assessment.

Rehabilitation of irrigation infrastructure in systems which suffer impaired functionality should be carried out to improve their production potential, regardless of whether upland crops should be grown or not. However, the requirements of field level improvements must first be established adequately and the rehabilitation activities designed accordingly to ensure a successful program. Farmers' participation in identifying the field needs is found useful in rehabilitation programs.

In formulating strategies to popularize adoption of upland crops in the dry season, augmentation of irrigation water supplies exploiting groundwater or additional surface storage should be seriously considered. It is recognized that heavy clay soils, which are prevalent in rice irrigation systems, have major physical limitations to growing upland crops and therefore the emphasis of crop diversification should be given to the favourable areas with light-textured soils.

Important factors that influence farmers' decision to switch from irrigated dry season rice to non-rice crops include soil texture and economic incentive. Whereas the soil texture can not be changed and physical manipulations on the farm to improve soil drainability are too expensive for small farmers, economic incentives through effective policies related to post-harvest processing and storage, market infrastructure development, price stabilization, price guarantee, institutional credit, etc., should receive major emphasis. Without improvement of the socio-institutional and economic environments in which farmer communities operate, it is doubtful that physical infrastructural improvements through rehabilitation will achieve the desired goal of crop diversification.

Most rice farming in the developing Asian countries is based on a mixed system of modern and traditional cultivation practices on small land holdings. The prospects of crop diversification on these farms are enhanced when short-duration modern rice varieties are adopted, because it releases more time for growing non-rice crops as a second or a third crop. In rice-deficit countries, farmers' income enhancement opportunities are likely to be more in growing a third crop (non-rice) than shifting from irrigated dry season rice to non-rice crops. The third crop has to be grown mostly using residual soil moisture and research is needed to explore large-scale use of this option.

If technological breakthroughs are not made in the near future, rice production increases needed to meet the demand from continued population growth rates in the developing countries will have to come from incremental gains possible through further improvements in rice varieties and innovations in resource management techniques. Irrigation water will remain the most critical input for these gains to be practically achieved. There is major concern now how well the rice production gains achieved so far can be sustained over the long run and how rice production systems can be safeguarded from the environmental degradation processes that are unrelated to rice culture as well as those that may be associated with irrigated rice culture. This aspect needs most serious research and development attention. There is a clear need to develop water-conserving rice technologies that would not sacrifice yield potentials. Crop diversification prospects will be brighter if such technologies are available and widely used in irrigation systems.

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Table 1: Compound growth rates of net irrigated area in Asia

	Growth rate (%)				
Period	SE Asia	S Asia	China	Korea	Near East
1965-69	0.9	2.7	2.9	7.3	1.7
1970-74	4.0	1.9	2.9	3.1	0.4
1975-79	3.0	2.2	0	6.2	0.7
1980-84	2.1	1.0	0	0.8	-0.8
1965-84	2.5	2.1	1.2	2.5	-0.3

Source: Levine et al, 1988

Table 2: Average annual lending and assistance for irrigation in South and South East Asia by four major agencies, constant 1980 prices (million $)

	S E Asia					S Asia				
Period	WB	ADB	USAID	OECF	Total	WB	ADB	USAID	OECF	Total
1969-70	-	35	-	6		-	18	-	0	
1971-73	-	61	-	7		-	8	-	0	
1974-76	319	52	-	16		349	32	-	0	
1977-79	467	134	-	29		514	85	-	4	
1980-82	237	153	17	31	438	651	100	54	15	820
1983-85	147	87	5	59	298	533	74	68	10	685
1986-87	88	96	9	18	211	317	48	29	3	397

Source: Levine et al, 1988

Table 3: National average yield (t/ha), actual price (in Philippine pesos* per kg), and relative profitability (pesos/ha) of various crops, Philippines, 1985

Crops	Yield	Price	Total returns	Cost of production	Net returns	Return/ costs**
Sugar cane	533.13	0.22	11689	10435	1254	12.0
Rice	2.40	3.24	7776	5370	2406	44.8
Corn - yellow	1.04	2.80	2912	2078	834	40.1
Corn - white	0.97	2.91	2823	2078	745	35.8
Soybean	0.99	7.30	7227	3697	3525	95.3
Sweet potato	4.62	1.76	8131	2245	5890	262.4
Mungbean	0.69	15.40	10626	3780	6846	181.1
Peanut	0.85	10.10	8585	6959	1626	18.9
Onion	6.66	11.53	76790	30207	46583	154.2
Garlic	2.46	33.44	82262	21787	60338	276.9
Tomato	8.36	4.10	34276	9305	24971	268.4
Cotton	1.01	14.05	14191	6324	7866	124.4

* Philippine peso 20.43=$1.00
** Per cent returns to cost of production; Bureau of Agricultural Economics, 1985.

Source: Adriano, M S and Cabezon, V E, 1987

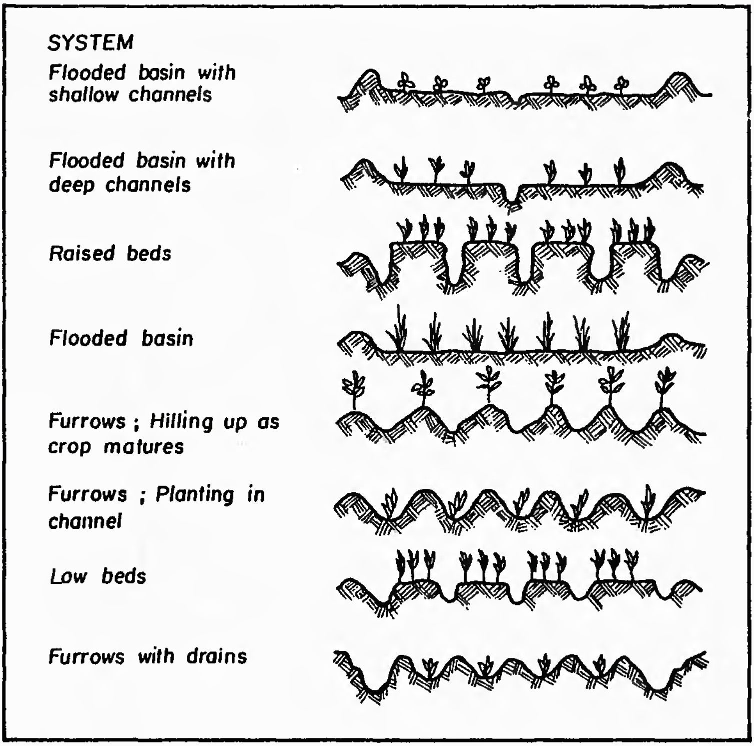

Fig.1 . *Methods used to apply and distribute irrigation water for dry season crops (Indonesia)*

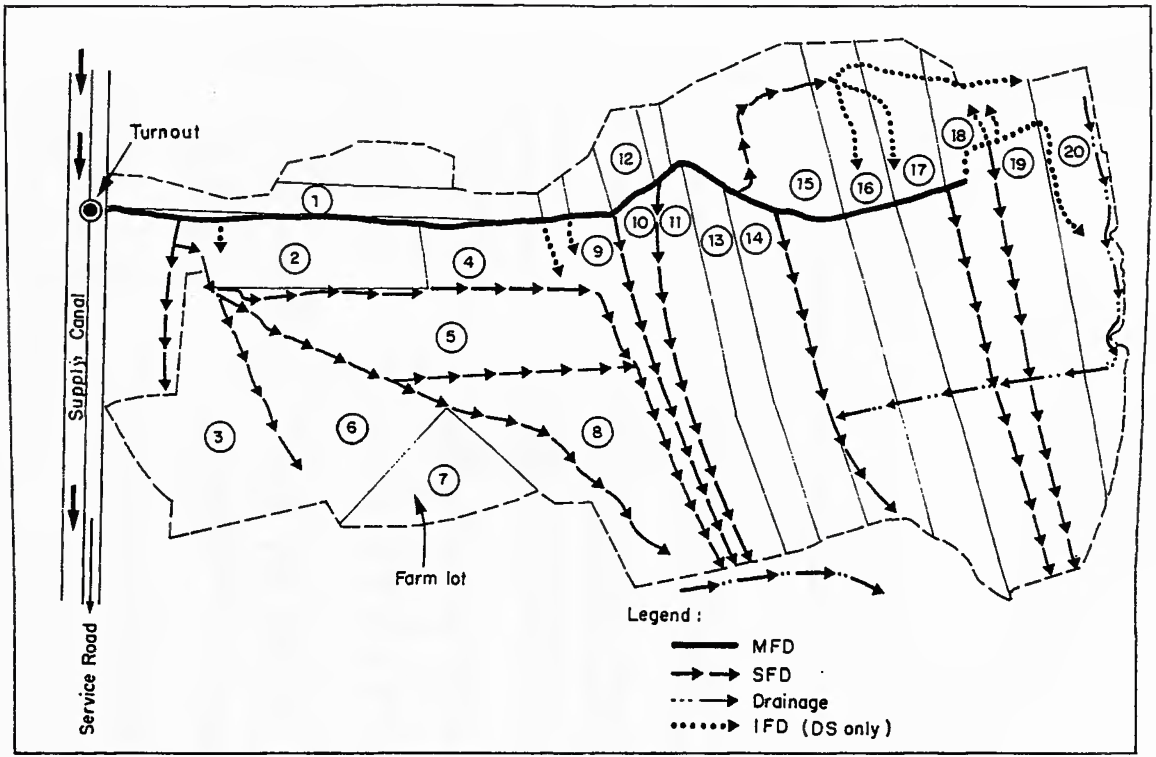

Fig. 2. A typical turnout service area (30-60 ha) in the Upper Talavera River Irrigation System, Philippines, showing water distribution facilities for rice (WS) and onion (DS). Additional seasonal (DS) on-farm facilities are shown in Fig. 4.

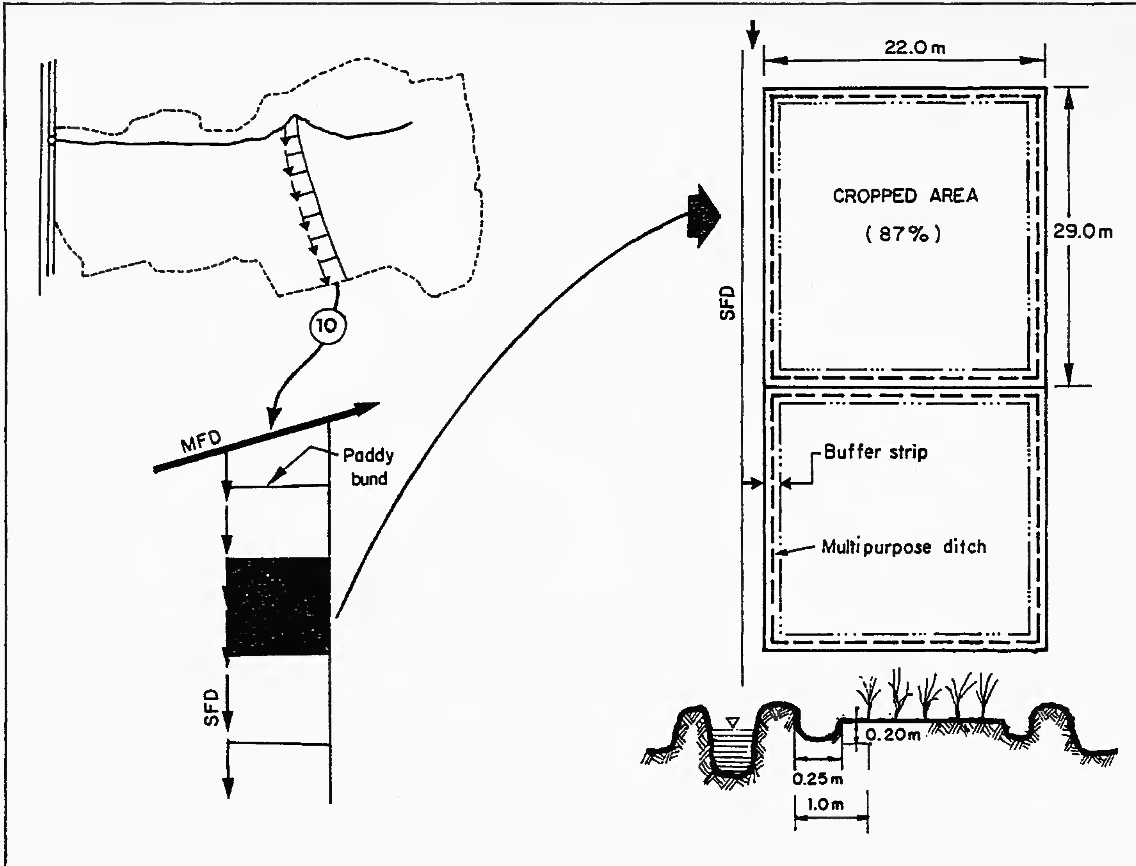

Fig. 3 Typical internal plot-level seasonal facilities developed by farmer for irrigation and drainage control in onion plots

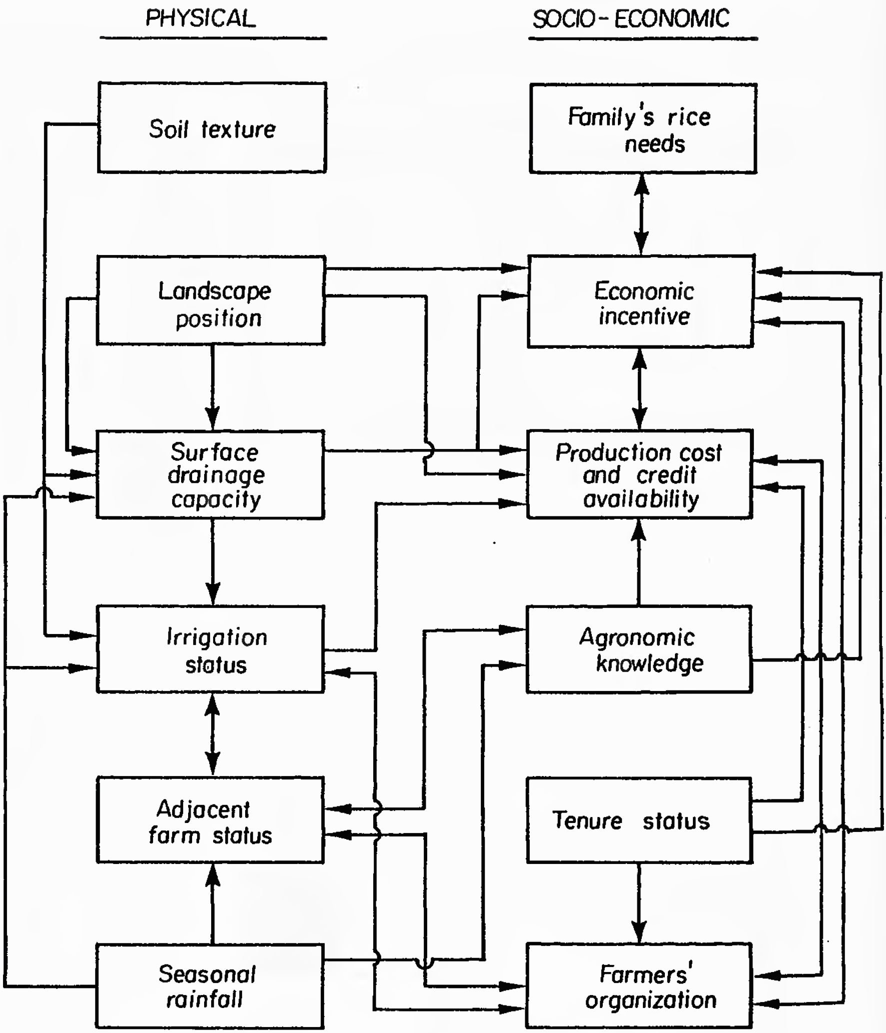

Fig. 4. Model showing different physical and socio-economic factors that affect farmers' choice of crop in dry season, and their interrelationships

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IRRIGATION MANAGEMENT NETWORK

NEWSLETTER

ODI/IIMI Irrigation Management Network Paper 89/2a December 1989

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.

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CTA

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NEWSLETTER

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NEWSLETTER

1. NEWS FROM THE EDITOR

As the new Research Fellow responsible for the Irrigation Management Network, I would like to take this opportunity to introduce myself, and tell you about some of the research interests I myself will be developing at ODI. My academic background is in geography and hydrology, but my work as a lecturer at the School of Development Studies, University of East Anglia, has given me both a range of practical consultancy and research experience in water resources development, and an appreciation of the wider issues of theory and policy in rural development. I hope therefore, I can continue to promote discussions and Papers on themes relevant to the interests of members, as well as continuing to encourage the debates between disciplines and interests in irrigation which are a key focus for ODI.

My own research focus will be evolving within the overlap of three irrigation issues; groundwater development and management, decentralisation, and irrigation in semi-arid areas. I have a particular interest in the development problems of irrigation in water-scarce and technically challenging environments, having worked in hardrock areas of central India, and the mountains of the Yemen Arab Republic. So, please contact me if you also have interests in this area.

Mary Tiffen will continue to spend part of her time working on irrigation, but I will be looking after the Network, so please direct Papers and correspondence to me from now on.

The Network also has new support staff. Amanda Barton is replacing Jyoti Bardwaj. We would like to thank Jyoti for her help in developing Network activities.

Linden Vincent

2. NETWORK PAPERS FOR DISCUSSION

The four Papers presented cover a number of themes regularly presented in this network; modernisation, farmer participation, technology policy and water charges. The Papers by Vermillion, and Levine and Coward raise complementary questions on equity and local knowledge, and their use in designing and modernising irrigation schemes. The Papers by Morton and Asaduzzaman reflect different aspects of tubewell development in Bangladesh, and Morton's paper joins that of Vermillion's in raising questions on the adequacy of design procedures in defining, for example, land capability for irrigation, and for calculating farmers' water needs.

Paper 89/2b, by Gilbert Levine and Walter Coward, *Equity Considerations in the Modernization of Irrigation Systems,* presents a critique of equity questions raised by irrigation schemes, focusing on issues relating to water allocation. They show how these concepts of equity can vary in space between different social groups, and over time, as the value of water changes or the social milieu itself changes. These concepts of equity result in different water distribution requirements, thus affecting structures, manpower and data collection needs. Differences in perception of what is, and what delivers, 'equity', between farmers and designers/managers are often the cause of poor performance and poor relations in irrigation schemes. Modernisation projects should study whether they are requiring, or enforcing, changes in concepts of equity, when changing the production environment or water distribution system. The authors provide a methodology for incorporating equity considerations in design decisions which should be read by all Network members involved in rehabilitation. It also seems a methodology relevant in the design of new schemes.

Douglas Vermillion provides paper 89/2c, on *Second Approximations: Unplanned Farmer Contributions to Design.* Using case studies from Indonesia, Vermillion studies the changes which irrigators made to a water distribution system, the ideas behind these changes, and then classifies these 'redesign criteria'. He then compares these 'farmer criteria' with conventional design criteria to show if they are compatible, incompatible or additional criteria. The paper shows that farmer participation is highly relevant to the design process, not just to 'social aspects', and illustrates by practical example several of the issues raised by Levine and

Coward. Vermillion suggests that we should have feedback systems in design that enable us to learn from farmer experience. The editor agrees and would like to say that the criteria defined as 'incompatible' or 'additional' are not impossible for engineers to use. They rather reflect the standardisation of procedures of design that fail to allow for local variations and needs in the first place. The known weaknesses of standard design procedures for defining land capability, or drainage and seepage calculations, are also reflected among the 'additional' criteria developed by farmers. Can we have some feedback from Network members on local design criteria, how to find out about them, and keep up the debate on how to make standard design procedures more flexible?

Paper 89/2d is by James Morton on *Tubewell Irrigation in Bangladesh*. It provides a critique of theories for the poor performance of tubewells in Bangladesh, and proceeds to focus on two issues. Firstly, Morton examines the relationship between variability in performance and the physical environment served. Secondly, he examines the effects of subsidies on well costs and thence on area irrigated, and also the way such a relationship affects the costs of water sold. Morton then shows how both of these are important in defining a strategy for the replacement of shallow tubewells by deep tubewells. We suspect that Morton's paper may be controversial to designers of pumping requirements, to those studying water markets and officials trying to operate zoning policies in Bangladesh or elsewhere. Please send in your own findings on these issues.

Paper 89/2e by M Asaduzzaman reports on the *Irrigation Charges in the Barind Integrated Area Development Project: A New Approach*. This paper describes procedures for recovering irrigation charges, and their use in covering recurrent costs, which have been developed in this project as a consequence of discussions in these Network Papers. The features which have made the experience of the Barind project different from other irrigation programmes in Bangladesh include clear statements of responsibilities, a mixture of incentives and penalties, and above all prompt service and maintenance that farmers can equate with charges paid. We have kept details in the paper on agreements between the farmer and the project as an illustration of relationships needing to be established. We do not have a discussion of the processes by which these major changes in ideas on cost recovery were achieved. The editor would like to hear of any studies which help us to analyse better how individuals interact with their environments to effect change.

3. NETWORK DEVELOPMENTS

With so many new staff in post this autumn, some work has been unavoidably delayed. The new Register of Members will be circulated Spring 1990.

We will be launching an Africa-focused Newsletter and set of Papers in 1990, and are now compiling our mailing list. We plan that the first African Newsletter will be mailed in February. For financial and administrative reasons we cannot send all three sets of Papers per year to all Network members, so we are proposing the following arrangement. All current members will continue to receive the two 'general' Newsletters and sets of Papers per year. These Newsletters will carry details of material in the Africa set, which members can send for; key Papers from the African material will also be reproduced. People listed for the African Newsletter will receive the 'African' set and both the 'general' sets, i.e. 3 sets of Papers per year. These three sets will be sent automatically to all Network members with addresses in Africa, *who do not need to fill in any additional form. If you are not resident in Africa, but have good professional reasons for wanting to receive the Africa-focused papers, please fill in the form enclosed.*

4. NEWS FROM IIMI

IIMI's five year work plan and strategy, and several new projects, were among the topics tabled at the 28 October meeting of IIMI's Support Group. The Support Group meets in Washington D.C. every October to consider the Institute's accomplishments and plans, and to make funding pledges for the following year, in this case 1990.

David Bell, IIMI Board Chairman, briefed the Group on the shift of IIMI's Headquarters in August from Digana Village to Colombo. The move was necessary, he said, to improve IIMI's communications systems and to assess serious operational difficulties caused by recent unsettled conditions in Sri Lanka. However, the transition has now been completed and all operations were functioning smoothly. As to the Institute's progress, Bell remarked that IIMI, though a young organisation, had established research activities in ten countries, developed a clear strategy and enacted an organisational structure to implement the strategy. Research, he said, was now starting to yield substantive results.

The Chairman also announced five IIMI new Board members for 1990: Ms N. Al-Shayji from Kuwait, Mr Robert Rangeley from United Kingdom, Dr M. S. Swaminathan from India, Mr Zaki Azam from Pakistan, and Dr Tsutsui Hikaru from Japan.

Dr Roberto Lenton, IIMI's Director General, followed the Chairman with a briefing on the Institute's progress since last year's meeting. Referring to the 1988 Annual Report, the Director General commented on several recent publications, including a synthesis of lessons learned from research on irrigation management for crop diversification, a set of case studies on irrigation financing, results from a study on internal decision-making in Sri Lankan irrigation organisations, and the culmination of studies in various country operations. (Further information on IIMI publications is available from Francis O'Kelly, Head, IIMI Information Office, Box 2075, Colombo, Sri Lanka.)

Dr Lenton said IIMI concluded several important projects during 1989 including a study on crop diversification in rice-based systems; two projects in Indonesia, one which investigated the match between water demand and supply, and another which looked at improved methods of turning over management responsibilities to farmers in small systems; and a study of the efficiency of farmer managed systems in the hills of Pakistan.

Among IIMI's new ventures, Dr Lenton singled out a major initiative on performance definition and quantification, a large project on the prevention of water logging and salinity in Pakistan and a training needs assessment in Malaysia.

Charles Abernethy, the Director of IIMI's Program Division, concluded IIMI's presentation with a series of slides summarising IIMI's 1990-94 Work Plan. Mr Abernethy said IIMI proposed to increase international staff strength from 35 in 1990 to 60 in 1994. It was proposed that staff continue their work in Sri Lanka, Pakistan, Indonesia, Philippines, Bangladesh, India, Nepal, Morocco, Sudan and West Africa, including Mali, Niger, Senegal, Burkina Faso and Nigeria. Towards the end of the five year period, Abernethy said IIMI hoped to initiate new country programs in Mexico, Egypt and China. To accommodate the increased effort, the plan proposed an increase in IIMI's budget from roughly $9 million in 1990 to almost $16 million in 1994.

The Director General added IIMI's past overall growth rate, coupled with prospects for increased funding from new and existing donors, gave IIMI the confidence to make these ambitious growth projections.

Several Support Group members paid tribute to IIMI's continued performance, and the quantity and quality of research, under difficult circumstances. Other members commented on IIMI's success in bridging the gap between national departments of irrigation and agriculture through collaboration in research.

5. NEWS FROM NETWORKERS

Networkers may be interested in a new brochure entitled *Technology Information on Water Resources* which began in 1988, published by NADLIN (National Documentation Centre Library and Information Network), Pakistan. This reports on developments in water technology and consultancy services marketed by companies in developing countries. Countries reporting are Brazil, China, Egypt, India, Kenya, Mexico, Pakistan, Peru, Philippines and Zimbabwe. So far 4 issues have been published. NADLIN are also producing *Water Resources Abstracts,* which will cover international material as well as information on Pakistan. To obtain these publications write to Nuzhat Yasmin, NADLIN, PO Box 2313, Islamabad, Pakistan.

Are you looking for appropriate and accessible technical manuals in hydrology? *HOMS (Hydrological Operational Multipurpose System)* is a new assistance programme developed by the World Meteorological Organisation, for the transfer of technical information on operational hydrology. WMO have developed over 400 useful components ranging from descriptions of equipment to explanations of analyses and computer programmes. Components include planning, network design, instrumentation, data storage and processing issues for all parts of the hydrological cycle, and also analyses relevant to economic evaluation of projects and their operating policies. The programme is being developed internationally through national HOMS offices. For details of the materials and your local HOMS office, write to: HOMS, Hydrology and Water Resources Department, World Meteorological Organisation, Case Postale No 2300, CH-1211 Geneva 2, Switzerland. UK Organisations can get information from the UK HOMS Centre at the Institute of Hydrology, Wallingford, Oxon OX10 8BB, (Telephone: 0491 38800. Contact: Howard Oliver).

A research Network on *Scarcity Water Management* is being initiated by the Water Technology Unit, Tamil Nadu Agricultural University. For more details, see the workshop on *Groundwater Use and Management in Low Rainfall Hard Rock Areas* discussed on page 15.

USAID have published a useful review of the work and achievements of its Water Management Synthesis II Project. It is called *Developing Irrigated Agriculture: A Socio-Technical Approach*. In addition to summarising their main programmes in Asia, Africa and Latin America, with their foci on design, management, diagnostic analysis, training and farmer participation, the report lists all WMS reports and videotapes. The two successor programmes are also described. These are ISPAN (Irrigation Support Projects for Asia and the Near East) and ISMAR (Irrigation Management Support and Research Project (focusing on Africa and Latin America, and on irrigated agriculture, interpreted broadly to mean various types of agricultural production that involve the use and management of water resources). The report is available from Dr L. Worth Fitzgerald, Bureau of Science and Technology, USAID, Washington DC 20523, USA.

Tony Garvey has been appointed Project Director of ISPAN, located at the Technical Support Centre, 1611 North Kent Street, Arlington, Virginia 22209, USA, Tel:(703)-243 7911. ISPAN provides services to bilateral projects being implemented in Asia and the Near East. Its initial work has been much concerned with monitoring and evaluation, in conjunction with regional and country organisations, to ensure programmes attain goals and are modified as necessary. Amongst the reports published so far are:

1. Indonesia, Facilitators' Report, SSIMP Second Implementation Workshop

2. Pakistan ISM Project Evaluation: Rehabilitation and Institutional Strengthening Components

3. India, Review of the Hill Areas Land and Water Development Project

5. Pakistan, Mid-Term Evaluation of the Command Water Management Project (2 volumes)

6. India, Evaluation of the Irrigation Management Training Component

7. Second Regional Irrigation Management Workshop, Kathmandu

15. Sri Lanka, Project Review Workshop for the Irrigation Systems Management Project

16. Nepal, Irrigation Management Project Midterm Evaluation Report

18. Egypt, Evaluation of the Structural Replacement and Project Preparation Unit Components of the Irrigation Management Systems Project.

To obtain a copy of any of these, write to Tony Garvey, briefly outlining the reason for your request.

ISPAN has also produced two fuller Studies. The first is the *Eastern Waters Study (1989)*, by Peter Rogers, Peter Lydon and David Seckler, one of several reports commissioned on strategies to manage floods in Bangladesh, which are to be reviewed at a meeting in London in December 1989, (the others being a UNDP study led by a British consortium, and French and Japanese studies). The second is *Medium Scale Irrigation Systems in Northeast Thailand: Future Directions (1989)*, by five senior Thai experts, Peter Reiss and Sam Johnson. This study raises important issues which will affect the operation and design of many other irrigation projects, such as the way the private sector is now expanding into activities previously carried out by the public sector, the critical importance of markets for non-rice crops, the role of water user associations, and competing water requirements within a river basin.

ISPAN is also moving into the training area. In addition to conducting a number of 'project start-up workshops', ISPAN has collaborated with EDI of the World Bank to produce *Guidelines for Preparing Strategies and Programs in Public Sector Irrigation Training*, (see page 27). The guidelines illustrate the process which can be used by irrigation agencies to develop comprehensive training programs based on clearly articulated agency goals and objectives and a training needs assessment (TNA). Using these guidelines, TNA is being undertaken by IIMI in Malaysia, and ISPAN is planning to collaborate with IIMI and EDI to assist similar efforts in Egypt, and possibly Pakistan and Morocco.

Operations Evaluations Department, World Bank, have carried out some very useful comparative impact evaluations of irrigation projects. In one case the comparison is between two Moroccan and two Mexican projects; a later study relates to projects in the Philippines and North East Thailand. It is hoped to bring these out shortly in blue covers - documents in the public domain. Because they follow a similar format, these documents provide a better basis for deriving planning lessons than previous World Bank Impact Evaluations, where each evaluating team seem to have had their own agenda. In particular, in these cases, the IRR some years after completion has been recalculated. The British ODA have also completed evaluations of two projects which it had supported, in Mauritius and Pakistan.

In 1986 Mary Tiffen completed a study commissioned by the UK Overseas Development Administration, which reviewed some fifty evaluations of irrigation schemes, to derive recommendations for the improvement of feasibility study planning. The main conclusions, that the IRR should not be the dominating criteria for project acceptance, since farm incomes and funding for operation and maintenance have a greater influence on project sustainabilty, and that projects must be designed to fit local circumstances as well as national needs, were summarised in Network Papers 87/1b and 87/3c respectively. The findings aroused a lot of interest, and Mary has also given a series of papers and seminars on the subject. She now intends to use the new material from the Bank, USAID and ODA to update her previous study, and to publish it complete with the ten detailed case studies on which it was based. The aim will be to bring out the lessons in a relatively condensed format, since most people will not have time to study the bulk of material now available, but at the same time, to provide sufficient detail to illustrate the salient points. The updating should be completed in the first part of 1990.

Mark Svendsen of IFPRI is working with IIMI on a framework and methodology for assessing irrigation performance. He is distinguishing 'performance indicators', which are internal to the organisation, and 'impact indicators', which link irrigation to external systems. He is also working on a typology of irrigation systems. A small workshop, to be hosted by Hydraulics Research, Wallingford, is being held in February 1990 to discuss the preliminary drafts.

After the 1987 Casablanca meeting the International Commission on Irrigation and Drainage (ICID) asked the World Bank to take an initiative to enhance technological research efforts relevant to developing country needs. Preliminary studies and discussions took place in 1988 and 1989. These led up to a study aimed at an analysis of the present status of irrigation and drainage research, identifying gaps, and presenting alternative scenarios for the structure and functions of organisations which could support an international research programme. The study was authored by W. R. Rangeley and W. Field and supported by the Bank and the UK ODA. It identified needs particularly in the control of water logging and salinity, in maintenance problems and methods, and in the adaptation of modern technologies to the needs of developing countries. In addition, there is an area, the interrelationships of management and design, which overlaps with IIMI's concerns. The relationship between IIMI and international research in the technological field is one aspect of the alternative scenarios; relationships with the CGIAR system is another. There will be further meetings early in 1990 to consider next steps. For further information contact Guy Le Moigne or Hervé Plusquellec, at the World Bank.

6. CONFERENCES

CONFERENCE REPORTS RECEIVED

International Conference on Irrigation Theory and Practice, 12-15 September 1989, Southampton, United Kingdom.
Some 300 people attended this conference to celebrate 25 years of irrigation studies at the Institute of Irrigation Studies, Southampton University. Over 85 papers were presented, relating to virtually every dimension of irrigation, by a wide diversity of irrigation officials and representatives, researchers and consultants. Areas of discussion included: assessing crop water requirements; design details; the use of computers; upgrading existing technology and infrastructure; water conveyance and distribution; drainage projects; mini-project technology; farmer participation; institutional deficiencies; health issues; environmental impact and operation and maintenance issues.

The major implications of these papers were that the era of new project development is passing, so that existing resources must be better utilised and marginal resources developed. Performance and financial problems are forcing turnover, or improvements in cost recovery. Operation and maintenance issues are getting better emphasis, but infrastructural deficiencies, (from design, funding and construction problems) persist and are widespread, as are weaknesses in conceptualising training and management needs to overcome these deficiencies.

Despite the impressive array of topics discussed, the irrigation community represented were still in a self-critical mood, and quite sombre on issues of gaps in design and financial planning, and the magnitude of modernisation needs. The audience agreed the need for definition of better methodologies and case studies on all the items mentioned in the first paragraph, and also pointed out some important gaps in the coverage. These included: field training needs (the engineers who aren't trained to operate), weather prediction and climatic change, pollution, environmental constraints of the future, the failure to look really into the future, (the '7th generation' view), and competition and reallocation pressures on water resources. More fundamental still was the gap of remembering why irrigation is being developed, with no paper covering the issue of poverty reduction.

Nevertheless, this was an impressive set of papers, and very impressively organised. The papers are available as a book *Irrigation Theory and Practice*, edited by J. R. Rydzewski and C. F. Ward (1989), available from Pentech Press, price £79 ($142). This high price puts it beyond individuals, but this would be a valuable book for any library, as it represents a "state-of-the-art" collection of papers. For more information write to: Alison Thomas, John Wiley & Sons Ltd, Baffins Lane, Chichester, West Sussex PO19 1UD, UK.

Workshop on Groundwater Use and Management in Low Rainfall Hardrock Areas, 4-6 October 1989, Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, India.
This workshop, organised by the University and the Ford Foundation, drew participants with interests throughout the dry areas of central and southern India. Twenty two papers were presented covering both technical and socio-economic issues in groundwater development, as well as more general studies of aquifer parameters and watershed management.

Papers were presented over six sessions which covered historical perspectives, current policies, case studies and approaches. With the discussion of current policies, it was still felt that the problem needed better discussion of what policies have been tried, a critique on the processes by which they are implemented, and how poor people benefit from them. It was also important to think of the variability of management needs of groundwater in relation to resources available, and the presence of tanks or canals in the vicinity. Hardrock areas need much more reliable resource data, and better financial costings of development.

A wide variety of case studies were presented, covering technologies of extraction (dug wells, tubewells, dug-cum-bore wells, percolation tanks), financial assistance with costs (banks, NGOs) and studies of farmers' conceptualisation of groundwater availability and types of well. An immense amount of information was presented, which showed that while some themes could be generalised, we had to pay very careful attention to different management needs and the impact of groundwater depending on what other sources of water were available. Robert Chambers summarised issues under '3Ds' - data, diversity and decentralisation. All the case studies showed the problem of finding out 'the truth', emphasised the variability of conditions so that standard designs (and related standard policies) were hard to develop, and thus led to the question of to what extent decentralisation could solve problems of investigation, analysis and action.

The 'approaches' section looked particularly at water harvesting and water saving irrigation methods, where issues of diversity of findings and impact again came to the fore.

The participants then split into discussion groups on: improved methods of data collection, analysis and dissemination; innovations in water saving; equity issues; costs of groundwater development, credit and subsidy; watershed-based planning and management; conjunctive planning and management of surface and groundwater. The discussion summaries give an excellent overview of what the current critical issues are, for research on groundwater in dryland India, and in turn, the scale of research needed if groundwater development is really to achieve the role scheduled for it in achieving both production and equity goals.

The workshop papers will be initially published as working papers of the Water Technology Centre, and the discussions of papers have been assembled as *Recommendations of the Workshop*. These can be obtained from: P. Kandaswamy, Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore 641003, India. The Water Technology Centre is initiating a research Network on *Scarce Water Management*. This Network will be collecting and disseminating information about related research, with the focus on Indian work or initiatives relevant to Indian conditions. If you are interested to join, write to Dr Kandaswamy at the above address.

Issues in the Development and Management of Groundwater Resources in East Uttar Pradesh, by Shashi Kolavalli, A. H. Kalro and V. N. Asopa (July 1989), draws upon material discussed at a workshop at the Narendra Development University of Agricultural Technology at Faizabad, India, arranged with the support of the Ford Foundation. The report considers reasons for the slower rates of development and utilisation of groundwater in eastern Uttar Pradesh (U.P), India, compared with western U.P, and asks how conjunctive use of groundwater and surface water can be promoted, and groundwater utilisation advanced. Eastern U.P provides technical and economic challenges in decisions about irrigation strategy. While well endowed with rivers, these bring flood risks.

While high water tables favour groundwater development, well development and operation costs may be hard to offset as supplemental irrigation is required in rabi only, and electrification has been slow. Surface water irrigation by canals has been the main strategy, but this has brought waterlogging and salinisation. The report concludes with a research agenda covering prospects for different kinds of groundwater development and the development assistance required; the influences of flooding, waterlogging and salinity on technology adoption and farm strategies, and reclamation of saline soils. The paper is published by the Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad, India.

Efficiency and Equity in Groundwater Use and Management by Vishwa Ballabh and Tushaar Shah (March 1989), provides an overview of the workshop on *Efficiency and Equity in Groundwater Use and Management*, discussed in the last Newsletter. The workshop was held in Anand, Gujarat State, India, organised jointly by the Institute of Rural Management and the Ford Foundation. The report summarises points on the general groundwater resource position in India, and then discusses key points for the Eastern-Gangetic region, the North-West region, and hardrock areas of the Southern Peninsula. Other sections cover institutional arrangements for public and community tubewells, legal issues in water organisation and groundwater markets. The report ends with an agenda for future research and actions recommended in these areas. It is available as *Workshop Report 3*, from the Publications Officer, Institute of Rural Management, PO Box 60, Arand 388001, India.

The conference on *The Role of Social Organisers in Farmer-Managed Systems*, May 15-20 1989 held in Khon Kaen Province, Thailand is reported in the latest edition of *TRIMNET (Thailand Research on Irrigation Management Network)*. Key sections of the conference included: defining 'farmer participation' and developing supporting policies for it; understanding alternative approaches to generating farmer participation; understanding the training and support needs of social organisers (S.O); appreciating issues of flexibility and sustainability of S.O programmes; institutionalisation of S.O. TRIMNET can be obtained from the Editor, TRIMNET, FPSS Project, PO Box 26, Khon Kaen University, Khon Kaen 40002, Thailand.

We have also received papers from the workshop on *The Role of NGOs in Minor Irrigation Improvement in Sri Lanka*, held 17 March 1989 in Digana, Sri Lanka. For more details contact M. H. S. Dayaratne, IIMI, Sri Lanka.

FORTHCOMING CONFERENCES

Land Drainage for Salinity Control in Arid and Semi-Arid Regions. February 26-3 March 1990. Cairo, Egypt. Contact: ILRI, PO Box 45, 6700 AA Wageningen, Netherlands, or Drainage Research Institute, Irrigation Building, 13 Giza Street, El Giza, Cairo, Egypt.

International Conference on Water and Wastewater. April 24-27 1990. Barcelona, Spain. The publishers of *Water and Wastewater International* are organising this conference for professionals in water resources development, including irrigation. For information write to: Conference Organiser, Pamela Wolfe, PO Box 125, Scotch Plains, NJ 07076, USA.

International Congress on Irrigation and Drainage. April 29-4 May 1990. Rio de Janiero, Brazil. For information contact: The Secretary, International Commission on Irrigation and Drainage (ICID), 48 Nyaya Marg, Chanakyapuri, New Delhi 110021, India.

International Symposium on Development of Smallscale Water Resources in Rural Areas. May 21-25 1990. Khon Kaen, Thailand. Contact: Carl Duisburg Gesellschaft, c/o Asian Institute of Technology, PO Box 2754, Bangkok, Thailand.

Infrastructure for Low Income Communities. August 27-31 1990. WEDC Conference, Hyderabad, India. For information contact: Professor John Pickford, WEDC, Loughborough University of Technology, Leics LE11 3TU, UK.

Water Resources in Mountainous Regions. August 27-1 September 1990. Lausanne, Switzerland. Details from Aurele Parriaux EPFL, GCBB (Ecublens), CH-1015, Lausanne, Switzerland.

International Seminar on Groundwater Resources Management. November 1990. Bangkok, Thailand. Details from Dr Asit K. Biswas, President, IWRA, 76 Woodstock Close, Oxford OX2 8DD, UK.

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Water for Sustainable Development in the 21st Century. May 13-18 1991. Rabat, Morocco. Contact: The Secretariat, VIIth World Congress on Water Resources, Administration de l'Hydraulique, Direction de la Recherche et de la Planification de l'Eau, Rue Hassan Ber Chekroun, Agdal-Rabat, Morocco, *or* Dr A. K. Biswas, President, IWRA, 76 Woodstock Close, Oxford OX2 8DD.

17th International Congress on Large Dams. June 1991. Vienna, Austria. Contact: International Congress on Large Dams, Secretariat, 151 Blvd Haussman, 75008, Paris, France.

7. TRAINING COURSES

Water, Engineering and Development Centre (WEDC), Loughborough University of Technology, Leicestershire LE11 3TU, UK. Diploma course from January 3-23 March 1990 on *Irrigation and Water Resources.*

The Institute of Irrigation Studies, The University, Southampton, SO9 5NH, UK, will run a short course on *Rehabilitation and Management of Irrigation Projects*, 21 May-28 July 1990. The course is run in association with Mott MacDonald International, Consulting Engineers, Cambridge. For details contact Mr. Martin Burton at the above address.

International Institute for Land Reclamation and Improvement (ILRI) are running their 29th International Post-graduate Course on *Land Drainage* (in English) from August 20-30 November 1990. For details write to: The Director, International Agricultural Centre, PO Box 88, 6700 AB Wageningen, The Netherlands.

CEFIGRE (International Training Centre for Water Resources Management), BP 113 Sophia Antipolis, 06561 Valbonne Cedex, France. Short courses will be offered on:
Rehabilitation et Maintenance des Perimetres Irrigues
May 28-15 June, Bamako, Mali.

Planning, Design and Implementation of Irrigation Schemes
September 24-19 October, Bangkok, Thailand.

Enseignement Intelligemment Assiste par Ordinateur (EIAO) dans le Domaine de l'eau, 19-30 November, Ouagadougou, Burkina Faso.

Write to CEFIGRE in France for details and for the full list of international training courses.

Mananga Agricultural Management Centre, PO Box 20, Mhlume, Swaziland (in association with Silsoe College, UK). 19-13 April 1990. *The Management of Irrigation Projects.* This four week course is for experienced irrigation managers and planners. Closing date for applications is 22 January 1990.

Centre for International Irrigation Training and Research, 217 Royal Parade, Parkville, Victoria, Australia 3052, will offer its six month course in *Irrigation Engineering Management*, June 18-23 November 1990, and 8 October 1990 - 22 March 1991. They also offer a Diploma course in *Irrigation Engineering* and a Masters course in *Irrigation Engineering Management.* For details write to Hector M. Malano at the above address.

Colorado Institute for Irrigation Management, 410 University Services Centre, Colorado State University, Fort Collins, CO 80523, USA, will be offering the following short courses in 1990. For details write to the Shortcourse Coordinator.

July 2-20, *Drainage for Irrigated Lands;* July 9-10 August, *Modern Irrigation Project Management;* July 23-10 August, *Modern Surface Irrigation Design and Management*; August 13-7 September, *Flow Regulation & Measurement in Irrigation Systems*; September 3-28, *Monitoring, Evaluation, Feedback and Management of Irrigated Agricultural Systems;* October 1-26, *Training of Trainers for Irrigation Management;* October 29-16 November, *Water Users Associations in Irrigation;* November 19-14 December, *Irrigation Systems Rehabilitation.*

International Institute for Civil Engineering, Colorado State University, Fort Collins, CO 80523, USA, will be offering short courses on *Microcomputer Applications in Irrigation Data and Project Management* from January 5-19 1990 and July 2-27 1990, and on *Microcomputers for Engineering Analysis of Irrigation Systems* from July 23-3 August 1990.

International Irrigation Centre, Utah State University, Logan, Utah 84322-4150, USA, will be running a variety of courses on irrigation during 1990, including: *Computer-Assisted Irrigation System Management,* January 7-15 December; *Waterlogging, Drainage and Salinity Control*, March 25-5 May; *On-Farm Irrigation Design and Evaluation*, May 6-16 June; *On-Farm Irrigation Scheduling,* June 17-7 July; *Main System Irrigation Scheduling,* July 8-28; *Farmer Participation and Irrigation Organisation,* August 26-15 September; *Instructional Methods and Products for Irrigation Training,* July 29-25 August; *Design of Wells and Pumps for Irrigation,* August 26-29 September; *Maintenance of Pumping System Components,* September 30-20 October; *Operation, Maintenance and Management of Irrigation Delivery Systems,* September 30-10 November. Some of these courses are in Spanish, as well as English.

8. NEW PUBLICATIONS

GENERAL

BOOK REVIEW ARTICLE

1. Robert Chambers, N. C. Saxena & Tushaar Shah, (1989), *To The Hands of the Poor: Water and Trees*. Oxford and IBH Publishing, Co. India ISBN 81-204-0428-9. (To be published by ITDG late 1989).

2. Bertin Martens, (1989), *Economic Development That Lasts: Labour Intensive Irrigation Projects in Nepal and the United Republic of Tanzania*. International Labour Office, Geneva. ISBN 92-2-106400-X.

3. Norman Long (ed), (1989), *Encounters at the Interface: A Perspective on Social Discontinuities in Rural Development*. Wageningen Studies in Sociology, 27.

These three books are all good examples of a rather rare commodity - studies which attempt to examine why we use irrigation in rural development, critically evaluate these policy interventions, and develop a framework for understanding why interventions go wrong. All too often, alas, we lose sight of these issues in a plethora of technical workbooks or generalised case studies.

To The Hands of the Poor by Chambers, Saxena and Shah concentrates on the potential of lift irrigation schemes (L.I.S), particularly groundwater, and of trees, to alleviate rural poverty in India, using Indian case study material. Although in the introduction and conclusions the authors seek to show the scope of water and tree programmes jointly in rural development initiatives, there is also a large section specifically on groundwater development, and also one on tree programmes. The book is extremely well written, in a style easy to read, with excellent abstracts at the beginning of each section. It also manages to provide very neat summaries of issues in phrases and tables which will be a bonus to fieldworkers and students. Meanings of poverty, (and escape from it) are studied through themes of 'survival, security and self-respect', and the potential of anti-poverty programmes looked at for providing land reform, asset provision and income and consumption support. The authors also take on considerations of practical political economy in studying the potential of different strategies to happen and effect change.

The practical development policies reviewed for L.I.S are: state tubewells, institutional and credit support, subsidies for resource-poor farmers, spacing and licensing norms, rural electrification and electricity pricing and management. However, the discussion focuses heavily on water markets and on electricity tariffs, with the authors strongly in favour of flat tariffs (to a decree likely to be controversial to proponents of other tariffs). Coordinated institutional support in power pricing, power management and support to resource-poor farmers is seen as crucial. However, the authors try to show that different policies have different potential for 'water abundant' and 'water scarce' regions.

The strength of this book lies in its summary of issues, but therein lies its one weakness. While the book has good case study material on 'water abundant' areas, and on the 'core' poverty area of India, it is less strong on the 'water-scarce' regions, and particularly some of the resource planning issues and high costs and risks of some groundwater development. Also, perhaps deliberately, it does not encompass a study of the kind of bureaucratic changes required to promote these beneficial interventions. We can only hope that this highly readable and informative book stimulates further policy debate and development initiatives that the authors can document in another book in the near future.

Special public work programmes (SPWP) have been used as development interventions in many countries. *Economic Development That Lasts* by Bertin Martens discusses SPWP projects funded by ILO in Nepal and Tanzania. The book first discusses the development of theory supporting the promotion of labour-intensive public works in developing countries. Three case studies are then used to test these theories, to show the kind of economic studies which should be used to test the viability of SPWP (and the weakness of existing methods), and finally to show the problems in developing SPWP and managing infrastructure installed. The case study in Nepal is Bhorletar in Gandaki zone, and in Tanzania the case studies are the Mnenia project in Dodoma region and Mto wa Mbu in Arusha region.

The book ends with a synthesis of findings in the areas of investment cost, construction technology, employment creation, popular participation, income generation and distribution, and sustainability and replicability.

This should be a useful book for planners involved with public works programmes, which all too often happen for pragmatic political reasons rather than the altruistic aspirations of the theory. The book shows that the 'self-help' ethos which some may associate with public works is neither that common nor that easy to develop. However, in the case studies the costs of the employment generated are outweighed by local and national benefits from the infrastructure, as the theory suggests, though not without some adverse local differentiation.

The book does not give detailed information of ideas on how to organise labour and budgets, or develop participation. However, through the case studies and conclusions it does demonstrate pitfalls in certain approaches and highlights important issues to be considered. Key points are made in the areas of funding, labour organisation, execution, equity, participation and sustainability.

Jointly the case studies provide an extremely useful illustration of the way failures to think about the balance of 'self-help' labour with wage labour, the methods of construction of primary and local structures, and about maintenance, have substantial effects on prospects for local participation and the sustainability of the project. The Tanzanian case studies also show the problems of declining labour productivity in an environment of inflation and currency depreciation. Equity concerns include differences between short-term and long-term beneficiaries, and differentiation as a result of the project and the wider effects of the expenditure on the locality.

The writer has made a commendable attempt to keep the text as simple as possible, while at the same time providing statistical and econometric studies to validate his work. The focus of the study is economic and social rather than technical: there is no sophisticated irrigation jargon, but a non-economist might need help in following up some of the statements relating to cost-benefit, exchange rates and shadow pricing. However, the book is written so that one can follow the arguments of the text regardless of specific detail.

Occasionally, the concise style of writing does make for difficult reading as points, facts or arguments are made in a series of short sentences. This seems mainly a problem with the Tanzanian studies, and may reflect what were clearly substantial problems in obtaining data and summarising it in a meaningful way. However, overall, it is an accessible and informative book.

Encounters at the Interface, edited by Norman Long, introduces the concept of an 'interface' to analyse interventions in the rural sector, with papers demonstrating this idea with extensive case study material on irrigation in Mexico. Long defines a 'social interface' as a 'critical point of intersection or linkage between different social systems, fields or levels of social order where structural discontinuities, based upon differences of normative value and social interest, are most likely to be found'. Long sees such a concept as useful in three urgent areas for research in rural development: (1) to develop a better analytical approach to understanding relationships between policy, implementation and outcomes; (2) to develop a sounder comparative analysis of the processes by which 'target' and 'non-target' populations respond to planned interventions; (3) to resolve serious theoretical gaps in the analysis of social change and rural development. Long's analysis of these three points is important, as is another theoretical paper by Jan Ubels on understanding irrigation development as an interactional process. Ubels summarises a number of important issues in irrigation literature, and suggests one conclusion from all of them - 'problems relate, not so much to the handling of the water itself, but to the ways in which people act and interact in response to the issues posed by the particular irrigation system'.

However, as Ubel points out, translation of this simple conclusion into concrete guidelines and concepts for the management of irrigation projects is often missing. His general points thus relate with the analyses of Levine and Coward, and Vermillion in this set of papers.

The theoretical papers are put together with a somewhat idiosyncratic set of ethnographic and agricultural studies, drawing heavily on Mexican irrigation experience (also Ecuador, Sri Lanka and Tunisia), as well as broader agricultural studies from Peru, the Dominican Republic and Indonesia. This latter group has some very interesting material on indigenous knowledge systems. Overall, it is a somewhat eclectic set of papers, possibly written in language too academic for many Network readers, but important for all workers concerned to improve the outcome of irrigation in rural development. The book helps to define the characteristics of investigations required, and the kind of research methodologies which are useful for these investigations of interaction.

This book, despite some abstruse sections, is a real reminder of the important contribution sociology and anthropology can make to methodology and theory in irrigation development, far removed from the restricted and insignificant role they are all too often given in planning and implementing irrigation projects.

The book by Chambers, Saxena and Shah may soon be available through ITDG 'Books by Post'. For their catalogue and order form write to: IT Publications, 103-105 Southampton Row, London WC1B 4HH, UK.

For the book edited by Norman Long, the ordering address is: Pudoc, PO Box 4, 6700 AA Wageningen, The Netherlands, or your bookseller.

OTHER BOOKS RECEIVED

David Freeman et al, *Local Organisations for Social Development: Concepts and Cases of Irrigation Organisation,* Westview Press, 1989. This is an important book which not only reports on case studies of farmer organisation - or lack of organisation - in particular sites in the Punjab, Pakistan, Madhya Pradesh, India and in Sri Lanka, but also uses them to construct an analytical concept and to draw out practical conclusions. The basic idea derives from

Drucker 'The best structure will not guarantee results and performance, but the wrong structure is a guarantee of non-performance', and applies it to water user associations. In WUAs, as in many other human activities, there is the basic problem of how to deny benefits to free riders who are naturally inclined to take advantage of the communal efforts of others. There is a need for a middle level organisation between the public irrigation system delivering water to a certain point and individual farmers; its structural requirements are 'local control over resources and appropriate linkages with the public organisation'. The case studies test the thesis that water control is an important determinant of crop yields and of farmers' willingness to act collectively to secure maintenance and equitable distribution. The organisational arrangements in each case have varying degrees of inadequacy, affecting yields and setting in motion a vicious circle.

Food & Agriculture Organisation (1989), Spate Irrigation. Land and Water Development Division Working Paper AG: UNDP/RAB/84/030. This is the published version of the *Proceedings of the Sub-regional Expert Consultation on Wadi Development for Agriculture in the Natural Yemen*, held 6 - 10 December 1987 in Aden. We first discussed these proceedings in the Newsletter 88/1a.

Spate irrigation refers to the use of seasonal flood waters for irrigation, which is a traditional form of irrigation practised in many arid countries, especially in the Middle East and North Africa. This report offers a 'state-of-the-art' collection of papers, which examine the technical and social options and issues in this irrigation technique. The challenges of modernisation, and of more general wadi development, are important themes. Country statements are given for PDR Yemen, Yemen Arab Republic, Algeria, Egypt, Morocco, Pakistan, Somalia, Sudan and Tunisia. Recommendations are made for: active study of traditional spate systems; information exchange; wadi hydrology; diversion structures; sediment control; flood protection and wadi training; distribution and field irrigation systems; agricultural aspects of spate irrigation; groundwater development; training, operation and maintenance.

If you have any difficulties obtaining this report, please contact Swayne F. Scott; Chief; Water Resources, Development and Management Service at FAO.

International Rice Research Institute (1988), Vector-Borne Disease Control in Humans Through Rice Agroecosystem Management, (in collaboration with the WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control). This is the Proceedings of the workshop on *Research and Training Needs in the Field of Integrated Vector-Borne Disease Control in Riceland Agroecosystems of Developing Countries*, held 9-14 March 1987. Twenty two papers are included. The first papers give an overview of tropical rice ecosystems and their links with disease, then a second section studies the impact of engineering, agronomy and water management on disease vectors. The last two sections look at strategies of control, both of the vectors and of the diseases in individual and integrated strategies. Several papers provide regional overviews for Africa, Southeast Asia and the West Pacific, as well as case studies from Japan, China and Indonesia. Diseases discussed include Japanese encephalitis, malaria, filariasis and rodent-related diseases. The papers attempt to answer questions like why vector-borne diseases are rare in some irrigation schemes and endemic in others, and how public health management can be better integrated with water management. IRRI Publications can be obtained from: Publications, IRRI, PO box 933, Manila, Philippines.

International Commission on Irrigation and Drainage (1989). Planning the Management, Operation and Maintenance of Irrigation and Drainage Systems. A Guide for the Preparation of Strategies and manuals. World Bank Technical Paper 99. ISBN 0-8213-1231-6. This book has been prepared to help organisations responsible for operation and maintenance of irrigation and drainage systems to develop strategies and prepare plans for proper and effective operation and maintenance. It provides the basis for the preparation of manuals necessary for managers and staff to perform needed activities at the proper time. The guide provides a comprehensive list of issues that should be addressed in operation and maintenance manuals for irrigation and drainage systems, and a listing of published materials and working papers which will assist in the formulation of plans for operation and maintenance.

Sections of the book look respectively at: operation and maintenance responsibilities at different stages of project development; detailed aspects of system operation and system maintenance; administration; water users; budget development and programming; monitoring and evaluation. Annexes provide: studies of documents necessary for operation and maintenance work and case studies on the Royal Irrigation Department, Thailand; the Narmada River Development in Madhya Pradesh, India; the Rural Water Commission of Victoria, Australia.

This guide should serve as a valuable tool to help improve performance of irrigation and drainage systems. It was prepared to assist managers in developing and improving effective organisations to serve water consumers better.

Public Sector Irrigation Training: Guidelines for Preparing Strategies and Programmes, May 1989, is a companion document to the manual just sited. It reviews approaches to training and discusses some important choices which managers must make in planning appropriate training strategies. The annexes include: lists of international and national institutions involved with irrigation training and techniques for conducting a training needs assessment. The report is presented jointly by the Economic Development Institute of the World Bank and USAID.

These two World Bank reports are available from the Publications Sales Unit, Department F, The World Bank, 1818 H Street NW, Washington, DC 20433, USA.

Dhawan, B. D. (1989), *Studies in Irrigation and Water Management*, Commonwealth Publishers, New Delhi, India. This volume is a collection of papers, published by the author since 1987, reviewing issues in irrigation management in India. The papers cover many critical topics for Indian irrigation, such as big dam development, the productivity of canal irrigation, promoting and controlling groundwater development, and conjunctive use of resources. The author uses both policy documents and field research to illustrate his points.

Plusquellec, H. (1989), *Two Irrigation Systems in Colombia: Their Performance and Transfer of Management to Users' Associations. World Bank Working Paper 264.* Two Colombian projects show how local farmers can manage an irrigation system in a developing country if the management and personnel are well-trained and motivated, and if the infrastructure is in good condition at the time management is turned over to the farmers. Copies are available free from The World Bank, 1818 H Street NW, Washington DC

20433, USA. This study has been carried out in collaboration with IIMI.

IIMI PUBLICATIONS

For information contact the Information Office, International Irrigation Management Institute, 64 Lotus Road, Colombo 1, Sri Lanka.

The summaries presented here are abstracts or summaries taken from the books themselves.

IIMI Country Paper - Sri Lanka, No.1. Namika Raby and Douglas J. Merrey (1989), *Professional Management in Irrigation Systems: A Case Study of Performance Control in Mahaweli System H, Sri Lanka*, (97 pages), ISBN: 92-9090-119-5. IIMI Pub 86-03. This book presents a descriptive study on decision-making in irrigation management. The authors have selected an irrigation management agency in Sri Lanka and have examined in detail the goals, alternatives, the formal and informal dimensions of the managerial process within the agency, and the outcomes of this process. Though the study focuses on Sri Lanka, its findings are applicable not just to Sri Lanka but to irrigation management the world over. The study will be of value to professional irrigation managers in particular and to the broader professional and academic community working on irrigation management problems.

IIMI Country Paper - Pakistan, No.3. Edward J. Vander Velde (1989), *Irrigation Management in Pakistan Mountain Environments*. (48p). ISBN: 92-9090-152-7. Although the mountains of northern Pakistan are, in large measure, the source of water for the large irrigation systems that dominate the Indus Basin, comparatively little is known about irrigation systems there or elsewhere in the mountains of Pakistan. However, Pakistan's mountain environments are increasingly becoming the focus of substantial rural development projects that seek to expand or strengthen the agricultural base of the economy in what are, arguably, the poorest regions of the country. Such programs are likely to require a different approach to irrigation system development as well as a more comprehensive water management strategy if the objective outcomes of such projects are to be sustained. This paper is an initial attempt to determine the extent of irrigated agriculture in Pakistan's mountains, to focus attention upon changes already underway in some areas as a result of irrigation development activities, and to identify important knowledge gaps that will need to be filled by more systematic and multidisciplinary research.

IIMI Case Study No.2. (Sri Lanka). A. M. S. Sunil Gunadasa (1989). *The Kimbulwana Oya Irrigation Scheme: An Approach to Improved System Management.* (52p). ISBN: 92-9090-111-X. IIMI Pub 87-10. This case study describes the problems which existed in the scheme prior to its rehabilitation in 1979 and the associated irrigation management innovations introduced by the author, who was assigned as a technical assistant by the Irrigation Department that year. Some of the management innovations included the provision of a simplified form of technical guidance to farmers and using organised farmer participation in the operation and maintenance of the system through a Water Issue Board. A systematic rotational distribution of water was introduced, with an advance in the cultivation calendar, and increase in cropping intensity. Farmers were motivated to take over the responsibility for the maintenance of the system from the government, and to continue to improve the physical and operational condition of the system.

IIMI REPORTS

Study on Irrigation Systems, Rehabilitation and Improved Operations and Management, for ADB Regional Technical Assistance 5273, (3 Volumes).

Vol.1. Activity A: Rehabilitation and Improvement for Management. This report makes a management-oriented critique of main canal operations, studying the implications of planning and design of main systems for their management and performance. Case studies used are from the Mahaweli Authority, Sri Lanka, the Kirindi Oya Irrigation and Settlement Project, Sri Lanka, the Rajangan Irrigation Scheme, Sri Lanka and the Upper Pampang River System in the Philippines. Main canal regulation has been analysed from three points of view: its impact on the distribution of flows from the main canal; its contribution to the manageability of the physical systems; its implications for managerial requirements. Field investigations and analyses, based on data collected 1988, examine the actual conditions under which (a) canal operators exert control on the flow of water, (b) decision-making for canal regulations takes place at various operational levels. The report gives both general and specific recommendations.

Vol.2. Activity B: Dry-Season Irrigation Management for Rice-Based Systems. This report gives a synthesis of IIMI's research on irrigation management for crop diversification in Indonesia, the Philippines and Sri Lanka. The report also summarises the various activities connected with the preparation and organisation of a research network on irrigation management for crop diversification which culminated in a planning and organisational workshop held at the Asian Institute of Technology (AIT) Centre in Bangkok, in early December 1988. Write to Dr Senen Miranda at IIMI if you would like more information about this network.

Vol.3. *Financing the Costs of Irrigation.* Details of this volume will be given in the next Newsletter.

9. JOURNALS RECEIVED

The last two sections of the *International Journal of Water Resources Development* have several articles pertinent to regular themes in our Network Papers. In Vol. 5(3) Mahmoud Abu Zaid looks at *Environmental Impacts of the Aswan High Dam - A Case Study* (pg 147-157), and Yacov Tsur et al use Israeli groundwater conditions as a study for *Fossil Groundwater Resources as a Basis for Arid Zone Development? An Economic Case Study* (pg 191-201). S. T. Somashekara Reddy contributes to the debate on groundwater in India in *Declining Groundwater Levels in India* (pg 169-174), while Umesh C. Chaube documents the controversies of larger schemes in India in *Rehabilitating Oustees in the Narmada Basin, India* (pg 174-182). Indian water resources were a strong feature also of the previous section, Vol.5 (2), R. Vidyasager Rao looks at *Large and Small Dams In India* (pg 136-142); Syed I. Hasnain looks at *Himalayan Glaciers as a Sustainable Resource* (pg 106-112), and Kumar and Pathak look at *Optimal Crop Planning for a Region in India by Conjunctive Use of Surface and Groundwater* (pg 99-105). Other countries also represented include Egypt, where Fatma Abdel Rahman Attia also considers groundwater development and regional conjunctive use in *Use of Groundwater for Irrigation in the Nile Valley* (pg 91-98), and Nigeria, where Are Kolawola joins the debate on performance with his article *Underperformance of Nigerian Irrigation Systems: Design Faults or System Mismanagement?* (pg 125-135).

Water Resources Management 3(2), 1989, includes two technical communications on the Chi River Basin, Thailand. B. S. Piper et al look at *A Simulation Model for Planning Water Resource Developments in the Chi River Basin* (pg 141-154), and at *The Chi River Basin Irrigation Demand Model* (pg 155-164).

WAMANA 4(3), 1989, has three papers relating to gravity-flow irrigation systems and their management in India, and a paper by S. Satish (pg 31-41), on public tubewells in Uttar Pradesh which continues the debate on the returns to investment on these types of groundwater development. The studies of surface water irrigation are by Satnarayan Singh, writing on *Issues in Canal Operations in South India* (pg 1-13), G. N. Kathpalia, who gives a study of the *Command Area Development Programme in India* (pg 14-23), and R. Venkataswamy, who documents a success story of a farmers' organisation in a tank system in Tamil Nadu (pg 24-30).

The *ODU Bulletin, No.15*, for July 1989, focuses on studies in reclaiming saline clay soils. This edition covers both a review of problems and details of studies from Turkey. The Bulletin also lists publications by Hydraulics Research on salinity in clay and sandy soils. For more details write to Dr Sanmangunathan, ODU, Hydraulics Research, Wallingford, Oxfordshire OX10 8BA, UK.

In the ICID Bulletin, Vol.38(1) for 1989, Oad and Podmore (pg 1-12), report data from Central Java, Indonesia in *Irrigation Management in Rice-based Agriculture: Concept of Relative Water Supply* in a study relevant to issues of crop diversification and management needs; Stegman (pg 31-41) looks at the relationship of expansion and markets in Brazil in *On Choosing Cropping Patterns and Rates of Implementation of Large Irrigation Projects;* Oad and McCornick (pg 42-53) look at *Methodology for Assessing the Performance of Irrigated Agriculture.*

Irrigation and Drainage Systems 3(2), 1989, includes articles by Small (pg 125-142) on *User Charges in Irrigation: Potentials and Limitations*; by Constable, Tregear and Foley (pg 169-180) on *Strategy and Programme Development for International Irrigation Training* looking at new training developments in Australia; Ahmad and Heerman (pg 193-203) report on *Irrigation Scheduling and*

Water Availability at Watercourse Command in Pakistan. In Vol.3(1), 1989, Frederiksen (pg 63-82) reports results from a questionnaire on *Operation and Maintenance Experience with Various Canal Linings* based on American projects.

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IRRIGATION MANAGEMENT NETWORK

EQUITY CONSIDERATIONS IN THE MODERNIZATION OF IRRIGATION SYSTEMS

Gilbert Levine & E Walter Coward, Jr

ODI/IIMI Irrigation Management Network Paper 89/2b December 1989

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EQUITY CONSIDERATIONS IN THE MODERNIZATION OF IRRIGATION SYSTEMS

GILBERT LEVINE & E WALTER COWARD, Jr[1]

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EQUITY CONSIDERATIONS IN THE MODERNIZATION OF IRRIGATION SYSTEMS

Gilbert Levine & E Walter Coward, Jr

1. INTRODUCTION

The failure of many irrigation systems in developing countries to achieve expected levels of performance, coupled with the relatively deteriorated state of many others, and the increasingly higher unit area cost of new systems,has prompted greater emphasis on the rehabilitation and modernization of existing irrigation systems. Illustrative of this is India's Seventh Five-year Plan[1] which indicates that a major objective of the plan will be "... to give the highest priority to the utilisation of the existing irrigation potential for optimising production by constructing field channels, land leveling and introduction of **warabandi**[2]."

This statement, which is typical of current views in a number of developing countries, incorporates both production and efficiency objectives. Other statements clearly identify social goals, e.g. "... giving priority to projects benefitting the tribal areas, drought-prone areas and areas with a sizeable scheduled caste population"[3]. Thus, we have a triumvirate of basic objectives for many current irrigation programs to increase production, efficiency and equity. The mechanisms usually identified to accomplish this are the assignment of priority to specific systems, improvement of the physical infrastructure of those systems, and the modification of their water allocation procedures.

In general, in system modernization agricultural production is the primary objective, system efficiency measures are the indices most frequently used to determine the degree to which success has been achieved, and equity or fairness of economic and/or social impact on the 'beneficiaries' is assumed to occur if the system functions as designed. The rationale for this perspective is relatively clear. Production is the operative mechanism for improvement in economic output of the system (and presumably for improvement in the economic well-being of the farmers). However, it is difficult to isolate the production effect of irrigation improvement from the effects of other components of the agricultural system, availability of inputs, market prices, etc. Thus, system efficiency measures, either on the input side (e.g. degree to which planned areas are actually served), or on the output side (e.g. system water efficiency[4] or crop water efficiency[5]), which are relatively easy to determine, have become widely accepted indices of system performance. Equity, however, remains an elusive parameter.

The equity identified as an objective in the Indian Five-Year Plan is a regional or class equity, which is anticipated to be met when a system is constructed and/or made to function in the region of its location. Within the irrigation professional community there also is a recognition of the need for 'head/tail' equity, usually cast in terms of equalizing the delivery of water between the extremities of the system. In the modernization of irrigation systems, especially where external donors or lenders are involved, the equity 'rule' that underlies system modernization is 'equality' in meeting crop water needs, usually with some specific crop or cropping pattern specified. But there are other views of equity that can be held by water users which have validity in specific situations[6]. Unfortunately, in systems operated by the state, equity from the perspective of the farmers is rarely explicitly recognized or considered in the planning, design, implementation, operation or maintenance of the system. It is the thesis of this paper that the failure to consider equity (fairness) from the farmers' points of view is a major cause of much of the relatively poor performance associated with system rehabilitation and modernization. This is not to argue that the farmers' perspectives always must be accepted in designing and implementing changes in the systems; there may be good reasons for wanting to change the current pattern of social relationships.

The role of equity in relation to the design process for system rehabilitation and improvement will be explored in the following sections: equity principles in water allocation; modernization interventions; and application of equity considerations in design decisions.

2. EQUITY PRINCIPLES IN WATER ALLOCATION

It is a truism that irrigation systems reflect their site specific characteristics, exhibit sensitive dependence upon the initial conditions of their formation, and thus are unique in many ways . Some aspects of site specificity are relatively static, (e.g. those directly constrained by the physical aspects of the site), but others are more dynamic, responding, with varying degrees of speed, to changes in economic and social conditions. Where the rate of adaptation in the system fails to keep pace with the needs associated with the changing environment there is increased pressure for rehabilitation. While much of the argument for rehabilitation is expressed in terms of the need to address the physical deterioration of the systems, the frequent inclusion of significant system modifications is recognition of the need for "improvement /betterment/ modernization"[7]. It is in the context of the need for improvement (change) that the requirement for explicit consideration of equity is most critical. Unfortunately, planners and system designers usually give major attention to the production and efficiency goals, and minimal attention to the prevailing equity situation in the system or to that which will result following the changes.

Water users perceive a pattern of water allocation as equitable if claims to water are based on some social principles that are accepted as fair or right. Such principles are found in most irrigation systems, e.g. that some users have priority because of seniority in the system or that crops suffering from water stress have priority over those not suffering, etc. These principles may, or may not, suggest the desirability of equal allocations of water to all users. There are differences in definitions of equity as seen in the variety of rules for water allocation that can be found in irrigation systems, both farmer-managed and governmental, around the world. Among the **least equal** are those that allocate the resource on the basis of **priority in time**, the first user has the first rights. This is typical of many systems in the western United States, as well as between systems in Asia that share a common water source. Examples include the irrigation associations in Taiwan drawing water from the Cho Shui River where there are time-priority differential rights to the water, as well as some tank-based systems in Sri Lanka, where villages with time priority pass "excess" water to a downstream village. In both examples, the inequality in access is not considered unfair. This uni-factor rule is the simplest and least efficient in technical and economic terms, in that it may not even consider the size of land holding, yet the allocations typically are in the form of **rights** which are very resistant to change[8].

More typical in Asia are systems that allocate water proportionally on the basis of land area[9],[10]. These may be of a very simple type, in which the available supply is proportionately distributed solely on the basis of the proportion of the commanded area farmed by the water user; or it may be based on the level of contribution the user made to the construction of the system (in the case of farmer-developed systems). In this latter case, the contribution usually is related to the size of the individual's land holding, thereby reinforcing the strength of the proportional equity rule. In some cases, however, the level of contribution and resultant sharing in allocation are independent of the size of the irrigated holding. This is illustrated in some systems in Sri Lanka[11], where labor contribution to construction of the canal entitled the farmers to a share of the canal supply and the water could then be used on as much area as the farmer could develop. It is also illustrated in Nepal[12], where farmers purchased water shares based upon construction cost and these shares are independent of the area of land to be irrigated. This type of proportional sharing of the supply does not differentiate on the basis of topography, soil type, crops grown or other factors, consideration of which presumably would lead to increased water efficiency and/or economic efficiency.

However, many systems do explicitly recognize such factors and modify the area/construction-input proportionality rule to consider them. This represents a different definition of equity, one in which the sharing is of the **utility of the water resource** rather than of the volume of the resource alone. This, in general, is the rule implicit in modern design procedure that starts with climatic, soil and crop water characteristics in determining the 'irrigation requirement'. In some systems with a **resource sharing** definition of equity there is a formal shift to the **utility sharing** rule under conditions of water stress. Illustrative of this pattern are the systems of Taiwan[13], where the normal rules of water allocation (based on time priorities and area) that differentiate between sub-systems are utilized until there is a significant shortfall in the water supply (usually about 30%). At that time, and with the acknowledgement of the shortfall by the system members, there is a shift to "technical rules" by which the traditional rules are temporarily abrogated and sharing is based on the needs of each irrigation small group. Even systems based on very simple resource-sharing rules frequently modify the rule informally during periods of stress to consider differential needs resulting from physical differences in the local environments[14]. This may be done through personal arrangements between individual farmers, as in Baluchistan, or through delegation to 'elders' of authority to make adjustments in flow delivery to meet critical needs of those in difficulty.

This utility concept of equity is advanced in some systems to include **economic productive potential**, in which the allocation rule considers not only physical differences in different parts of the system, but also differences in economic opportunity[15]. For example, in some systems in Indonesia a specified fraction of a village area must be devoted to production of government controlled crops; these crops yield lower economic returns than paddy rice. Decisions about allocation of guaranteed water for paddy rice production include consideration of the cropping history of individual farmers, particularly the time since they grew the mandated crops[16]. A different principle is illustrated by the Pani Panchayat systems in India, where water is allocated on the basis of family size, with water for one-half acre/person up to a maximum of 5 persons[17]; this defines economic equity in absolute, rather than relative terms.

Many examples exist where water charges are varied to reflect differences in potential economic return from the irrigation. These may be associated with different crops, with higher value crops being charged higher fees, as in a number of systems in India; they may relate to differential availability of water supply, illustrated in Taiwan where different fees are associated with "two crop rice areas" in comparison to "one-crop" areas.

Thus, we can find in irrigation systems a wide range of water allocation rules or policies, with very different implications for technical and economic efficiency, as well as for the amount of water received by each user. In their individual settings, each may be perceived as **fair** or **unfair** by a majority of the water users; changes toward other equity rules, including **equality** based on technical determinants may be resisted strongly, enthusiastically endorsed, or both. This has clear implications for the process of rehabilitation/bettermen

3. MODERNIZATION INTERVENTIONS

The 'improvement' or 'modernization' of irrigation systems in developing countries usually envisions some combination of the following: extension of system control further into the farming areas; increased use of concrete and steel in channels and control structures; increased capability by system managers to measure and adjust water flows; revisions in water schedules to permit more flexibility in responding to production opportunities; and development of water user organizations. In certain situations, changes in the irrigation system will include some degree of land consolidation. Thus, improvement anticipates significant changes in the ability to control and distribute water, and potentially important changes in the rules for that allocation. Occasionally, but not universally, there will be increases in the basic supply. There frequently is an expectation that after improvement there will be an increase in the area irrigated, especially when the basic water supply has been increased.

3.1 Extension of System Control

The extension of system control usually takes two forms: (a) physical, in terms of increased density of channels and control structures; (b) managerial, either by the government irrigation department or by some type of water user group. This latter is gaining significant favour, for economic and political reasons.

Fundamental to the judgement that irrigation distribution systems should be extended is the view that each farming unit should be served directly from an irrigation channel. The benefits from individual delivery are clear in the case of non-flooded crops, but may exist to a lesser degree for paddy rice where, under reasonably reliable supply conditions, field to field distribution can be as effective and efficient as individual field outlets[18]. Notwithstanding the potential benefits from increased density of delivery channels, these changes frequently affect both absolute and relative amounts of water among the water users, and may affect timing. In addition, there may be significant problems in obtaining rights of way, and maintenance responsibilities for the extended channels may devolve disproportionately to the tail end water users.

These problems are frequently exacerbated by the inability of many governments to design and construct effective channels, hampered by the demanding requirements for topographic precision, inadequate numbers of qualified surveyors, inexperienced construction firms, major problems of construction supervision and a failure to utilize farmer knowledge appropriately. This has been the case in the Upper Pampanga River Irrigation System in the Philippines[19], where 40 percent of the turnout structures were determined to be inappropriately located or inadequately constructed, in the 'dykes and ditches' project of the Central Plain of Thailand, in the Tertiary Development Projects in Indonesia and in the Mahaweli Project in Sri Lanka. Physical extensions that do not serve as intended introduce new stresses among the water users, as well as between the users and the irrigation departments.

In areas where fields are not served individually, flow proceeds from field to field, often involving a number of different landowners. The downstream users usually are at a disadvantage with respect to timing and amount of water, but generally have worked out accommodations with the upstream owners which they may consider reasonably fair (or unfair). Extension of channels to serve individual owners (or smaller groups) has the potential to improve the timing and amount of water received by the downstream users, changing the pattern of relationships with the upstream users. In some situations, this change will be resisted by the upstream water users, and specific efforts would be necessary to avoid conflict among the water users and between the users and the irrigation department. These efforts frequently involve an accompanying extension of control, either by the farmers in a group mode or by the government, through its irrigation agency.

In some instances, for example in the Sirsia-Dudehra system in Nepal, upper farmers have been adversely affected by the lack of adequate field channels when downstream farmers have moved water over fields near harvest or being prepared for planting, In this type of situation there is benefit to all the users and acceptance of this type of change is more rapid.

3.2 Changed Construction Practice

Around the world, many irrigation channels and structures are constructed of locally available materials. In the case of channels this usually means unlined earth; weirs, dividers and other distribution control structures may be of wood, as is customary in farmer-developed systems, or of concrete and steel as in newer government systems. The emphasis on more durable structures is a result of pressure to reduce maintenance costs - pressure from external sources, as illustrated in a recent report of the U.S. Government which recommends "... stronger project design and construction criteria to reduce recurrent costs."[20], as well as from water users themselves. The pressure from this latter group often results from increasing difficulty in obtaining the necessary local materials or mobilizing the required labor. In Thailand, for example, the increased policing of public forests as well as increasing scarcity of bamboo and various types of wood products for small dam repair has resulted in petitions for concrete structures.

While concrete and steel (well constructed) can reduce the frequency of repair (though not necessarily the cost), usually it also will reduce the ability of the farmers to effect those repairs since materials and necessary skills may not be locally available. However, the glue that binds many water user groups and provides the incentive for upstream or more powerful members to accommodate to the needs of their disadvantaged coworkers is the need to unite for maintenance activities, as is the case in many systems in Nepal and Northern Thailand. A reduction in this need can have serious effects on the viability of the water user organization, and on the maintenance of operational equity.

3.3 Water Control Capability

With few exceptions, farmers in developing country irrigation systems use forms of distribution control that are simple, but effective in implementing the operational rules. Where the allocation rule is a sharing of time, as in Warabandi, only on/off control is necessary and very simple gates are used; where the allocation rule is proportional sharing of the resource (as in many rice-based systems), fixed proportional dividers (preferably rectangular openings) coupled with on/off capability are sufficient. Openings from field channels usually are specified as to size and elevation, and thus determine the flows. The introduction of variable opening gates is necessary only when there is a potential benefit from being able to modify water deliveries to more nearly coincide with 'crop water requirements'. This benefit might come from saved water (utilizable elsewhere), from increased yield or improved product quality. Thus, the introduction of increased control capacity of this type into an irrigation system **implies** a change in the **equity rule** from one of sharing the resource to one based upon sharing of the economic potential of the water. This, then implies a need to explicitly foster acceptance of this altered view.

3.4 Water Measurement Capability

The ability to measure flows is generally considered essential to the operation of modern irrigation systems. However, different levels of measurement capability imply different types of distribution patterns (and their related equity). At the present time, even in systems where significant measurement capability exists, it is used infrequently (usually at the beginning of the irrigating season, or in unusual drought situations) and the data often are inaccurate. Lack of calibration and recalibration, failures in monitoring and inappropriate information processing combine to lower the management utility of measurement capability. The introduction of tertiary water measurement into irrigation system operation, therefore, usually implies the need for improvement of the entire information handling system and decision-making structure, as well as the potential changes in equity.

The relationship between a particular water distribution pattern (with its implied equity definition), and the level of water measurement capability necessary to implement it, can be illustrated by two types of water distribution rules. The **Warabandi** system of India and Pakistan, is based on the **proportionate sharing of time of channel access** (it does not guarantee a specific amount of water, though there is an implication of an amount sufficient to irrigate similar proportions of each farmer's holding). If the system is in reasonable repair, the distributary channels are designed to provide a specified amount of water/unit land when operated at full supply level. Two measurements, water elevation at the head and tail of the channel (relatively simple measurements), define full supply level. Periodic observations to identify discharge problems would then be the only other regular measurement required.

The **Demand** system, in which individual farmers can request water at times and in amounts convenient for their operations (frequently subject to specific system constraints, but with an implied objective of providing the best operating conditions for all the users) generally requires flow measurement, and information handling capability at least to the level where the requesting water user can control the entire flow, frequently to the individual farm, but at least to the field channel.

3.5 Operating Schedules

Equity rules are implemented, deliberately or de facto, by the schedules for water delivery. Where the schedules are predetermined or established prior to the start of the season, and consist of time of flow and/or fixed outlets, the system basically is an **administered** system, and a proportional sharing of the resource is implicit. When the associated water supply is severely limited, as in the original Warabandi systems, this type of operating rule can be efficient in physical and economic terms.

Where there are more abundant water supplies and the operating schedule is varied in response to information from the field, the system is a **managed** one and the implicit equity rule is one of sharing the utility of the resource. Modern demand systems are designed to permit individual farmers to make their own farming decisions, usually in the context of relatively large quantities of water, adequate channel capacities and a responsive organization. Technical efficiency can be achieved in demand systems, but effective control of demand is required[21]. Design decisions about operating schedules, therefore, essentially determine the equity rules under which the system will function, as well as the physical and organizational infrastructures necessary for effective implementation.

3.6 Water User Organizations

Water user organizations are being fostered for a number of reasons, among them better operation, improved communication and the desire to shift operating and maintenance responsibilities (including costs) to the users. The techniques used to organize user groups can have a marked effect on the resulting allocation of water and maintenance responsibilities[22]. The groups may reinforce and/or expand existing disparities in service or act to reduce them, depending upon how power is shared in the group. Organizations established by fiat from above, with leadership vested in existing authority frequently reinforce existing disparities. In addition, experience has shown that unless these organizations are reasonably equitable they are ineffective in achieving the stated objectives. Organizations do not occur automatically, but reasonable groups with effective input from the disadvantaged can be organized in many situations. While obtaining an effective role for the disadvantaged is not easy or cost-free, experience in the Philippines, Sri Lanka and Nepal indicates that it can be done.

4. EQUITY CONSIDERATIONS IN DESIGN

The interactions between physical infrastructure, the roles of the irrigation bureaucracy and the water user organizations, and the rules which order those relationships, including rules related to equity, are rarely considered explicitly in planning, design and implementation of new systems, or in the rehabilitation of existing ones. In part, this omission occurs because irrigation systems are usually viewed as technical facilities, a predictable consequence of the dominance of engineers in irrigation bureaucracies. In addition, this oversight is sustained by the complexity of the interrelationships. Finally, it also is a result of the absence of a methodology for incorporating consideration of these complex relationships in the design process. Yet, failure to recognize and address the potential problems resulting from inappropriate relationships is, in our view, a major cause of irrigation system operation and maintenance problems.

It is not possible, at this time, to suggest a methodology which would consider all the important relationships. However, we propose the use of **equity considerations** as a basis for such a methodology, and one which should have a significant beneficial effect on system improvement decisions and subsequent performance.

In reviewing a number of examples of farmer-managed and government-managed systems in a range of agro-ecologic regions, we have seen that those systems which appear to be successful, in technical and economic terms as well as from a social point of view, **have clear equity rules, appropriate physical structures and organizational procedures that permit effective implementation of those rules.** Examples include the Yun Lin Irrigation Association in Taiwan, some farmer managed systems in Nepal and some of the Warabandi-based systems in northwest India. The definitions of equity vary among the systems, as suggested earlier in this paper, but it is clear that a concern for equity is a driving force in all the systems.

A methodology for incorporating equity considerations in design decisions for governmentally-supported irrigation systems is outlined below, and briefly explained in succeeding sections. (This procedure is intended primarily for the government staff involved in design activities.) The steps in the methodology are specified in some detail, and may give the impression of adding significant time and expense to the overall design process; we do not believe this to be the case. By comparison with the efforts made to obtain and utilize basic physical information relating to climate, hydrology, topography and soils, and even to the effort associated with the economic analyses, this methodology would represent a small additional effort, with a number of the steps being carried out concurrently or in close sequence.

1. For existing systems, especially those with a relatively long life, identify the rules and operational procedures for water allocation and distribution in actual use and their implicit (or explicit) equity basis. For new systems, state explicitly the planned operating rules and procedures, and their equity basis.

2. Determine the key features of the definitions of equity in water allocation and distribution held by the water users, including attention to variations in important sub-groups.

3. Evaluate the congruence and differences between the existing (or proposed, in the case of new systems) rules and operational procedures and the local views of equity.

4. Evaluate the appropriateness of the system rules and operational procedures, both farmer preferences and system realities, for the system's external environment of relative values of water, land and capital resources.

5. If necessary, propose new rules and/or operating procedures that would be appropriate for the external environment anticipated for the next 10 to 20 years.

6. Evaluate the proposed rules and procedures through discussions with the water users.

7. Identify the changes, physical and/or organizational, which would be supportive of the implementation of the new rules and operational procedures.

8. In making specific design decisions, evaluate the alternatives from the perspective of potential impact on the ability to implement the equity rules and procedures.

4.1 Rules and Operational Procedures

In government administered systems one can conceptualize four sets of equity rules that coexist: (1) the nominal rules and procedures incorporated in the system design and intended operation; (2) those that reflect actual operation of that portion of the system under control of the operating bureaucracy; (3) those that are operative in the part of the system under the control of the users; and, (4) the 'ideal' rules and procedures in the minds of the users.

The equity basis for the nominal rules and operating procedures may not be explicitly stated, but usually are relatively easily inferred. Actual operation is more difficult to determine since operational monitoring is not common, and special studies usually will be necessary to obtain the information. Studies during water stress periods should reveal the relevant rules and operating procedures and the implications for equity or inequity.

4.2 Farmers' Definitions of Equity

Few irrigation systems serving small-holders in developing countries are controlled to the parcel outlet by the operating bureaucracy. Along field channels, and frequently to significant levels above the field channel, farmers control the functioning of the system. This is true, even with the relatively rigidly controlled warabandi systems of the Indian and Pakistan Punjab provinces. The ways in which the farmers exercise this control reflect their perceptions of equity, as well as the degree of power they can exercise, either as individuals or in groups.

Water user perceptions of equity can be understood through in-depth interviews with farmers with different size holdings and in various parts of the system. They can also be inferred from actual user practice and the type and extent of irrigation conflicts. It is probable that a number (perhaps many) views of the existing situation will be forthcoming, since the farmers in different parts of the systems and with different land resources frequently will have contrasting perceptions of system operation. Similarly, it is likely that more than one view of the desired rules and operating procedures will be proposed.

4.3 Evaluate the Agreement Between Existing Actual Rules and Procedures and User Views of Equity

A comparison of the equity implicit in system rules and operations with farmer definitions of equity should reveal the extent of agreement and disagreement. This comparison, coupled with information about types and extent of problems in the system, should suggest the importance of the disagreements. When there are significant disagreements, the design of rehabilitation should explicitly attempt to reconcile the differences between preferred and actual equity.

4.4 Evaluate Appropriateness of Existing Rules

The appropriateness of the existing rules and operational procedures is related both to the degree of fit between the current equity situation and the definitions of equity held by the farmers, as suggested in the preceding section, and the fit with the needs shaped by the **external environment.**

In section 2, we suggested that systems operate within a relatively dynamic external environment in which the **relative values** of factors important for system operation and utility change over time. To a major extent, these changes in relative values reflect changes in the economic and political environments beyond the system itself. The economic environment determines the absolute and relative values of the land and water resources, with obvious implications for the appropriateness of different rules relating to their use, as well as for the appropriate level of investment for increasing their use efficiency. The extent to which existing or proposed rules and procedures move the system toward increasing efficiency of the scarcer resources is a second measure of the appropriateness of those rules.

The development of new systems, or the rehabilitation of existing ones, is frequently associated with contemporary government views of economic and/or social objectives. The shift from 'protective' to 'productive' systems, in Pakistan, is illustrative of changed economic and social objectives. This is a major change, from equity as the proportional sharing of a limited, critical resource among the widest number of people, to a definition that emphasizes the right to maximum economic return for a limited number of farmers. By contrast, the increasing demands for water (industrial and municipal) and, thus, the increasing value of water in Taiwan were accommodated through the substitution of technical rules of water allocation and distribution for customary rights, while maintaining the basic equity objective of equal opportunity for productive rice production by each farmer.

The emphasis on greater farmer participation in system operation and maintenance, evident in a number of countries in Asia, is a reflection of both financial and social equity considerations, fostered by major political decisions. The appropriateness of new or revised rules and operating procedures, therefore, must be evaluated on the basis of their agreement with these political directives.

4.5 Propose Revisions or New Rules

The evaluation of the relative values of the factors associated with irrigated agriculture should permit the identification of rules and operational procedures that would accomplish efficient utilization of these resources, and which are considered equitable (at least by the planners). If these proposed rules and procedures differ significantly from either the actual rules, or those desired by the farmers, difficulties in implementing and sustaining the changes can be anticipated. A pattern of water allocation and delivery that persists over time (sometimes as short as two years) can be perceived as a right, and a change in this pattern perceived as an unwarranted taking away of this right. If the pattern has persisted for a relatively long time, this may have established a right that has de facto legal status. If new rules effectively take away 'rights' they are likely to be resisted, sometimes in the courts, more often through unsanctioned acts. Thus, rules that significantly change amounts or patterns of water delivery must be weighed in terms of the benefits to be obtained and the costs, including political, associated with their implementation.

4.6 Involve the Farmers

If the government planners decide that the 'more efficient' rules and procedures should be implemented, careful consideration must be given to the **process** of implementation. Rarely is it possible to introduce effectively significant changes by fiat. Therefore, the change process must provide the conditions that will generate understanding, acceptance and approval by the water users. At the least, this means effective participation by the users in the entire process, including the identification of problems and the need for change. To the extent that the farmers can be productively involved in the actual implementation of the changes, the changes are more likely to be adopted and maintained. In some cases, implementation may require substantive quid pro quo if the farmers are being asked to give up perceived **water rights**.

4.7 Identify Supportive Changes

In design of new systems, initial emphasis is laid on the physical system necessary to capture and distribute the water, and in rehabilitation to repair deteriorated physical works. To implement new rules and operational procedures, however, it probably will be necessary to make changes from the existing physical and organizational structures. The design process for both the physical and organizational changes should **start** with **tentative** decisions about the **equity** objectives and the related patterns of **operation and maintenance**, working **back** to the physical and organizational structures required to achieve these. A deliberate effort should be made to consider a wider range of options for operation and maintenance patterns and for specific techniques than is usual, to permit identification of the most economical and efficient practices and facilities.

4.8 Make Design Decisions

Each specific decision about necessary infrastructure should be judged on whether the proposed decision will **enhance or impede** the **probability** of achievement of the desired equity and associated operation and maintenance plans. For example, if the rule is one of strict proportionality in sharing the water (or its proxy, time of channel access), variable turnout gates are unnecessary and may impede effective implementation. Simple on/off gates would be much more appropriate forms of outlet control. By contrast, if the rule is one of sharing the utility of the resource among the widest number of users, with an expectation of significant taxation (fee payment) from individual profits, then adjustable gates would be appropriate, but **only** if accompanied by effective monitoring and response procedures. The decisions should be based upon the **probabilities** of effective implementation, and not on **possibilities**, modern irrigation experience has more than its share of systems designed on the basis of possibilities that were not realized.

5. CONCLUSIONS

The dynamic nature of the context within which irrigation occurs frequently necessitates changes in physical infrastructure and organizational arrangements, including those which determine system operation and maintenance. For effective operation, these changes must fit with farmers' definitions of what is **fair** or induce modifications in those definitions.

Rules and operating procedures are implemented by use of the physical works as well as by the actions of the controlling agency and the farmers. Thus, decisions about the physical structures, the procedures of the operating agency, and the roles of the water users must be made with explicit consideration of their interacting nature. Consideration of these interactions is facilitated by using the impact of proposed changes on the probability of achieving the desired equity in the system as a performance measure.

A system that is considered **fair** by most farmers is more likely to be productive and efficient than one that the State has designed on the basis of productivity and efficiency, but which is considered unfair by the users. Experience suggests that individual self-interest, in many instances, is not so narrowly defined or so rigidly held that changes in water sharing cannot be effected with cooperation and success.

NOTES

1. As reported in the Economic Times, India, 10 November 1985.

2. Warabandi is a form of timed rotation of irrigation characteristic of the Punjab in India. See Malhotra,S.P. 1982 The Warabandi System and Its Infrastructure, Central Board of Irrigation and Power Publication No.157, New Delhi,for a complete description.

3. Economic Times, India 10 November 1985.

4. Ratio of the amount of water utilized by the crop to amount diverted into the system (System Water Efficiency), or at specific points in the system.

5. Kilograms of crop/unit water, or similar water-based crop output indicator.

6. This view has also been expressed by Sampath [Sampath, R K (1988) "Some Comments On Measures of Inequity in Irrigation Distribution", ODI-IIMI Irrigation Management Network 88/2f], who proposes a methodology for characterizing inequity in terms of rich/poor and head/tail in the context of different cropping pattern demands.

7. For a fuller discussion of the rehabilitation/betterment issues, see, Levine G. The Challenge of Rehabilitation and Betterment, in Fowler,D.A.(ed) The International Conference on Irrigation System Rehabilitation and Betterment, Volume 2: Papers. Water Management Synthesis II Project. Jan 1987.

8. For an example of a system with a mechanism for change, see: Levine,G. Irrigation Association Response to Severe Water Shortage; The Case of the Yun Lin Irrigation Association, Taiwan, in Rural Development and Local Organization in Asia, Vol.2 East Asia. N.Uphoff,ed. MacMillan, N.Delhi 1983.

9. For interesting accounts of farmer-managed systems with this allocation rule see: Tanabe,S. 1981. Peasant Farming Systems in Thailand: A Comparative Study of Rice Cultivation and Agricultural Technology in Chiengmai and Ayutthaya. PhD dissertation, The School of Oriental and African Studies, Univ. of London.; Martin,E. and Yoder,R. 1983. Water allocation and resource mobilization for irrigation: a comparison of two systems in Nepal. Paper presented at Annual Meeting, Nepal Studies Association, Twelfth Annual Conference on SOuth Asia, Univ. of Wisconsin, Madison.

10. For a few descriptions of government-managed systems with this proportional allocation rule see: Malhotra,S.P. 1982. The Warabandi System and its Infrastructure. Central Board on Irrigation and Power, Publication NO.157. New Delhi.;

11. See, Leach,E.R.,1961. Pul Eliya: A Village in Ceylon. Cambridge University Press.

12. Martin,E. and Yoder,R. 1983. Water Allocation and Resource Mobilization for Irrigation: A Comparison of Two Systems in Nepal. Paper presented at Annual Meeting, Nepal Studies Association, Twelfth Annual Conference on SOuth Asia, University of Wisconsin, Madison.

13. For examples, see: Ko,H-S and Levine,G. 1972. A Case Study of On-Farm Irrigation and the Off-Farm System of Water Delivery in the Chianan Irrigation Association, Taiwan, Republic of China. Report prepared for seminar on Management of Irrigation Systems for the Farm Level. Cornell University, Ithaca.

14. See, for example: Tanabe,S. 1981 op cit (8).

15. Different forms of incorporating economic potential can be seen in India, in the Pani Panchayat program; and in Indonesia, (see, Oad.R. 1982. Water Management and Relative Water Supply in Irrigation Systems in Indonesia. PhD Dissertation, Cornell University, Ithaca).

16. See Duewel,J. 1982. Central Java's Dharma Tirta WUA "Model": Peasant Irrigation Organisations Under Conditions of Population Pressure. Agricultural Administration, 17(4).

17. Sathe,M.D., 1989. Pani Panchayat- A Theme in Common Property Resources for Water in Maharashtra. Paper presented at the Workshop on Efficiency and Equity in Groundwater Use and Management, Institute of Rural Management, Anand, Gujurat (Jan 30 - Feb 1, 1989).

18. Wickham,G. and Wickham T. 1974. An Evaluation of Two Alternatives of Water-sharing Among Farmers. Unpublished report of consultancy to the National Irrigation Administration, Upper Pampanga River Irrigation Project. Quezon City,Philippines.

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20. U.S.General Accounting Office. 1983. Irrigation Assistance to Developing Countries Should Require Stronger Commitments to Operation and Maintenance. USGAO, Report to the Administrator, Agency for International Development, GAO/USAID-83-31, August. Washington,D.C.

21. The introduction of an unconstrained demand schedule in the Dez Pilot Irrigation Project,Iran, resulted in a lowering of water use efficiency from approximately 30 percent to about 11 percent. (Personal Communication, Chief Engineer)

22. See Uphoff,N. 1986. Improving international irrigation management with farmer participation: getting the process right. Boulder, Colorado: Westview Press.

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IRRIGATION MANAGEMENT NETWORK

SECOND APPROXIMATIONS: UNPLANNED FARMER CONTRIBUTIONS TO IRRIGATION DESIGN

Douglas L Vermillion

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SECOND APPROXIMATIONS: UNPLANNED FARMER CONTRIBUTIONS TO IRRIGATION DESIGN

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SECOND APPROXIMATIONS: UNPLANNED FARMER CONTRIBUTIONS TO IRRIGATION DESIGN

Douglas L Vermillion

1. INTRODUCTION

As people design irrigation systems, either explicitly or implicitly, they predict future cropping patterns, irrigation demand requirements, water supplies and use efficiencies, probability of drought or flooding, and command area boundaries. In essence, irrigation design has to anticipate a mode of management (Levine and Coward, 1985). This includes conceptions of whether management will be demand or supply driven, what kinds of information will guide management decisions, what O&M tasks will be handled at what levels of the system, whether by the agency or farmers. Design should also consider what performance criteria will be acceptable by future managers, including equity, distributional efficiency, adequacy, timeliness, reliability, and sustainability issues (Abernethy, 1988).

In the design process, the assumptions are often more imposing than the amount of actual local information utilized. The reasons why irrigation design so often does not adequately reflect irrigation management tend to be because of the following factors:

1) the range and intensity of relevant information is inadequate;

2) in rehabilitation or upgrading, technical design criteria are usually "satisfied" solely by the application of hydrologic and structure theory to "collectable" information (i.e. design often is not aided by any transfer of knowledge based on local management <u>experience</u>);

3) design engineers may assume too narrow a definition of management (e.g. may include demand/supply parameters but not account for expected rotational practices, timing constraints,

or adaptability of distributional procedures to changes in crop patterns, such as a trend toward crop diversification);

4) design is conceived and implemented as if it were a single task which produces a definitive product (a project mode precludes a phased trial-and-error approach);

5) design and construction is done by multiple parties which are not accountable either to one another or to the future users and managers of the system.

The physical, institutional, and financial sustainability of irrigation systems have become some of the most important indicators of management performance success (Easter, 1986). If done properly, especially with farmer involvement and investment, the design process can be the cornerstone of system sustainability. If done improperly, structures tend to get damaged or to deteriorate quickly, management is hampered, and farmers are less inclined to pay irrigation service fees when they perceive structures as being faulty, unmanageable, or extravagant.

In information theory (cybernetics) conventional irrigation design processes can be depicted as "single-loop learning processes", where the actor (design engineer) learns about what action to take (design layout) on the basis of selective information (survey) which is obtained and evaluated solely in reference to given, operating norms (technical design criteria), (see Figure 1; also Morgan, 1986, Pg 84-95). By design criteria, we mean principles specified by designers by which the existence, type, location, shape, size and materials of a given, physical irrigation structure can be determined relative to function and setting.

This approach would be acceptable as long as two conditions are met:

1) information utilized reflects the relevant complexities of the environment;

2) design criteria adequately determines what aspects of the environment are relevant to design a given network successfully.

Unfortunately these two conditions are not often realized in dynamic socio-technical environments, where system objectives and needs may change over time, and where design problems may wax and wane and require locally-evaluated trade-offs against competing criteria.

In this paper we attempt to illustrate the potential extent of multiple, incremental and interactive reactions stimulated by outsider design intervention. In our examples, farmer irrigation systems existed prior to government interventions in design and construction, and government activity promoted a series of dynamic and partly unpredictable responses.

For example, an enlarged cement weir was constructed in Solok, West Sumatra in 1981 to replace a brush and stone gabion weir. This increased water levels in channels which then stimulated a crop planting schedule with a higher water demand. However, the added flows also caused higher conveyance losses. These two factors prompted subsequent demands for lining. Eventually much of the main canal was lined, which in turn restricted the number of direct farm off-takes permissible from the canal. This created the need for additional field channels, which then gave rise to land use and rights-of-way issues to be settled between farmers.

We now report a more detailed investigation of such reactions to design interventions from the Dumoga Irrigation Project in Indonesia. The study referred to herein was an exploration of the nature and range of socio-technical criteria and knowledge farmers may use in evaluating irrigation design options. Field observations and interviews were conducted with farmers in order to identify instances where farmers revised, or were revising, what had been designed and built by engineers in the tertiary network development of the Kosinggolan Scheme of the Dumoga Irrigation Project in North Sulawesi, Indonesia in the early and mid 1980s. This study was done while the author was undertaking field research for his Ph.D dissertation (Vermillion, 1986).

Criteria used by farmers to make the design changes were identified to demonstrate both the nature, range, and relevance of knowledge inherent in the farmers' experience, as well as the kinds of information which tend not to be available to engineers. Farmer redesign cases were identified along a major secondary canal, within all tertiary blocks in Ihwan village (in the upper part of the system), and at tertiary blocks seventeen, eighteen, and twenty-four (in the middle part of the system). Tertiary network construction had not yet been completed, or used long enough by farmers in lower blocks of the system (i.e. for at least three seasons) for these areas to be represented in this sample.

Farmers interviewed frequently reported approaching construction labourers or supervisors in the field to suggest changes and were usually told that the design had been established by the Government and could not be changed. Often farmers relocated the construction markers when the crews had left. Others waited until construction was finished and the contractors had moved on, before altering the structures. Altogether 27 case locations of design alterations were identified in the sample blocks. Many cases involved multiple alterations which were interconnected.

The Dumoga valley has about 30,000 cultivable hectares surrounded by steep mountains which send many streams onto the plain, many of which were checked for irrigation prior to the irrigation project. The valley has had a rapid expansion of population, mainly due to immigration, growing from about 8,000 in the early 1960s to over 50,000 by the mid 1980s. In the area studied single landholdings were one hectare for transmigrant land allotments or less for non-transmigration land. Blocks often contain considerable micro-variation in soils, topography, cropping patterns, and planting dates. They also frequently have multiple water sources, interconnectedness (between fields, blocks, and even systems), and return flow from drainage or seepage into lower areas. Hence this was a formidable place to design an irrigation system.

The Dumoga Irrigation Project was designed utilizing topographic surveys which focused primarily on information about landform, soils, and natural waterways. Local information on prior use of natural waterways, farmer-built structures, landholding boundaries, and land use was not integrated into the design. Tertiary layouts were based on topographic surveys using a 1:2000 scale and 50 centimetre elevation interval lines. Design and construction was done by multiple consultants and contractors. Tertiary blocks generally were between 50 and 150 hectares in size.

Farmers had prior experience irrigating padi and many farmer-built structures were in use in the area prior to the project. Before the project weir was completed in 1976, farmers were already irrigating 2,000 of the planned 5,500 hectares of the scheme, due to their own efforts. By 1983 approximately 3,000 hectares were being irrigated. Hence, generalizations herein may be less applicable in other settings where farmers have had no prior experience with irrigation, or where new irrigation is introduced.

2. FARMER DESIGN ALTERATIONS

The most common kinds of alterations observed were channels being relocated (involved in 11 of the cases), streams being diverted or ponded (8 cases), project channels being abolished or not used (7 cases), channel off-takes or divisions point being relocated (6 cases). Other actions included redirecting project channels into drains or streams, making new channels, adjusting division box gates to alter water divisions, making new flumes, destroying project flumes and lining channels. Several cases involved relocating channels to follow farm boundaries, to accommodate low water requirement crops, or to continue to make use of pre-existing structures built by farmers, such as small weirs, channels, and ponds.

In their need for small-scale manageability within tertiary blocks, farmers often mentioned reasons for making design changes which were different from, and incompatible with, project criteria. One type of rationale was the wisdom of diversifying one's water sources wherever possible as a strategy for avoiding the risk of dependency upon the project channel only. Farmers frequently tapped multiple water sources as supplements to system channels or individual fields. Such sources as small streams, springs, marshes, ponds and drains were prevalent throughout the command area, and were commonly exploited by farmers as water sources additional to the project. The project originally was designed without reference to such alternative sources, assuming that the Kosinggolan Weir would be the sole source.

Another strictly farmer criteria was that of, wherever possible, combining conveyance and drainage functions in the same channels, so as to maximize reuse and the utility of the channels, and minimize the number of channels. The project design required the separation of the two functions into different channels. Farmers frequently redirected project channels into streams which were checked to make collecting ponds. This had the effect of maximizing water reuse and redirecting drainage water to add to the centralized supply being conveyed through project channels. Water was then diverted out of the ponds to downstream users. This common pattern helped ensure that the channel had value, at any given point, to both upper-enders (for drainage) and to lower-enders (for supply). Maintenance was more important to both upper and lower-enders than was the case where supply and drainage functions were kept distinct in different channels. However project design criteria separated supply from drainage channels. The project defined all natural streams as drainageways. Every six months it routinely destroyed farmer-built brush weirs along small streams and natural depressions within the command area with the intent of "normalizing the drainageways" to prevent obstruction of drainage.

Farmers were inclined to minimize both the number of channel divisions (especially at the upper ends of blocks) and the levels of network hierarchy. The project however, was based on a four-tier design, with the assumption that farm-level off-takes would be made only along quaternary channels. Farmers did not like to have lower-order channels branching out from higher-order channels and running parallel to each other for "long" distances (>200 metres). Many farmers were convinced by experience that such "excessive dividing" (especially if done too far upstream) increased conveyance losses. Light-textured soils were especially prevalent in the upper sections of the tertiary units. Hence, many quaternary channels were abolished or not used by the farmers. Turnouts were relocated downstream to where they branched away more directly from mother canals. The effect was to tend to consolidate flows into fewer channels.

One example of how farmers altered the design in a step-wise, trial-and-error approach involving socially-evaluated trade-offs, was in Block 18 where farmers chose to relocate a tertiary channel in accordance with farm boundaries, rather than in strict accordance with topography. They knew this would make it difficult or impossible for at least one or two relatively high terraces on one farmer's landholding (Farmer A) to get water from the realigned channel. They also knew that having the channel follow the boundary was very important to the farmer's productive capacity (Farmer A). They also knew that the field neighbour (Farmer B) always had more than adequate shallow groundwater beneath his land (mostly seepage from upper fields), which came to the surface in his lower field as this holding is situated in a slight basin, and that this water could be drained across the channel, via a small bamboo aqueduct, into the needy terraces of the Farmer A. Both farmers were on good terms, so the local water users association decided that the "receiving" farmer (Farmer A) would have an individual right to make private the neighbour's drainage (which otherwise would have gone back into the public channel). Only he (Farmer A) could pull out the aqueduct as needed, for drying.

Nevertheless when the small aqueduct did dry up under conditions of water scarcity, the needy farmer (Farmer A) opened up a new, temporary intake in yet another location to direct water into the terrace. Ordinarily this would not be allowed, but the group recognized the farmer's right to make this alteration temporarily. This decision to relocate a tertiary channel along farm boundaries as opposed to following the exact topographic line was dependent upon a period for testing water adequacy from multiple sources, negotiating rights of access to alternative water sources and evaluating the trade-off between part of a landholding not being served by the channel versus having land traversed by the channel.

3. ANALYSIS OF FARMER DESIGN CRITERIA

From the farmer interviews, criteria used by the farmers were elicited and categorized based upon the functional implications of the design alterations, as expressed by the farmers. A total of 113 criteria were specified in the cases, which represents an average of 4.2 related criteria per case. Criteria expressed or directly implied by the farmer design changes were grouped into ten categories of criteria. Their frequencies of occurrence are displayed in Figure 2. The criteria are of three types: 1) farmer criteria which conceptually were also used by the project (although obviously were quantified into hydraulic theory by the engineers), 2) farmer criteria which were additional to project criteria; and 3) farmer criteria which were incompatible with project criteria. The frequency of these types of criteria found in the interviews is shown in Table 1.

Regarding the first order of criteria, both farmers and project engineers accepted the rule that water head should be relatively even and adequate to reach the intended service area. Both were in agreement that distribution should be equitable according to area served. Both agreed that the tertiary-level structures should be within the abilities of farmers to operate and maintain. The problem was in the different information base which the farmers brought to bear against the criteria. It was micro-level, socio-technical and grounded in local experience. Farmers have told this author about significant variations in soil textures (sandy to loam) within single padi terraces of their parcels. The project's information was naturally survey-based, primarily limited to technical criteria (hydraulic, structural, agronomic, and meteorologic) and based on hydraulic theory. 42% of all redesign criteria elicited were cases where more detailed local knowledge prompted a different design, although the criteria were not in dispute between the agency and farmers (see Table 1).

A second order of criteria were those which were additional to, but not necessarily incompatible with, those used by the project. Three types of such criteria were expressed by farmers: 1) channels should follow farm boundaries whenever possible; 2) actual farmer land use preferences (such as planting tree crops); and 3) the design should incorporate prior farmer-built structures where these are still deemed useful by the users. These additional criteria accounted for 29% of the total elicited criteria.

The third order of criteria were those which were incompatible with project criteria. These were: 1) the utility of using multiple water sources; 2) combining conveyance and drainage functions in the same channel; and 3) minimizing channel divisions and levels of network hierarchy. This type of criteria constituted another 29% of the total criteria identified.

As shown in Figure 2, the most frequent criteria reported by farmers as a rationale for making design changes were questions of conveyance and distribution efficiencies, farm boundaries and the conjunctive use of alternative water sources. Together these criteria accounted for 61 of 113 incidences of elicited criteria (54%). Farmer criteria which were either additional to or incompatible with project criteria accounted for 58% of the farmer criteria elicited. Hence the majority of redesign criteria were outside the scope of project criteria.

4. CONCLUSION

This paper has sought to demonstrate the nature of contributions farmers can make in the design process. It has not evaluated the actual performance effects of the farmer alterations, although this should be a research priority. Farmer knowledge has four characteristics which make it a distinct and essential asset for the design process. It is: 1) holistic (cutting across disciplines of expertise); 2) experimental; 3) historical and dynamic; 4) sensitive to micro-level contextual diversity; and 5) in part, derived from locally-evaluated trade-offs and negotiating. This is not to say that these characteristics are only positive. Sensitivity to the micro-level context may include vested factional interests or preclude a system-wide perspective. However, a design process which is interactive, admits "double loop learning", and has system-wide performance objectives, should be structured to incorporate the positive aspects of local knowledge at the system level.

Sometimes it is asserted that farmer participation is needed so that the "social aspects" of irrigation will not be left out, implying that the technical aspects are the realm of the engineers. However the cases observed contained aspects which were as much of a technical nature as social. Design revision sometimes required negotiation and testing over several planting seasons. However exhaustive, resilient, or flexible a set of design criteria may be, it cannot substitute for the local knowledge obtained through dialogues with the farmers and the negotiated settlements of design trade-offs.

In such settings as this, conventional system designs should be considered as only preliminary approximations. What is usually needed in the irrigation design process, particularly where farmers have prior irrigation experience and will be future managers, is a "double-loop learning process" which would permit the questioning and potential revising-in-process-of-using "operating norms" (i.e. of design criteria), (see Figure 1); this is also referred to as a management capacity for "learning to learn" and "self-organizing."

Such a process requires two-way communication and mutual adjustment between design teams and the water users because part of the essential local knowledge and management criteria is only in the minds of the users (Smith, 1988). In such agency-farmer meetings, attention should be directed toward anticipated functional outcomes, performance expectations, local sustainability of new structures and operation and maintenance workplans of water users associations (see Coward, et al, nd, Pg IV-74).

Where agency staff or consultants are not trained or oriented to engage in such activities, the use of institutional organizers has often proven to be effective in ensuring a more participatory process. There is evidence that this does effect better designs and system performance as well (de los Reyes and Jopillo, 1986). However it has proven difficult to replicate this model on a national scale. Nevertheless the Indonesian program to turn over small-scale irrigation O&M to the farmers is currently attempting to do just that, by using agency staff as institutional organizers (Helmi and Douglas L. Vermillion, 1989).

The fact remains that most of these intensive efforts at more participatory design processes have been pilot projects, not routine national operating procedures. However, largely as a result of lessons learned from such pilot studies, the Indonesian Directorate General for Water Resources Development has recently formulated national policy guidelines to support farmer participation in future small-scale irrigation development (DGWRD/LP3ES, 1989). These guidelines include such things as:

1) the agency will react to farmer requests for assistance (rather than being the primary initiator);

2) farmers will submit a list which ranks the priorities of proposed improvements;

3) water users association (WUA) participation is required in each stage of the assistance process;

4) an agency field staff will function as a motivator, mediator, and facilitator for the WUA;

5) a simple farmer version of the design will be prepared, with the assistance of an agency staff, and will form the basis for preparation of a technical version;

6) the WUA will have a role in construction supervision;

7) local WUA investment along with the agency assistance will be encouraged.

It will be no small challenge for the Indonesian provincial irrigation services to reorient themselves toward implementing such progressive policies.

Table 1. Frequency of Occurrence of Three Types of Criteria

Type of Criteria	Frequency
Compatible Criteria but Different Information Base	47 (42 %)
Additional Farmer Criteria	33 (29 %)
Incompatible Criteria Between Farmer and Engineers	33 (29 %)
Total Related Criteria	113 (100 %)

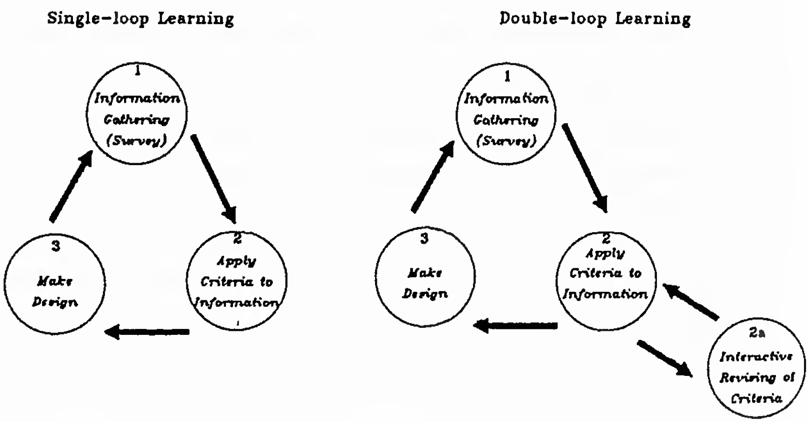

Figure 1. Alternative Irrigation Design Learning Processes

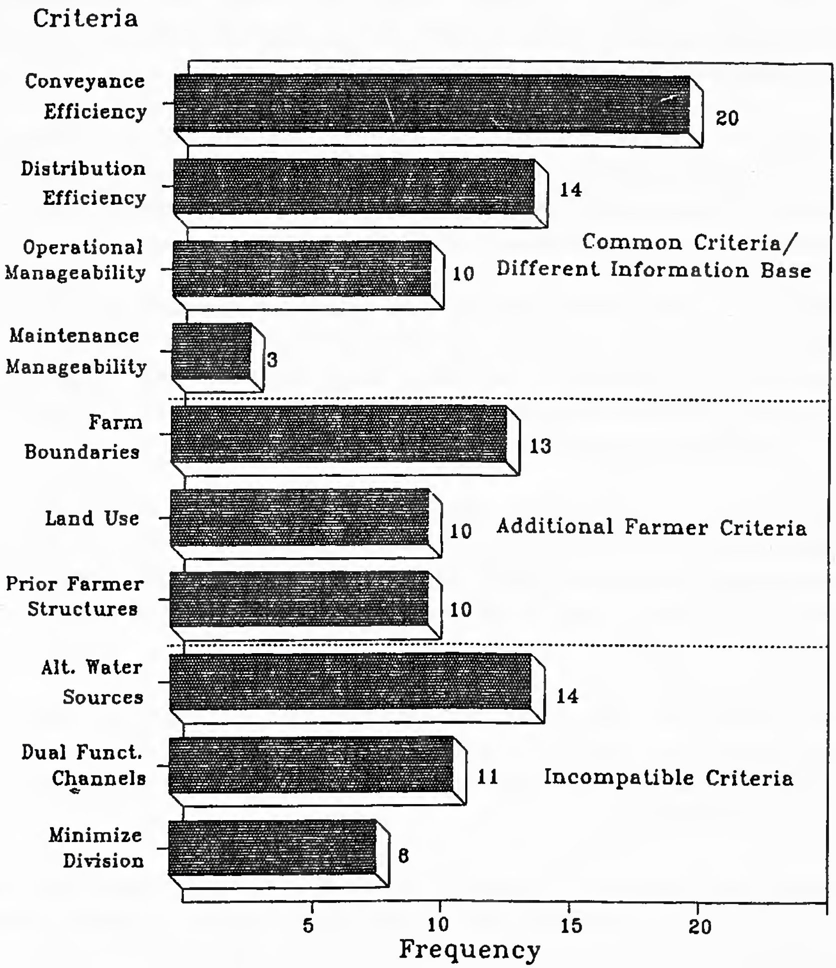

Figure 2. Frequency of Occurrence of Farmer Redesign Criteria
(27 Cases, 113 Total Frequency of Criteria)

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TUBEWELL IRRIGATION IN BANGLADESH

James Morton

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TUBEWELL IRRIGATION IN BANGLADESH

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TUBEWELL IRRIGATION IN BANGLADESH

James Morton

1. INTRODUCTION

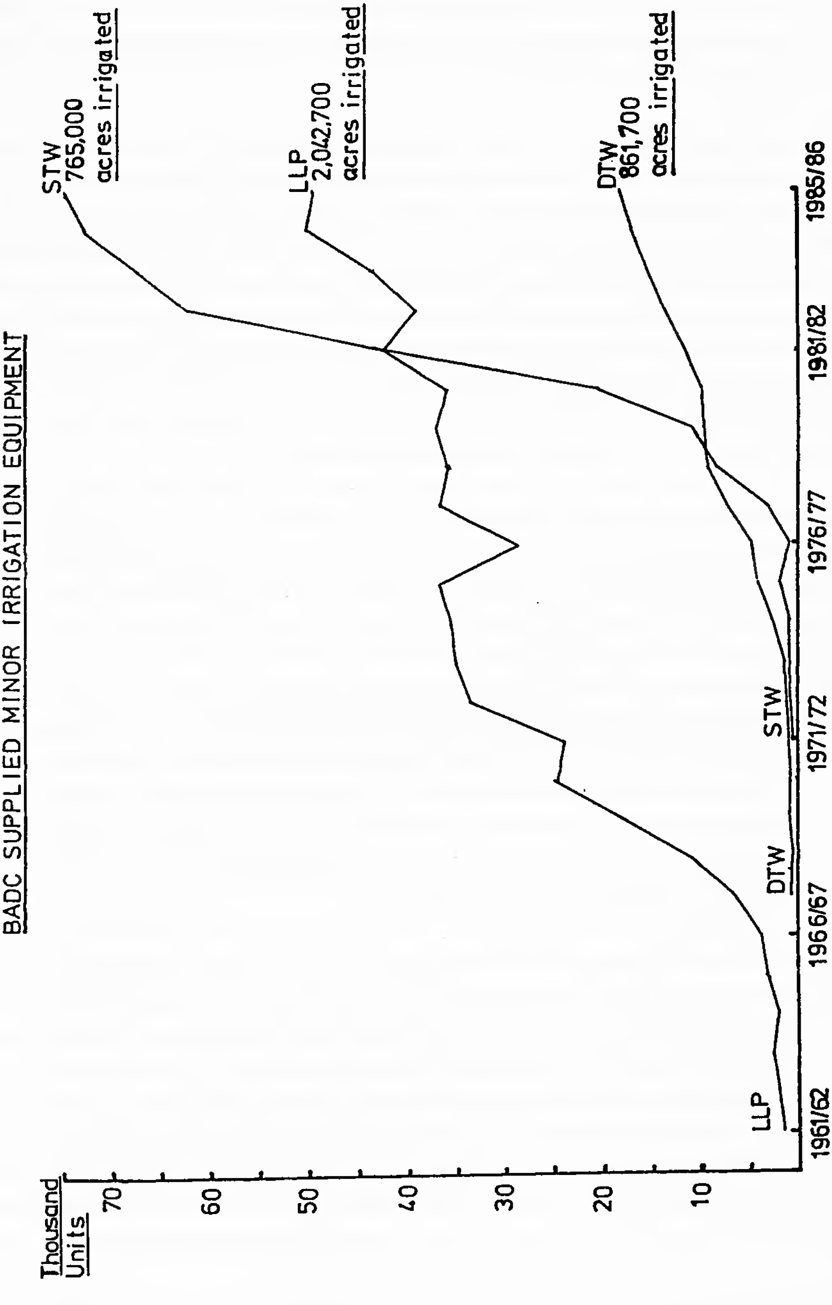
Traditional methods of raising surface water to irrigate dry season crops have made an important contribution to agricultural production in Bangladesh for a long time. More recently, the 1960s, 1970s and 1980s have seen a rapid expansion in the use of mechanical pumps in order to bring much larger areas under command. Figure 1 illustrates the pattern of expansion. During the early part of the period, low lift pumps (LLP) made the largest impact although deep tubewells (DTW) were also introduced on the higher ground. Hand tubewells (HTW) and shallow tubewells (STW) came later, but there was a particularly rapid expansion in the numbers of STW in the early 1980s. There have also been many gravity-fed surface irrigation schemes in Bangladesh but these raise different issues and are not considered here.

Despite the strong positive contribution to agricultural production, tubewell irrigation has become a subject of intense debate. Two points have attracted considerable attention:

1. Efficiency of utilisation - since the early period of DTW irrigation there has been disappointment that the irrigated acreages, per unit of rated discharge, have persistently fallen short of that which is estimated to be technically feasible. The norm has been 50 to 60 acres per 2 cusec DTW against a potential of more than a hundred. STW performance is equally poor. Drop out rates have also been high and much equipment has gone out of use or been diverted to non-irrigation purposes as a result.

2. Equity - There has been widespread concern that rural elites would capture control of minor irrigation equipment and use

FIGURE. 1


BADC SUPPLIED MINOR IRRIGATION EQUIPMENT
Thousand Units
70
60
50
40
30
20
10
1961/62
1966/67
1971/72
1976/77
1981/82
1985/86
LLP
DTW
STW
STW
765,000
acres irrigated
LLP
2,042,700
acres irrigated
DTW
861,700
acres irrigated

that control to further strengthen their position and exploit their neighbours. The coinage "waterlordism" sums up this possibility.

An attractive thesis links these two concerns, suggesting that the controlling elite deliberately restricts the irrigated area because the power to deny water is a weapon in factional struggles, even a means to prevent the poorer farmers benefitting. Much research work has, as a result, focused on the social aspects of tubewell operations: the interactions between the operator and the farmers and between both parties and the supporting government agencies. A number of projects have endeavoured to overcome these social constraints through cooperative or landless group management.

One purpose of this paper is to suggest that this emphasis on command area, together with social and equity factors, has obscured other aspects that are equally important and less well researched. These include:

1. Land Class - The land resource in Bangladesh forms one vast alluvial plain and there appears to be little variation. There are, however, significant differences in soil type and susceptibility to flooding. These variations affect the whole farming system. Evidence will be presented below showing marked differences in irrigated area per DTW between one land class and another.

2. Farming Systems - Everyone grows rice. However this apparent lack of variation once again conceals important differences in cropping pattern and technique. There are three growing seasons: Aman (Monsoon), Rabi/Boro (Dry Season) and Aus (Early Monsoon). The varieties grown and the techniques used are different for each season. Farmers must manage complex combinations if they are to achieve the optimum balance between the three rice seasons and between rice and other crops. The introduction of irrigation can

mean that substantial adjustments to the balance are necessary affecting all three seasons, not just the dry season.

3. Intensity - Depending on the land class and the farming system used, the way irrigation affects the system varies widely. In some cases it may enable a one hundred percent increase in crop intensity, in another it may actually lead to a small reduction. Although improved yields may still provide significant benefits in the latter case, it is almost inevitable that irrigation will prove less profitable and less attractive where it does not offer the chance to increase the number of crops grown per year.

4. Water Requirements - Crop water requirements, more precisely pumping requirements, are central to all calculations relating to mechanical irrigation, yet there is relatively little information on the amounts of water applied and the extent to which these fall short of or exceed the optimum. Much of the planning work that has been done, is based on theoretical crop requirements, the biological optimum. This may differ widely from both the economic optimum and the actual amounts applied, i.e. the farmer's own optimum. The fact that the economic water application is variable, depending on the cost of water and the value of the product, is usually ignored.

5. Financial Returns - There is a body of data on the profitability of the main irrigated crop, boro rice, although even that could be improved. The major lack is data on the profitability of other crops in the system, especially those in competition with boro rice. Since 1985, there has been a deceleration in the rate at which new tubewell irrigation equipment is being installed. This slowdown is a strong, if indirect, indication that the financial returns are not as attractive as they appear on the basis of existing data.

It is generally accepted that food self-sufficiency is a priority that must override all others in Bangladesh. However, the economic return to tubewell irrigation may be relatively low and the foreign exchange costs of achieving self-sufficiency high. The most cost-effective use is, therefore, very important. This depends on two factors: the choice of the most economical equipment and the efficiency with which it is used once it is installed.

In Section 2, an attempt is made to consider all the possible reasons for poor tubewell performance under four broad headings: technical, social, land class and economic. It is concluded that the last two have much the most significant impact on irrigated areas. In the context of land class, it is emphasised that irrigated area is a poor measure of economically efficient performance. The Net Incremental Cropped Area, a measure of the change in intensity, is a much better proxy although the Net Incremental Production is the only true measure. (For simplicity, however, the phrase 'irrigated area' is used except where the more exact definition is required.)

In Section 3, an analysis is made of the way in which the most economical technology mix is to be decided. This is a complex problem, the resolution of which involves all of the factors mentioned above. The distinction between the economic and the biological optimum crop water requirement is crucial. Time is a further complicating factor. It is necessary to decide not merely which technology, HTW, STW, or DTW, is most appropriate for each area in the long term but also how long the development period should be and which technologies may be appropriate in the short term, interim phases of that period.

This attempt to bring together all the elements that affect tubewell irrigation, raises more questions than it answers. It is hoped that it will, at least, indicate what is needed for a full evaluation of the various classes of equipment in use and highlight some areas where efforts to improve performance might be concentrated.

2. EQUIPMENT FACTORS

The reasons for poor tubewell performance may be sought in five separate areas:

i. Poor technical performance of the well
ii. Social barriers
iii. Mode of operation
iv. The land class
v. Economics

2.1 TECHNICAL PERFORMANCE

Aquifer problems, poor well design and poor construction can all mean that a tubewell does not produce the amount of water (discharge) it should. It is natural therefore to look for a connection between the discharge of the installed wells and the area irrigated. Several studies have, nevertheless, reached the conclusion that discharge is rarely a significant factor. One example may be quoted:

> "The research reported here has confirmed the occurrence of lower than design discharges and inefficient canal layouts with high conveyance losses, but it has shown that these are not related with the performance of the minor irrigation equipment".
> (Biswas, et al, 1986.)

The study quoted covered 100 units managed under a number of different institutional arrangements in two relatively small areas in Tangail and Dhaka districts. Monitoring data from the IDA DTW II Project, taken in conjunction with the project records of well performance at the time of installation, allow an analysis of the same question for over 1000 deep tubewells in 36 upazilas of Dhaka, Mymensingh and Kishorganj districts. This analysis confirms that even when only one technology under one institutional arrangement, DTW under the IDA project, is considered, discharge is not a significant influence on well performance as measured by the irrigated area. The correlation coefficient calculated for the relationship between the irrigated area at each DTW in 1987 and the discharge of the well measured at installation was only 0.041, indicating that discharge has almost no influence on area.

The conclusion must be that at the majority of sites, some other factor prevents the achievement of a large irrigated area. Most are too small for tubewell discharge to be a constraint. "While technical deficiencies existed there was no shortage of water except where cooperation among farmers and water suppliers had resulted in a considerable expansion of the command area." (Biswas, et al, op cit.)

It has also been suggested that slow engine running speeds are a factor. There is certainly evidence that some equipment is run at below the specified speed. There appear to be several reasons for this. It is, for example, often easier to manage smaller quantities of water, especially where distribution channels are weak and prone to collapse. Reducing rpm reduces the discharge to a manageable level. There is, also, a widespread feeling that slow running reduces the risk of breakdown and contributes to a longer machine life. In many cases this may even be true,. especially where poor construction means that vibration is high. In general it is clear that the "engine speed setting is a rational economic decision designed to economise power costs rather than an independent variable explaining performance". (Biswas, et al, op cit.)

If low discharge or slow running speeds were the major factor behind the small irrigated area, it would be expected that the equipment would be used for long hours in order to compensate.

Once again the IDA DTW II monitoring data does not support this. The hours operated on the busiest day of each month was recorded. The average of this, which is very much a maximum figure, for all wells monitored did not exceed 8 hours, even in peak season.

There is one indirect manner in which the technical performance of the equipment could affect the irrigated area: if it was so unreliable that farmers would not risk an irrigated crop. As will be discussed, the water market in many areas of Bangladesh is highly competitive and farmers often switch from one tubewell to another for their water. Unreliability is one of the commonest reasons for changing to a new supplier. However, switching between suppliers does affect the overall irrigated area; one well's loss is another one's gain. There is less evidence of farmers refusing to risk an irrigated crop because they did not trust the equipment.

To sum up, it does not appear that the technical performance is a major constraint to command area utilisation, at the present level of operation. This is not to say that there is not considerable scope for improvements in well design, installation and maintenance. Costs of operation could be substantially reduced at may sites. Nevertheless the major barriers to tubewell performance lie elsewhere.

2.2 SOCIAL FACTORS

"The widespread factional conflicts among farmers, the conflicting interests and relationships between large and small farmers and the understandable suspicions that are held of the motives of richer farmers who typically come to control water supplies, often lead to failure of cooperation over the distribution of water". Thus Palmer-Jones in his paper 'Research on the Landless Programme of Proshika', (in Biswas, et al, 1986) neatly sums up a common perception of the situation.

Clearly, one overriding factor, and one that can only be solved by balanced development in the Bangladesh economy as a whole, is the intense pressure of population and hence competition for a meagre farm livelihood. Against this background there are, however, two separate forms of tension: the social, where irrigation is caught up in some wider struggle within the community, and the financial where the battle is more direct, between the operator of the tubewell, as the supplier of water, and the irrigating farmers, as consumers of water. This latter aspect is considered in the next section.

"Widespread factional conflicts" reflect the vertical divisions with society, that is to say between kinship or neighbouring groupings. "Conflicting interest and relationships between large and small farmers" reflect the tendency to polarisation by social class in rural society. Such horizontal, class divisions are incompatible with vertical factional divisions. In order to maintain factional unity all classes are likely to have an interest in working together and vice versa.

It is not easy to assess the extent to which the evident social tensions in rural Bangladesh are caused by class rather than faction, a question well beyond the scope of this paper. It should, however, be noted that although the distribution of land is unequal, it is almost continuous. That is to say that there is no clear point at which a dividing line between "small" and "large" farmers can be drawn. The elimination of the medium-sized farm is one of the first signs of agricultural stratification and of emerging class divisions. The large farms get larger and the small, smaller and a gap appears in the middle. The fact that there is no such gap in the distribution of land in Bangladesh indicates that class divisions are as yet relatively weak. The techniques used, and the levels of intensity, are also very similar on all classes of farm. There is little evidence that economies of scale are *driving out the* middle farmer and creating two distinct classes of operation.

Nevertheless, it might be that powerful irrigation equipment will increase the power of the better-off to an extent that a process of agricultural stratification is reinforced, or set in motion. This would be expected to manifest itself through increased sales of land by the medium and small farmers and through the larger farmers preferring to operate a greater proportion of their land themselves rather than lease it out. The 1985/86 Annual Evaluation Survey of IDA deep tubewell sites (EPC, 1986) found no evidence that this was happening. Sales of land were negligible at all levels and the larger landowners rented out a substantial proportion of their holdings. An earlier study in a different area reached similar conclusions. "The position regarding rural elites must be kept in perspective. In the study area, land holdings are relatively uniform in size and even the farmers with larger holdings are working farmers." (MMP/HTS, 1982.)

Even if class divisions did exist, it is difficult to see how they should be a barrier to efficient tubewell use. If larger farmers wished to use their control of a tubewell to squeeze out their neighbours, their goal would be to gain control of the smaller farmers' land and then use their tubewell to irrigate it once they had done so. In short, it is more likely that the efficient use of tubewell equipment will lead to class stratification than it is that class stratification will be a block to such efficient use.

To sum up, it is difficult to derive a logical mechanism that explains how class-based social tensions might pose an obstacle to efficient tubewell operation. In addition, the evidence that social factors of either type are a major factor is not as compelling as is often reported. "Only in one of twenty live schemes studied was there the <u>possibility</u> that social factors were sufficiently strong to disrupt the group." (MMP/HTS, 1982.)

2.3 MANNER OF PAYMENT

Except where complicated by social factors, "the suspicions that are held of the motives of the richer farmers who typically come to control water supplies", described in the Palmer-Jones quote above, reflect the tensions that are to be found between any group of consumers and their supplier. From the consumers' point of view, the principal points of conflict are the quality of the service supplied and the cost. The suppliers' main concern is to ensure payment.

Palmer-Jones and Mandal have shown that the manner of payment is "one economic variable quite strongly associated with (tubewell) performance" (Palmer-Jones & Mandal, 1987). It seems most likely that the payment system is closely linked to the state of the consumer-supplier relationship and it is worth trying to analyse the implications of each particular system. There are three systems in common use. The first one broadly accords with that recommended under the government sponsored Irrigation Management Programme (IMP). That is to say that the operator, or the cooperative group, draws up a budget in advance of the season and calculates a per acre charge for water. In principal this charge includes allowance for the costs of capital repayment, depreciation, pump driver's wage, etc. However, there are many variations. Sometimes the capital charge is collected separately and it is common for the driver to be paid in kind. In almost all cases the charge is paid in several instalments through the season rather than as a lump sum in advance.

The second approach is for the major variable cost, fuel, to be charged for separately at the time of watering. A lower flat-rate, per acre charge is still made to cover fixed costs. At the extreme this system requires each farmer to bring his own fuel and hand it to the operator at the time he wants to water his field. It is possible to see a collection of old bottles, jugs and pots of diesel queued up outside a pump-house when this system is being used. Clearly this could lead to heavy water losses if farmers from different parts of the command area called for water at the same time. Stopping and starting the engine too often would also be wasteful. In fact, it appears that the farmers do usually organise themselves into sensible groups so that a block of fields is irrigated on one session even though each man brings his own fuel.

Those involved advance two reasons for adopting this system. First, it significantly reduces the supplier's collection problem if the consumer pays at least part of the costs himself. Second, it provides an incentive to economise on the use of water and allows the farmer to control the major quality factor, the amount of water he gets. Under the flat rate system, every farmer is going to demand as much water as possible since it costs nothing extra and this is a natural source of conflict with the supplier who will want to minimise his operating time.

More technically, the direct fuel supply system introduces an element of marginal cost pricing in that the owners of more distant fields, which require longer pumping to offset channel losses would, in theory, have to supply more fuel. In practice, it appears that the fuel is not always measured to this degree of accuracy. Often there is merely a rule-of-thumb measure that decides how much fuel must be supplied for a given area.

The last method of payment is by crop share. The most common rate at present is one quarter, although there is evidence that it is variable according to market conditions. (Palmer-Jones, & Mandal, 1987.)

It would appear that payment by crop share offers the consumer, i.e. the farmer, advantages. First, it means that the supplier has a direct interest in supplying sufficient water. Second, there is an element of what might be called marginal product pricing. That is to say that those who achieve a high yield pay more and those who do not, especially those on the margins of the command are who receive less water, pay less. There are, nevertheless, reported cases of farmers resisting a change to this system.

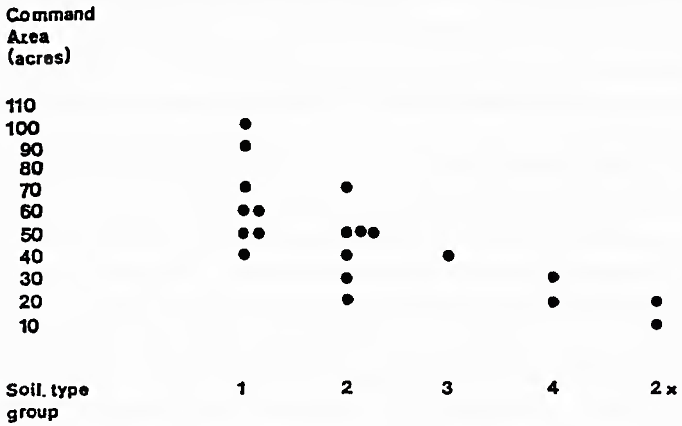
The fuel-supply and the crop share system represent two opposite poles in one important sense. The first minimises the operator's working capital investment in that he does not finance the major variable cost. Under the crop share system, on the other hand, the operator finances all the working capital right up until the harvest. This represents a saving to the farmers and hence is a further advantage to them. Despite this survey, results have shown that both systems perform worse, at least in command area terms, than the flat rate charge. (Palmer-Jones & Mandal, 1987.) It is possible that it is the common factor between the two systems that is important. Both minimise the management problem, in particular over the collection of water charges. Where management is weak or relations between the tubewell manager and the farmers are poor then command areas are likely to be small and both sides are more likely to opt for one of the two payment systems described. Where there is more trust, the more formal payment system is preferred and at the same time a greater irrigated area is achieved.

2.4 LAND CLASS

A small survey of 20 DTW carried out as part of the feasibility study for the Asian Development Bank (ADB) Second Tubewell Project (MMP/HTS, 1982), indicated that land class was a significant factor in the way the tubewells performed. Irrigated areas varied markedly over a range of land classes. However, this was shown to be a very imperfect indication of the tubewells' performance because crop intensities in classes with high average command areas were much lower. The net incremental cropped area (NIA) attributable to tubewell irrigation was therefore much more even between land classes. It must be stressed that it is the latter parameter, the net incremental area, that is the true measure of tubewell performance, not the

FIGURE. 2

RELATIONSHIP BETWEEN SOILS & COMMAND AREA



RELATIONSHIP BETWEEN SOIL TYPE & INCREASE IN CROPPED AREA

AFTER DTW INSTALLATION

Note; Each ● represents one scheme
Total cropped area = command area x cropping intensity

source - MMP/HTS 1982

irrigated area. Figure 2 illustrates the way both the irrigated area and the increase in cropped area (NIA) varied according to land class in the ADB study.

The five soil types shown in the figure are described as follows:

Group 1 - good paddy soils
2 - other paddy soils
3 - light, arable non-paddy soils
4 - unsuitable soils including very light soils
5 - unsuitable sites in Madhupur tract.

The most striking feature is the relatively poor performance of the good paddy soils in NIA terms. Much more research is required on the way the various farming constraints interact before this can be fully explained. However, since it may cause surprise that irrigation can be used without a significant impact on crop intensities it is worth discussing the most extreme case, which is by no means unusual.

In low lying areas, typical for good paddy soils, the traditional pattern combines a major monsoon crop, deep water rice, with limited areas of early dry season crops such as mustard. The rice is largely at the mercy of the floods and the secondary crop depends on residual moisture. Neither yields particularly well but both are cheap to grow as expensive inputs are not used. Under these circumstances it can be attractive to convert to an irrigated dry season crop, boro rice. This allows the use of a full HYV seed and fertiliser package, generating substantially higher yields. It does, however, mean that both the deep water rice and the secondary crop are given up and a small reduction in crop intensity results.

It is not clear why it is not possible to combine the boro and deep water rice crops. It may be that there is not enough time between the end of the boro harvest and the arrival of the floods to allow the deep water rice to be planted. Whatever the reason, the loss of the monsoon crop represents a major opportunity cost attributable to tubewell irrigation. The net benefits of irrigation are therefore significantly less in these areas when compared to those where the introduction of an irrigated boro crop does not preclude a second, monsoon season rice crop.

Analysis of the irrigated areas reported in the monthly monitoring of DTW under the IDA II Project reveals substantial differences by land class, confirming at least the first stage of the ADB study's conclusions: that land class affects performance. Table 1 shows the results. The table also shows the percentage of high land and the percentage of land with permeable soils in each class, these being the characteristics that are most likely to affect tubewell performance.

These results make it clear that land class is a highly significant factor. Even if classes with relatively few operating wells are excluded, there is a difference of over 15 acres per well between the better and poorer land classes. The difference between the best and worst is 44 acres. Most noticeable is the fact that almost all those land classes where the average irrigated area is over 50 acres have less than 10% permeable land. Only two classes, 2A and 7D, which have less than 10% permeable have less than 50 acres irrigated.

Where the proportion of permeable soils is higher and the acreage is lower, the situation is less clear cut. For example, class 3A has an average area 14 acres higher than 3C for nearly identical percentages permeable. Classes 7F and 7G have nearly the same acreage for widely different combinations of high and permeable land.

Table 1: IDA II DEEP TUBEWELLS BY LAND CLASS, 1987 IRRIGATION SEASON

Land Class	Highland %	Permeable %	AV crop area acres/DTW	No of DTW operating
2A	31.5	3.8	48.4	19
2B	86.0	6.0	56.8	24
3A	66.3	18.3	48.3	108
3B	4.9	9.4	60.9	9
3C	30.2	19.6	34.6	17
4A	62.0	0.8	55.1	114
4B	17.6	0.2	56.7	61
4C	55.4	0.0	55.5	155
5B	0.0	0.0	68.9	8
5D	100.0	60.0	56.2	4
6A	46.2	51.2	39.2	30
6B	12.4	20.9	41.5	209
6C	0.0	3.6	59.4	8
7A	86.2	66.6	41.6	28
7B	58.6	53.8	41.8	90
7C	40.6	35.6	25.0	2
7D	70.0	0.0	41.8	11
7E	81.3	25.8	39.8	37
7F	65.7	39.4	48.8	29
7G	1.0	11.1	47.6	9
9E	1.1	0.0	58.5	8
9H	12.0	0.0	60.0	3

NB: Land classes as described in Consultants Working Paper No 14 Annex I, IDA DTW II Project, BADC Dhaka. Classes 7A to 7G are on the Madhupur tract, an area of higher land with distinctive orange soils. All the other classes are on the floodplains of the Padma and old Brahmaputra rivers.

Permeable soils affect irrigated areas in several ways. An increased crop water requirement to compensate for high percolation losses is only one of them. The ADB study (MMP/HTS, op cit) indicates that the way earth channels tend to collapse on the lighter soils is one of the biggest barriers to an increase in irrigated area.

It is clear that the most effective approach to improving irrigation performance will differ considerably between areas where low permeability and other factors allow large areas to be irrigated easily and those where soils and topography are a significant constraint. In the former it is likely that early attention to raising crop intensities will be necessary if the full potential improvement in total annual cropped area is to be achieved. In the latter, the existing emphasis on distribution techniques will continue to be more important.

2.5 ECONOMIC FACTORS

In the past, the capital cost of tubewell and other mechanical irrigation equipment has been heavily and directly subsidised. Despite moves to reduce it, there remains a considerable subsidy element, both direct and indirect. There are many rental DTW still operating despite an official policy that they be sold. Rents are well below the full cost. Even when sold, the price of a DTW is subsidised on the principle that the unit cost of DTW water should not exceed that for water from a shallow tubewell, for which the capital cost is much less per gallon of water delivered. In principle, STW are now sold at full cost. However, "as anyone who knows the reality of rural Bangladesh must realise" the widespread failure to repay loans taken out to purchase irrigation equipment represents a further massive element of indirect subsidy. (Biswas M R, et al, op cit.)

It has been suggested that the high subsidy is not a disincentive to the proper utilisation of tubewell equipment because it is a subsidy on the fixed, capital cost. Since tubewell operators will aim to fix the area irrigated by matching marginal revenue with marginal cost, which is unaffected by changes in the fixed cost, so subsidies on capital do not affect command area.

A major purpose of this paper is to demonstrate that this argument is false and to submit that much of what is seen to be happening in the Bangladesh water market is the direct result of the low price of irrigation equipment. This is because the argument fails to draw the distinction between the economics of an individual firm, in this case the tubewell operator, and the economics of the tubewell irrigation industry as a whole. For the industry the fixed capital cost is a key factor directly affecting the average area irrigated per tubewell unit. This is because a low equipment price means high profits which encourages the purchase and establishment of too many units, each irrigating a less than efficient area.

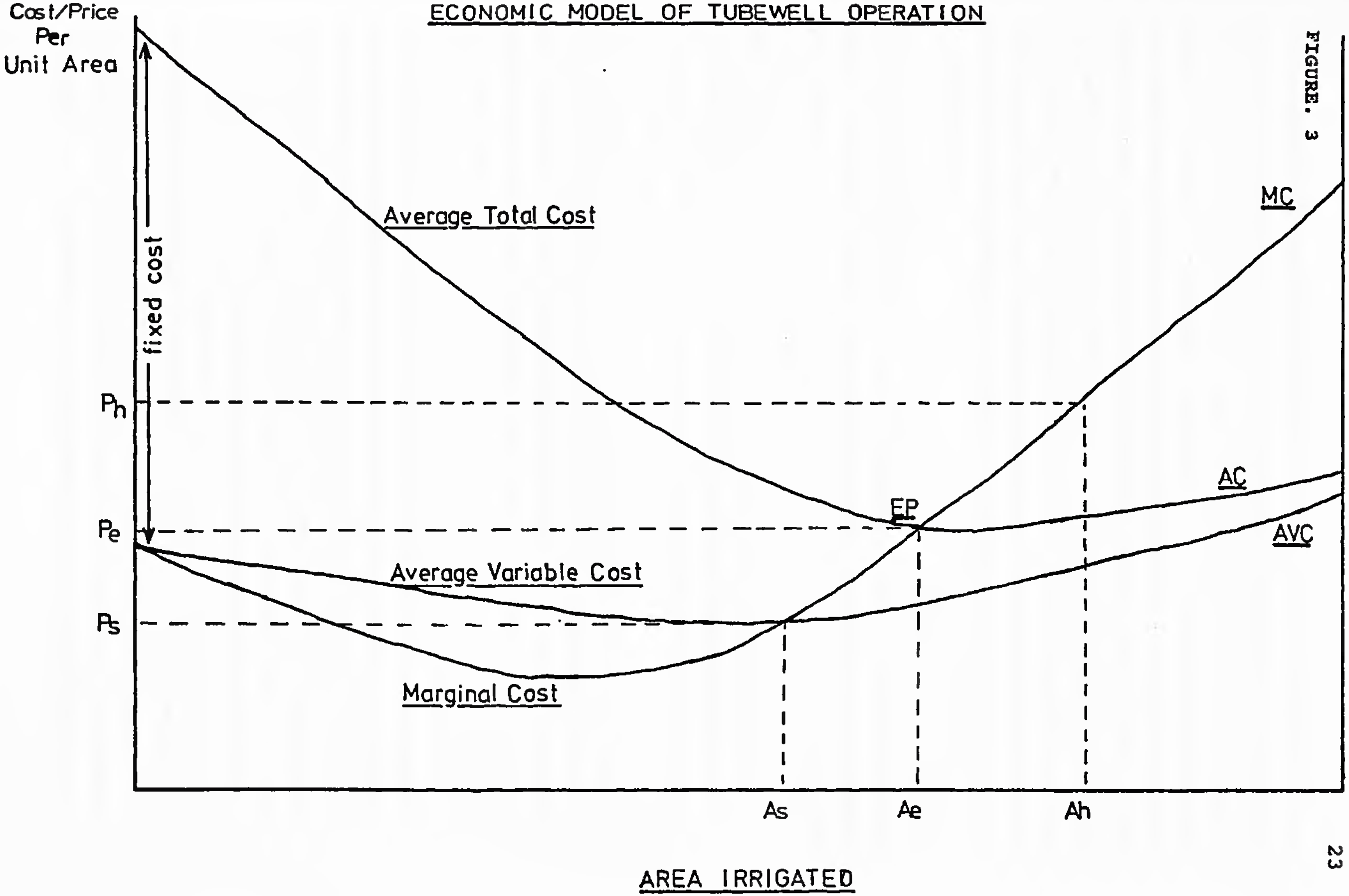
In their publication 'The Water Market in Bangladesh' which has already been quoted several times, Biswas M R, et al raise the question "Inefficient and Inequitable?" as a subtitle. They show extensive evidence of fierce competition between suppliers in the irrigation water market. This competition is most evident in the widespread occurrence of overlapping command areas. It is commonplace to find several STW operating within a DTW area and there is considerable overlap between STW areas as well. Although DTW siting is more controlled there are still many cases of overlapping DTW areas. Even as early as 1981/82, the ADB study, mentioned above, was reporting similar competition: "The main command area studies indicated that overlap with other irrigation units (particularly STWs) was often a distinct constraint." (MMP/HTS, op cit.) The result is that many farmers are able to choose between two or more suppliers of water.

Biswas concludes, undoubtedly correctly, that the water market is, at least, efficient. This clearly conflicts with the equally solid evidence that the equipment is not being used to its most technically efficient capacity. The crucial link between these two facts is the level of subsidy which has encouraged the establishment of excessive concentrations of tubewell equipment. In short the market is working efficiently but it is reacting to the wrong price signals.

Figure 3 illustrates the way the subsidy affects the average area irrigated per unit of equipment, i.e. per well, in a more

FIGURE. 3

ECONOMIC MODEL OF TUBEWELL OPERATION



rigorous manner using an entirely standard theoretical model of an individual tubewell operation. The X axis measures the area irrigated and the Y axis the average marginal costs as well as the unit area price for irrigation. The curve marked AC shows the Average Cost per acre, the AVC curve the Average Variable Cost and the difference between them indicates the Average Fixed Cost. At zero acres irrigated this difference is equivalent to the Total Fixed Cost. As determined by the mathematics of the situation the Marginal Cost (the MC curve) lies below the AVC and AC curves while each of them is falling and cuts them from below at their lowest point.

For the purpose of this analysis the point labelled EP, where the MC curve cuts the AC curve is crucial. The argument is as follows:

1. If the price per acre irrigated is higher than Pe, say Ph, then the tubewell owner will supply Ah acres so as to equate price and marginal cost.

2. However, at the position Ph/Ah the owner will make excess profits because the price is above the average cost. (Normal profit, i.e. the opportunity cost of capital and management effort is already included in the AC and AVC cost.)

3. Conversely, if the price per acre is lower than Pe, say Ps, then the operator will not cover his costs, including normal profit. Between Ps and Pe he will continue to operate because he will at least cover his variable costs. Below Ps he will not operate at all and he will close his tubewell. (Technically Ps is the Shutdown Price.)

4. Above Pe, in the region of excess profits, it is attractive to other entrepreneurs to enter the irrigation industry. Below Pe those already in the industry will be trying to liquidate their fixed costs and stop operation. Above Pe,

increasing numbers of operators will drive the price per acre down. Below Pe, a reduction in industry capacity will drive it up.

5. The position Pe/Ae, where the MC curve cuts the AC curve, therefore represents the industry equilibrium: i.e. that point at which tubewell owners (more correctly the marginal owner) make normal profits only. None will be making a loss and so closing down but equally none will be making excess profits sufficient to attract entrepreneurs to set up new tubewells.

This point EP, for Equilibrium Point or more tellingly Entry Point, where an entrepreneur decides whether or not to 'enter' the industry, is the critical determinant of both price and the <u>average area irrigated</u> per unit of tubewell equipment. As the figure shows, an increase in the fixed cost would move the Average Cost curve, and with it EP, up and to the right along the MC curve, leading to an increased price and a higher average irrigated area.

There are a number of points that arise from this model. First, the extent to which an increase in the fixed cost raises price and the extent to which it raises the irrigated area per unit of equipment depend on the slope of the MC curve. If variable and marginal costs are increasing slowly, then MC will be flat and the majority of any increase in fixed cost will be recovered through an increase in the area per unit. Price will not increase by much. Conversely, if MC is steep then price will rise sharply and the area per unit will not change greatly.

As mentioned at the beginning, it is widely believed that tubewell irrigation equipment is not being used to its technical capacity. This should mean that area can be expanded cheaply and the slope of MC will thus be small. Nevertheless the evidence on land class discussed in Section 2.3 suggests that there are technical barriers to greater irrigated areas which may be expensive to overcome. Section 2.2 indicates that transaction and supervision costs are significant and they too may increase quickly as area grows. For both these reasons MC may be steep.

This raises crucial questions about the value of subsidies on tubewell equipment since such subsidies reduce the fixed cost. This means that they have a direct effect on the irrigated area per unit of equipment, i.e. on performance. As the model shows, the size of that effect depends on the slope of the MC curve which is determined by the technical and socio-economic constraints to area expansion. If the MC curve is flat, area per unit of equipment can be expanded cheaply. Subsidies would, therefore, be counter productive since they would encourage excessive investment in irrigation equipment without making the price of water significantly cheaper or inducing any expansion in the total area irrigated.

If, on the other hand, the MC curve is steep, subsidy may be a more useful means to support farmers and the resulting inefficiency in the use of irrigation equipment may be taken as an acceptable cost which must be borne in order to provide that support. It might also be valid to argue that some degree of inefficiency is worthwhile if it ensures a genuinely competitive water market. There are significant equity benefits. More entrepreneurs, especially those with relatively little capital, gain access to the market and hot competition is a defence against monopoly or cartel practices that might be used against the farmers.

Despite the evidence in Sections 2.2 and 2.3 that there are significant constraints to unit area expansion, the intensity of competition between tubewells indicates that the tubewell industry as a whole is currently operating in an area where the MC curve is flat. That is to say that a reduction in subsidy is likely to induce an improvement in unit performance and a reduction in the number of tubewell units in operation without any significant increase in the cost of water to the consumer.

3. CHOICE OF TECHNOLOGY

For irrigation in Bangladesh there are two choices to be made. First it has to be decided whether surface water is to be used, by means of gravity fed or LLP schemes, or whether some form of tubewell development of the groundwater is more suitable. The second decision concerns which type of tubewell to adopt: DTW, STW or HTW. It is this second choice, and in particular the choice between DTW and STW that is considered here. The widespread evidence of competition between STW and DTW indicates that there are several areas where one or other technology is inappropriate, since DTW are more expensive and should only be installed where STW are unable to access sufficient water. Both types should not be operating in one area. Some means to assess which is the correct technology in a given area is required.

This might seem a relatively straightforward matter, decided merely on the balance between the available groundwater and the land to be irrigated. Where there is sufficient water at depths accessible to the cheaper technology, STW, for it to irrigate all the available land then that must be preferred. Where it is only by the use of DTW that enough water can be reached to ensure that all the land can be irrigated then that is the technology to use. There have been variations on this theme whereby, for example, STW zones are declared to be those where 90% of the land can be irrigated from shallow aquifers. Otherwise the area is a DTW zone. Despite the variations, this same basic line of thought has underlain all attempts to plan groundwater development to date.

There are two problems with this approach. The first is that STW equipment is easily moved and very large quantities are now available so that the enforcement of zoning is difficult. The high degree of competition in the tubewell water market, which has already been discussed, reflects the failure of zoning.

However, the second problem is much more difficult, and that is how to actually draw the boundaries between one zone and the next and decide which is suitable for STW and which is not. It is for a start, hard to assess the available groundwater accurately enough for these purposes. Even more complex is the calculation of water required to irrigate the available land and hence decide whether STW alone will suffice or some recourse to DTW will be necessary.

Most planning models define the water requirement using standard crop evapotranspiration calculations combined with assessments of soil permeability and other factors. As already mentioned, this represents the biological optimum water requirement which does not necessarily equal the economic optimum or the most profitable level of irrigation for the farmer. The use of this biological optimum to indicate the maximum allowable level of groundwater extraction is the safe, conservative approach to determining the total level of extractive capacity since it guarantees enough water for all users. Unfortunately it can lead to the wrong conclusion when used to determine the choice of technology.

This needs some explanation. Take, for example, a discrete area of land with its own unique groundwater resource. At the maximum, STW can extract enough water to irrigate 60% of the land to the full crop water requirement, the biological optimum. In order to irrigate the whole area to the same level DTW will be necessary. However, the marginal cost of water is such that, in fact, farmers find that the marginal yield increment at the biological optimum is too low. They only apply, therefore, 60% of the estimated full crop water requirement, at which level the value of the marginal yield justifies the cost of pumping. This means that STW can, at the levels of water use farmers will choose, actually irrigate the whole area. The introduction of DTW will, therefore, only result in heavy subsidy costs and probably, since the marginal cost of DTW water is likely to be higher than for STW even after subsidy, a reduction in yield since farmers will cut their water applications back even further.

It is worth emphasising that these considerations are much more important in tubewell irrigation, where the marginal costs in fuel etc are high, than they would be in a gravity fed irrigation scheme where the marginal costs are low and farmers' water applications will come close to the full crop water requirement. Many of the techniques used to assess water requirements were developed for gravity fed schemes and insufficient adjustment is sometimes made for crucial differences in the character of tubewell irrigation.

To sum up, it is possible, indeed likely, that farmers will apply less water than the maximum crop water requirement. As a result the cheaper STW technology has a bigger role to play than that suggested in planning models based on maximum water requirements.

Time is a complicating factor. The life of a STW is roughly half that of a DTW. Since it inevitably takes several years to build up to a level of 100% irrigation, there will be a long period in which STW are perfectly viable even in an area where DTW are, in the long run, the only choice. Take the example area once again and accept that STW can only irrigate 60%. Any STW that is installed more than five years before the 60% level is reached is likely to be profitable since it can be used to full capacity for all that time. Indeed, there will not be any violent cut off when the critical level is reached. Instead there will be a more or less gentle decline in the amount of water available to STW as DTW start to extract more. Many STW will continue to be profitable for some time after the 60% level is breached and DTW are introduced. There may even be some areas where STW are always viable even at 100% development.

FIGURE. 4

A MODEL OF MIXED TECHNOLOGY DEVELOPMENT

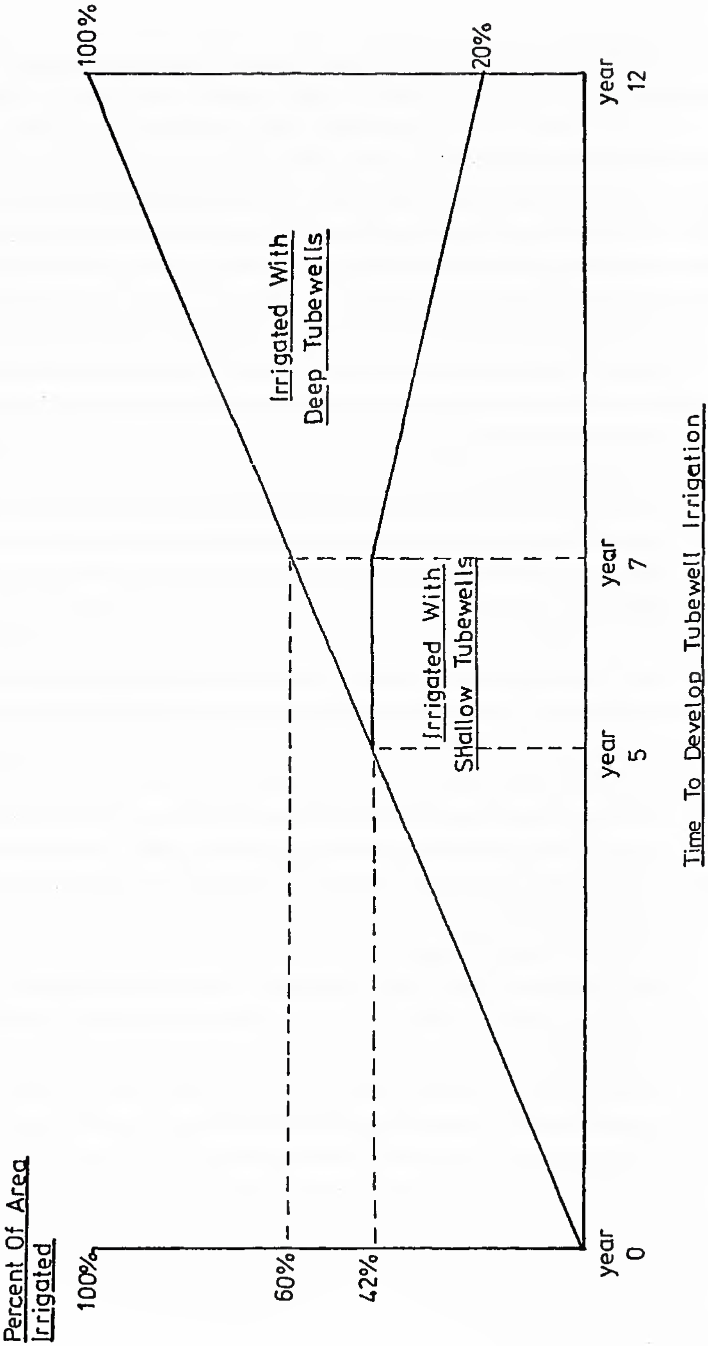


Figure 4 illustrates a very simple model indicating the ideal pattern of development over time. In the early stages any STW installed are likely to have more than enough time to pay back their investment costs before the water runs out. By year five, however, the deadline of 60% irrigation is only two years away and STW development should stop. DTW will be introduced then, to continue the expansion. Later on, as STW reach the end of their lives, DTW will start to take over land which was first irrigated with the smaller equipment. The area irrigated by STW will thus fall back to a base level of 20% at which they remain viable even when full development is achieved.

To make the model more realistic, many factors such as equipment life, payback periods and interest rates would have to be considered, even where the technical characteristics of the groundwater availability and the crop water requirements are fully understood. The most important factor of all, however, is the ability of the farming community to absorb irrigation capacity. This will determine the length of the development period. Over a long development, STW may be viable up to a level close to the 60% cut off. If the development is quick, on the other hand, few STW will have long enough to repay the capital invested and DTW will be introduced early.

This seems very academic and it might be suggested that a relatively broad approach to planning is all that is necessary or indeed possible. This is not so because of the risk of major over-expenditure on either one or other technology. If STW expansion goes too far, then many wells will go dry before they have paid back the investment made. If DTW are introduced too early, an unnecessary subsidy cost will be incurred.

To conclude, the vital requirement for a resolution of the technology choice is an understanding of the relative economic performance of both types of equipment, especially the viable life of each, and an accurate estimate of the economic level of irrigation water to apply. It may be emphasised that where the conclusion is doubtful, the decision should probably go to STW. These are much cheaper and more flexible and they have a shorter pay back period.

For these reasons, STW are to some extent, self-regulating. Where high extraction starts to drive the water level out of the reach of STW, it will be relatively easy for some of the operators to liquidate their investment and move their equipment elsewhere so that extraction is brought back into balance with supply. Careful monitoring in predominantly STW areas would allow a relatively timely decision on whether to start the introduction of DTW and when. This would be preferable to endeavouring to accelerate the pace of development by anticipating the moment for DTW. The costs of this approach, in subsidies and wasted resources, would be high.

4. CONCLUSION

This paper has raised a number of different points, some more closely related than others. There is nevertheless one underlying theme. That is to highlight the need for a full understanding of the technical and economic characteristics of tubewell irrigation at the micro or farmer level, before major planning decisions are made:

i. Social factors are not as large a barrier to the efficient use of irrigation equipment as is sometimes believed. However the transactions cost of managing irrigation by large groups of small farmers is significant.

ii. The net incremental cropped area for the whole year is the true measure of tubewell performance, not the area irrigated alone which ignores the way irrigation affects the non-irrigated crop, a significant opportunity cost.

iii. Tubewell performance is strongly affected by land class, i.e. by the combination of soils and topography. Efforts to improve performance must be specifically designed to suit each area.

vi. Subsidies on equipment are directly reflected in excessive competition in the irrigation market and consequently, poor per unit performance.

v. In many areas a choice has to be made between STW and DTW. Because of the large difference in cost between them the choice must be correct but it involves a complex set of factors that will be very difficult to estimate accurately. The best approach may be to give the lead to the cheaper technology, STW, and ensure by careful monitoring that the moment for a change over to DTW is not missed.

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IRRIGATION CHARGES IN THE BARIND INTEGRATED AREA DEVELOPMENT PROJECT: A NEW APPROACH

M Asaduzzaman

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M ASADUZZAMAN

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EDITOR'S PREFACE

Cost recovery, water pricing and fee collection systems which encourage financial discipline and operational efficiency have been a regular item of discussion within these IMN papers[1]. *This paper describes the evolution of charges, collection procedures and their use in the Barind Integrated Area Development Project in Bangladesh (BIADP). These developments are a direct result of dissemination of the debate on irrigation charges. The BIADP started in 1986/87, and has the expansion of a deep tubewell (DTW) programme as a major component. This recent beginning has enabled it to benefit both from discussion in the literature on irrigation charges, and the experience of earlier programmes of irrigation expansion in Bangladesh. The irrigation charges levied in the BIADP were first derived in relation to recovery of the capital costs of irrigation infrastructure, while also being related to the increased incomes available from irrigated production. Charges recovered were repaid to the Government, who in turn released funds for recurrent costs which bore little relation to actual costs. This poor relationship threatened the efficiency of the maintenance service that could be provided, and the commitment of the staff involved. In turn, the farmers were unable to see the relationship between fees paid and the service provided, which lessened incentives to pay charges. These types of problems have been discussed by Sagardoy (1982) and summarised by Tiffen (1985).*

The BIADP policies recognise the importance of a direct financial and contractual relationship between the agency providing the service and the farmers receiving it. The management of BIADP also knows that reliability of supply is critical if farmers are to generate the income to pay for the service, and therefore, it focuses on regular services and prompt repair of pumps.

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[1] All related papers are listed in the bibliography.

Procedures have now been changed so that a proportion of the charges collected are allowed to be used to cover Project recurrent costs, leaving a balance that can contribute towards capital costs. The charging system developed has both incentives and penalties linked to timely payment of charges by farmers, and should soon have an incentive system to promote efficient performance by the Project staff. The Project has also increased the involvement of farmers in providing and managing some of the recurrent costs themselves (see Carruthers, 1986).

In Section 2, Mr Asaduzzaman discusses the objectives of the BIADP. Section 3 details the derivation of the irrigation charge and its collection, and Section 4 shows the success of the BIADP in meeting its targets. The performance of BIADP is briefly compared with other irrigation organisations in Bangladesh. Section 5 demonstrates the magnitude of recurrent costs in the BIADP, and the policies now being developed to cover this and encourage an efficient and responsible maintenance service. As yet, the Project is recovering only one third of its target in terms of combined capital and recurrent cost recovery, because irrigated area per tubewell remains considerably below the assumed potential. However, there is a commendably high rate of payment per area actually irrigated. These payments already cover more than the recurrent costs including staff salaries and overheads, so that there is already some provision for depreciation and capital repayment. Moreover, the system set up seems to contain the potential for improvement. In its three year life so far the Project has shown a steady increase in irrigated area per well and a very large increase in production and yields. The latter may eventually permit irrigation charges to be raised and the rate of capital recovery to be further increased. Much has depended on motivating staff; the new system ensures they are paid promptly and it is hoped also to raise salaries by an incentive system. Mr Asaduzzaman concludes with a summary of key differences between the strategy of BIADP and other irrigation organisations in Bangladesh, and prospects for BIADP in the future.

We would welcome hearing from other Networkers who have tried out ideas suggested in a Network Paper. We can all learn from your experiences, whether the results were good or bad. Please fill in the enclosed form, or write, if your have an experience to communicate.

Linden Vincent & Mary Tiffen
Irrigation Management Network

IRRIGATION CHARGES IN THE BARIND INTEGRATED AREA DEVELOPMENT PROJECT: A NEW APPROACH

M ASADUZZAMAN

1. THE BARIND PROJECT

The Barind Integrated Area Development Project (BIADP), comprises 15 upazilas[2] of the districts of Rajshahi, Naogaon and Chapai Nawabgonj of the greater district of Rajshahi in northwest Bangladesh. The Project area covers about 1900 square miles. Geomorphologically the area is a terraced landscape representing a series of fault blocks, crossed by the border of India and Bangladesh. The elevation ranges between 40 feet to 150 feet above mean sea level.

The BIADP is one of several development projects in the current third Five Year Plan of Bangladesh. The component objectives and works of the Project are:

a. the exploitation of groundwater by sinking 3,000 deep tubewells of, on average, 2 cusec discharge capacity;

b. the augmentation of surface water and development of fisheries, poultry and pisciculture by re-excavation of 14,000 Government-owned khas (ponds) and 305 miles of khari (canals) and dara (water flowing channels), and the development of horticulture on the newly formed banks;

c. to minimise the cost of lifting irrigation water, and thus the cost of agricultural production, by electrification of irrigation equipment;

d. to increase the intensity of cropping by diversification of crops and partial mechanisation;

[2] Local Government unit; lowest administrative unit with about 250,000 people.

e. to provide marketing facilities and obtain fair prices for agricultural products, and to improve communications by constructing feeder roads.

After implementing the plans of the Project, the benefits will come in the shape of more agricultural growth. This will help the country to reduce its total yearly food shortage and also generate additional employment in rural areas.

2. THE DERIVATION AND COLLECTION OF CHARGES

The aim of this paper is to discuss the functional points of irrigation charges that need to be regulated when putting tubewells and low lift pumps into operation for irrigation purposes. However, in discussing the functional procedures of irrigation charges, the term 'irrigation charge' itself should be made clear.

An irrigation charge may be defined as a charge per unit area of land brought under cultivation by using water from either tubewells or low lift pumps, to be realised from the user of water in a predetermined command area served by particular irrigation equipment. The management of the BIADP guarantees water supply to farmers in return for payment of the irrigation charge. The farmers' group belonging to a tubewell bears the cost of routine maintenance, oil and fuel or electricity consumed by the prime mover of the pump, but the servicing costs are borne by the Project, and the pump belongs to the Project.

The irrigation charges are prescribed and enforced according to the irrigation water rate ordinance of the year 1983, at the following rates:

1. 35 Taka per bigha[3] of land for high yielding varieties and local improved varieties of boro paddy (105 Taka[4] per acre);

2. 30 Taka per bigha for paddy cultivation in the aus season (90 Taka per acre);

3. 20 Taka per bigha for potato or wheat cultivation in the rabi season (60 Taka per acre);

4. 10 Taka per bigha for each transplanted aman[5] paddy season as supplementary irrigation (30 Taka per acre).

Before starting any irrigation season the farmers pay the irrigation charge to the authorised representative of the Project, through printed and serially numbered money receipts. The Project ensures that the irrigation facilities work by providing free servicing and maintenance through deputing adequate numbers of trained technical hands for a particular area.

For BIADP the irrigation charge per DTW was calculated in the light of two factors:

1. the annual charge should, by the end of the expected lifetime of the equipment, equal the capital cost of the tubewell and spare parts during its expected lifetime of twenty years;

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[3] Bigha = 0.135 hectares, 0.33 acres (1 acre = 3 bighas, 1 hectare = 7.41 bighas).

[4] In 1988 the official exchange rate was Taka 32 = US$1, in 1983 it was Taka 25 = US$1.

[5] Boro, aus and aman are seasons for cultivating rice (for months, see pg 11). Rabi is the dry season, November-March.

2. the charge should be related to the additional income the equipment makes possible for the farmer to earn from different crops.

To confirm the viability of the irrigation charge, first we must estimate the probable cost involved for sinking, installation and ancillary works of a tubewell, and the possible additional income generated through its use. We should also analyse what percentage of the additional income generated by the use of tubewells could be paid by the farmers of the Project area as an irrigation charge.

The basis of the calculation is as follows:

a. the present sale value of a DTW at Taka 175,000, a price established by the Government, and including all ancillary items such as the pump, prime mover and pump house. (The actual cost, without subsidy, of a DTW is around Taka 500,000.)

b. the present cost of an additional diesel engine of Taka 60,000 since its expected lifetime is normally ten years;

c. the repair and maintenance cost of the diesel engines for 20 years, totalling Taka 69,000 - the cost of repair per year for the first three years of each of the engines is calculated as Taka 1,000, and for the next seven years is calculated as Taka 4,500 per year;

d. the service charge of 5%, levied annually on Taka 175,000, or the cost remaining for the DTW after annual repayments of Taka 15,000 per year (see calculation * overleaf), totals Taka 55,500. The salvage value of a tubewell and its engine is fixed at Taka 65,000 by the Government;

e. Salary and Project costs are not included in this costing, and are referred to later.

Therefore, the total value of the above costs, to be recovered over 20 years through irrigation charges in the irrigated area, is:

Taka (175,000 + 60,000 + 69,000 + 55,500) = Taka (359,500) - (65,000) = Taka 294,500.

Thus, the amount to be recovered in the form of irrigation charge per tubewell per year is (Taka 294,500 ÷ 20 years = Taka 14,725.00), say Taka 15,000.00 *.

The expected irrigable area under crops for each tubewell is shown in Table 1:

Table 1: EXPECTED AREA IRRIGATED, BY SEASON, PER TUBEWELL

a. Boro (Irri)	100 bigha from the month of December to March
b. Aus	150 bigha from the month of May to August
c. Potato/Wheat	200 bigha from the month of November to March
d. Transplanted aman	300 bigha from the month of July to November
Total	750 bigha

Note: It is assumed that the seed beds would be raised in locations other than the command area.

This yearly cost of a well of Taka 15,000.00 has to be realised through irrigation charges from the benefitted area. The average irrigation charge per bigha of land becomes (Taka 15,000.00 ÷ 750 bigha), which equals Taka 20.00 per bigha (the total area of land that can be irrigated through a tubewell per year in different crop seasons is considered to be 750 bigha). However, we should also consider that the group of farmers under each tubewell bear the cost of routine maintenance, oil and fuel of the diesel engine or electrical charge consumed by the electrical motor, although free servicing and repair is ensured by the Project. The quantity of water required to raise different crops varies, thus the irrigation charge should also vary. Hence, there is provision to pay less irrigation charge for raising crops which require less water under the Project, as follows:

Table 2: IRRIGATION CHARGES, BY SEASON AND CROP

Name of crops	Irrigated area under each tube-well (bigha)	Irrigation charge (per bigha in Taka)	Yearly irrigation charge per well (in Taka)
1.Boro/Irri	100	35.00	3,500.00
2.Aus	150	30.00	4,500.00
3.Wheat/potato	200	20.00	4,000.00
4.Transplanted aman	300	10.00	3,000.00
Total	750 (250 acres)		15,000.00

Note: Irrigation charge at the rate of Taka 20.00 per bigha is payable for any other winter crop and Taka 10.00 for any other kharif crop.

The farmers should be encouraged to raise those crops which involve less expenditure and require less volume of irrigation water such as wheat, potato, barley and pulses etc. The benefits from this are diversification of traditional food habits and less dependency on rice. Further it will enhance per capita income by producing additional output.

It is in fact unrealistic to suppose the farmers can immediately get an average of 2.5 crops per year, as Table 2 might indicate. Currently we are getting about 100 acres per tubewell, including transplanted aman (see Table 3). However, the irrigation charge must be estimated and fixed with active consideration of the ability of the farmer to pay. The charge is within 1% to 5% of the farmer's additional income through irrigation for different crop seasons, which still leaves a margin for his future needs and investments, and for his own contribution to the running costs of the well. The total cost to the farmer of irrigation water, when these running costs are included, is Taka 200-400 per bigha per season, as can be seen in Appendix C, page 31.

The rules, regulations and practices adopted under this Project to realise the irrigation charge and to implement management are given in Appendices A to C. The Upazila-based Project Implementation and Coordination Committee, of which the relevant Upazila Chairman (people's representative) is the President, demarcates the command area under each tubewell or low lift pump and guarantees irrigation water to this area.

Before the start of any irrigation season the farmers of the demarcated area pay the pre-determined irrigation charge to the authorised representative of the Project through a money receipt. The beneficiaries pay the cost of oil and fuel or charge of electrical energy consumed to run the machines, and the salaries of the group leaders and the pump operator.

The beneficiaries elect one group leader among themselves to organise their group and to act as liaison. The Upazila Chairman, and the Assistant Engineer of the Project posted at each upazila, monitor the payment of irrigation charges by fortnightly reports, and take all necessary steps to achieve the target realisation of irrigation charges. Adequate and prompt arrangements have been made at each upazila to repair the irrigation equipment and guarantee irrigation water as a pre-condition of realisation of irrigation charges.

3. RECOVERY LEVELS OF IRRIGATION CHARGES

We would now like to illustrate the success of the BIADP in meeting its financial and economic targets. In Table 3 we show details of the improvement of irrigation facilities, and of charges recouped between 1986/87 and 1988/89. Available discharge for irrigation has tripled both for tubewells and low lift pumps. The numbers of operating deep tubewells has increased from 594 to 2142. There have been important successes also in closing the gaps between drilled, commissioned and operating tubewells, so that by 1988/89 93% of commissioned deep tubewells were working, and 80% of drilled wells were commissioned. The better performance of wells may be seen in the three-fold increase in irrigated area per cusec of discharge. The number of beneficiaries has also tripled, but irrigated acreage has increased over eight times, mainly for paddy. There have been big increases in numbers of owner-cultivators and sharecroppers. However, owner-cultivators dominate the acreage, and have increased their percentage participation relative to sharecroppers.

However, relative to this article, the most important achievement is in the percentage of costs recouped. We discuss this in Table 4. This sets out the 'accrued' charge levied according to acreage under the various crops, against the 'realised' charges actually collected. These are given for both tubewells and low lift pumps. Unfortunately, details of crops cultivated under the two technologies are not distinguished to illustrate stages in the derivation of the accrued charges. This table shows that collections within the year are running at least 80% of charges levied, and are running at 95-100% when allowance is made for the collection of overdues.

Not a single parallel organisation in Bangladesh has achieved such success so far in securing payment of irrigation charges for irrigation equipment.

Table 3: STATEMENT OF IMPROVEMENT OF IRRIGATION FACILITIES UNDER BARIND PROJECT AREA, RAJSHAHI

	1986/87	1987/88	1988/89
1. DEEP TUBEWELLS (DTW)			
a. Nos of DTW sunk	1347	2102	2856
b. Nos of DTW commissioned	998	1361	2300
c. Nos of DTW operating	594	1245	2142
d. Total cusec of discharge utilised	1443	2420	4084
2. TOTAL NO. OF LOW LIFT PUMPS FIELDED (LLP)			
a. 1 cusec capacity	21	74	188
b. 2 cusec capacity	38	67	80
c. Total capacity, cusec	97	208	348
3. IRRIGATED AREA WITH STATUS OF BENEFICIARIES			
a1 Nos of owner-cultivators	17697	43214	71376
a2 Irrigated area (acres)	16648	53841	86298
b1 Nos of share croppers	12783	25050	34573
b2 Irrigated area (acres)	7613	19366	44406
c1 No of contract cultivators	1073	1847	1907
c2 Irrigated area (acres)	347	1741	1833
4. TOTAL NO. OF BENEFICIARIES	31553	70111	107856
5. TOTAL IRRIGATED AREA (ACRES)	24608	74948	212564
a. Paddy	21772	67481	203240
b. Wheat	2049	7248	8240
c. Others	787	219	1084
6. TOTAL PRODUCTION (METRIC TONS)	42201	349934	584103
a. Paddy	37333	344059	575515
b. Wheat	1522	5434	6928
c. Others	3346	442	1660
7. APPROX VALUE OF PRODUCE	2297+	19050+	31541+
8. IRRIGATED AREA PER DTW (ACRES) (Assuming 2 cusec discharge)	39	56	62 99*
9. IRRIGATED AREA PER LLP (ACRES) Per cusec of discharge	16	28.51	32.45

+ in 100,000 Taka, @ Government procurement price.

* Includes 80027 acres of irrigated transplanted aman

Table 4: POSITION OF IRRIGATED CHARGES ON THE BARIND PROJECT AREA, RAJSHAHI

	1986/87	1987/88	1988/89
DEEP TUBEWELLS			
Accrued charges	2,050,534	5,584,310	14,386,712
Realised charges	2,005,246	4,585,227	13,224,144
(as %)	98%	82%	92%
Non-realised charges	169,093	997,583	1,124,568
LOW LIFT PUMPS			
Accrued charges	229,225	521,600	1,085,500
Realised charges	229,225	482,000	948,600
(as %)	100%	92%	87%
Non-realised charges	-	41,000	136,900
TOTAL			
Accrued charges	2,279,759	6,105,910	15,472,212
Realised charges	2,234,471	5,067,227*	14,172,744
(as %)	98%	83%	92%
Non-realised charges	169,093	1,038,583	1,261,468

* This sum has since been augmented by Taka 1,022,424 collected as overdue payment. This brings the actual realisation for 1986/87 and 1987/88 to 99% of the total.

It is not possible for this paper to describe in detail the investment and cost recovery strategies of other irrigation organisations. However, we would like to end this section by comparing our performance in cost recovery with that of the Bangladesh Water Development Board (BWDB), to emphasise the differences in our strategy and how these contribute to improved collection of charges.

The BWDB first gave irrigation facilities free of cost up to 1975/76, but then imposed irrigation charges which were higher than those of BIADP, because these charges were fixed supposedly to cover operational costs (salaries, fuel, electricity, etc), though in practice real operational costs may be as high as Taka 834 per acre. In comparing them with the BIADP charges shown in Table 2 it should be remembered BIADP farmers are responsible for fuel, etc.

The charges levied by BWDB are:

a. kharif - 1 crop (March-June) - Taka 150 per acre (50 per bigha);

b. kharif - 2 crop (July-October) - Taka 50 per acre (16.6 per bigha);

c. rabi crop (November-February) - Taka 150 per acre (50 per bigha).

Table 5: COLLECTION OF WATER CHARGES BY BANGLADESH WATER DEVELOPMENT BOARD

	Name of major project	Total amount assessed from 1976 to April 1983 (million Taka)	Total amount collected from 1976 to April 1983 (million Taka)	Percentage of realisation %
1.	Ganges Kobadak Project	15.748	0.335	2.12%
2.	GWD Project and LLPI schemes in Northern district including Buri-Teesta	5.691	0.214	3.76%
3.	DND Project	4.608	0.131	2.84%
4.	Durang Irrigation	0.405	-	-

We show the actual state of collection of these charges in Table 5; they are currently only 2-3%. Collection has been the responsibility of the Revenue Department.

Another important irrigation organisation is the Bangladesh Agricultural Development Corporation (BADC). They have experimented with the supply of irrigation equipment in return for payment of a pre-determined yearly rent, a system which proved unviable due to large amounts of over-due, unpaid rent. The system was discontinued and replaced by a 'sales' system run in conjunction with the Bangladesh Rural Development Board (BRDB) and scheduled banks. The banks lent farmers grouped in cooperatives money to purchase equipment. However, default on repayments on irrigation equipment have jeopardised the chances for the agricultural cooperatives concerned to obtain other loans. The bank system has also had intricate procedural formalities for loans which deterred farmers. As a result, around 15,000 imported DTW have been lying idle in different BADC stores for the last four years.

Cost recovery is not only important for funding future investments, as Mr Guohua Xu (1986) pointed out so clearly. It has current implications throughout rural development initiatives, both by affecting maintenance and operation for irrigated production and the operation of loan programmes for other rural programmes.

4. APPORTIONING AND PAYING RECURRENT COSTS

The BIADP has begun with a very encouraging level of performance in collecting charges, but we remained concerned that failure to dovetail actual recurrent costs in the Project with funds released by the Government would rapidly reduce both irrigation output and fee recovery. The BIADP initiated discussions with the Government on the allocation of a proportion of fees collected for its own recurrent costs, and since 1989 we have been permitted to use the money collected for the payment of salaries and general infrastructural maintenance (canals, pumpsets, etc). The balance of charges collected is banked by the Project, where 13.5% interest accrues. We are thus hopeful that fees collected will not only cover recurrent costs but make a substantial contribution to capital recovery (their original purpose).

We are also trying to develop an incentive scheme to benefit the field staff teams who secure the payment of all the charges in their locality, similar to schemes in the Philippines. Table 6 shows the incentive scheme we are trying to develop.

Table 6: PROPOSED INCENTIVE SCHEME FOR BIADP

Percentage of realisation of irrigation charge	Proposed percentage of incentive on the realised amount
100%	10%
90-99%	7%
80-89%	5%
70-79%	2%
60-69%	1%
100% of backlog	2%

As shown in Section 2, the BIADP has a multitude of responsibilities. If we apportion the overhead costs relating to the DTW programme, this works out at about Taka 1096 per DTW. In 1988/89, general repairs and maintenance came to around Taka 1559 per DTW. Thus our recurrent costs are around Taka 2655 per DTW. For brevity we cannot include all related calculations here, but these are available from the author.

The charges collected (Taka 13,224,144 from DTWs in 1988/89, as shown in Table 4), are not the only income for the Project. Miscellaneous earnings for the BIADP, such as the sale of fuel to farmers, generate in total around Taka 913,000. This gives a total of Taka 14,137,144 in 1988/89, or around Taka 4947 per DTW. Thus our system of using charges collected to pay recurrent costs is currently taking about 53% of charges paid. Our proposed incentive scheme will increase this proportion. However, this still enables us to repay some component of capital costs, especially with the interest paid on balances. The Project management is making every effort both in collecting charges and in efficiently controlling recurrent costs. Our hope for the future is that these recurrent costs will be kept within one third of the income of BIADP.

In conclusion it could be noted that a good level of realisation of irrigation charge per irrigation equipment is an indication of achievement of good command area per such equipment.

5. CONCLUSIONS

Given the data on the performance of the three agencies just discussed, let us return to the original point of discussion on the viability of any investment. In any economic enterprise, if an investment fails to recover funds for further reinvestment within an acceptable time limit then it will contribute to economic stagnation within the national economy.

The procedures of collecting the irrigation charge used by the BWDB and by BADC have differences which provide an excellent example. Who is responsible for the failures in collecting the irrigation charge or recovering the cost of machineries, and for such huge sums of public money remaining unrecovered? Revenue boards, banks or governmental policy? In relation to this affair, we quote Svendsen (1986), "poor collection rates are more a function of irrigation departments' unwillingness to collect than of farmers' unwillingness to pay". Now if we research the causes of unwillingness to collect the irrigation charge then we can understand weaknesses in the policy for its collection.

In the case of BWBD, the responsibility for collecting the irrigation charge lies with the Revenue Board, which has no connection with the management of irrigation, except that the farmers come to its office to make the payment.

The same thing has happened in the case of BADC and BRDB. Here it was agreed that the banks would collect the dues from the farmers, but the banks remain idle after disbursing loans to the farmers, as the banks are not disadvantaged by irrigation problems. So no direct relation develops between the farmers and the banks. It is seen that in both the cases those who collect money from the farmers are not engaged in providing an irrigation service. They are related to farmers for collecting money only; they neither act to ensure maximum utilisation of irrigated land nor take steps to increase production through bringing more land under irrigation.

As the farmers do not get any direct service either from the Revenue Office or the banks related to irrigation, the relation between the farmers and the revenue office or bank, i.e. payer and payee, deteriorates. In BIADP it was very important to make those who are operating irrigation services and working in related irrigation departments, from whom the farmers do get services, responsible for collecting money from the farmers. The responsible irrigation departments should have duties to make the farmers keen to increase the total area of irrigation under each irrigation facility, and to ensure maximum services to the fields of the farmers. But the BWDB, BRDB and BADC have failed due to complexity in procedures and management of irrigation.

The author believes the Barind Integrated Area Development Project is trying to overcome the above problems. The achieved target in irrigation charges under the Barind Project is satisfactory because here the Project authority is securing payment of the irrigation charge from the farmers directly, by guaranteeing the water supply and providing a good irrigation service. No other agency or organisation stands between them, so communication between the farmers and the field workers of the Project is direct. The concept makes the engineers and other professionals much more accountable to the clients they serve.

At the beginning of any irrigation season the Barind Project Authority know that the farmers will not pay an irrigation charge unless it ensures the irrigation water supply to the farmers; similarly the farmers feel that unless they pay the irrigation charge they will not get irrigation facilities and cannot make the Project personnel responsible for repairing the irrigation equipment. As a result everybody is clear about his duties and responsibilities. Key differences in the strategy of BIADP have been:

1. to make the farmers responsible for some of the operational costs such as routine maintenance, oil, fuel or electricity and the salaries of the group leader, operator, and drainman;

2. to set up a collection system with clear responsibilities for payment, including incentives and penalties;

3. to use the charges collected to cover salaries and maintenance needs so that farmers see immediate results for their payments, and employees are able to keep their systems running efficiently and are paid regularly and appropriately;

4. to have Project staff responsible for collection of charges rather than Revenue or bank representatives;

5. the BIADP charges are based on crops grown, not just time of year, and are thus more related to income generated. They may also act as an incentive to reduce cultivation of crops with heavy water requirements.

We know that the management of the irrigation development in the Project is not free from faults, but there is time to rectify the observed defects. To overcome any problems of irrigation management an Upazila Coordination Committee is constituted so that no so-called "water lord" can materialise. This committee is charged with the task of appointing a drainman, operator and group leader, etc, for efficient distribution of irrigation water in the demarcated command area under each tubewell. The maximum realisation of irrigation charges from each irrigation facility comes through planning for maximum utilisation from each facility. Thus it is possible to increase the revenue raised by increasing the area under irrigation, and that will make the total amount of irrigation charge adequate for future re-investment. All efforts are being exerted by the Project Management to keep the Project economically viable and stable, through realising the irrigation charges which will cover recurrent costs and a certain percentage of the capital costs, even if this percentage is only a part of the total investment.

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APPENDIX A

REBATES AND PENALTIES

Regulations on water rates, rebates and penalties are covered by the provisions of the Bangladesh Irrigation Water Rate Ordinance. Rules 10 and 11 state:

10. Rebate: There shall be allowed a rebate of water rate at 20% of the rate payable if the payment is made within the period of 30 days from the date it becomes due. The rebate shall be reduced to 10% if the payment is made within a period of 45 days.

11. Interest for default: a. In the case of any default on the part of the assessee in making payment of water rate, the defaulter shall be liable to an interest at 15% of the water rate for payment after the due date including the grace period specified in rule 10; b. In case of any default for making payment of water rate of a particular crop season before the next same crop season commences, the assessing authority may, without previous notice, stop the supply or regulation of water in the land of the defaulter and no loss or compensation can be claimed for the damage, if any, of the crop that may remain standing in such field at the time of such stoppage.

These rules are being implemented in the field and it is decided to fix the 'due date' as 31 December of each year.

It means that any farmer who pays his irrigation charge by 31 January is eligible to get 20% rebate, and from 31 January to 15 February the farmers will get 10% rebate. If the farmer does not pay by 15 February then he will be charged an additional amount of 15% from the 16 February. For practical purposes this overdue charge is determined as an additional Taka 3/- per acre per month or fraction of a month.

APPENDIX B

DEED OF AGREEMENT

A Deed of Agreement is made between the Barind Integrated Area Development Project - BADC and the Barind Deep Tubewell Water Users' Association for each deep tubewell scheme. The Deed of Agreement is executed giving due consideration to the relevant rules notified by the Government from time to time. The language of the Deed is in Bengali. The relevant portion of it is translated into English and given below. The Deed is registered in the court to give it legal status. This agreement enables the beneficiaries to purchase the deep tubewell at the initial stage on cash payment, or through a bank's loan sanction provision, or if they continue on the irrigation charge basis, they can purchase through depreciated cost after the experience of a few years of operation. In fact, a wide range of options has been developed for farmers.

DEED OF AGREEMENT

1. Barind Integrated Area Development Project - BADC: 1st party.

   and

2. Barind Deep Tubewell Water Users' Association: 2nd party.

1. We, the 2nd party hereto, agree to pay Taka 175,000 only towards the cost of a Deep Tubewell which has been sunk by the Authority of the Barind Integrated Area Development Project either in cash or subject to the receipt of Bank loan.

2. An amount of Taka 29.17 for each decimal of land would be collected from the owner of land within the minimum command area of the said deep tubewell of sixty acres as demarcated by the Barind Integrated Area Development Project - BADC and We

the second party will pay the cost of the Deep Tubewell having a capacity of discharge ranging from 1.2 to 2.0 cusec.

3. There will be no hindrance be placed by us, the 2nd party for constructing a drain (underground/surface channel) through any plot of land within the command area for distribution of irrigation water from the Deep Tubewell and it will not be accepted by any Court of law if there be any such objection raised therein.

4. Primarily there will be an arrangement of 360 shares in total and the owner of each 17.0 (seventeen) decimal (one half bigha) of land within the predetermined command area of the Deep Tubewell will be a shareholder entitled to purchase the Deep Tubewell[6]. There will be a provision for one share for those farmers who have land less than 17.0 (seventeen) decimal. Those farmers who have more than 17.0 decimal of land will get one share for each additional 17.0 decimal of land.

5. A shareholder will have right to cast his vote to determine the management and operation of the Deep Tubewell on the basis of number of shares he holds in the "Barind Deep Tubewell Water Users' Association", as follows:

   A shareholder with two shares will have right to cast two votes in the case that the Users' Association have made cash purchase of a deep tubewell. But a share holder will have no right to cast more than one vote irrespective of the number of shares he holds when the the deep tubewell is operated under the irrigation charge basis.

6. The cost of oil, fuel, electricity, spare parts and the salary of the drainman, operator and the group leader for the operation of the deep tubewell will be borne by the owners of

[6] 60 acres is 180 bighas, or 360 half bighas. One half bigha is 0.17 acres.

land under the command area of the deep tubewell in proportion to the land the owner possesses.

7. The above conditions No. 3, 4, 5 and 6 hereto stipulated are also applicable for ownership, management and operation of a deep tubewell purchased under a bank loan.

8. The "Barind Deep Tubewell Water Users' Association" has agreed and herein it is obligatory to them to pay the irrigation charge as fixed by the "Barind Integrated Area Development Authority" as per Irrigation Water Rate Ordinance 1983 (Ordinance No.31) as formulated by the Government of the People's Republic of Bangladesh and as per the rate fixed by the Gazette notification of the 18th January 1984 and notification of the 2nd February 1987. The above mentioned interim arrangement is made in order to use the deep tubewell just after its sinking, in case there be any delay in purchasing the deep tubewell either in cash or through a bank loan. Any later formulations of law or ordinance relevant to this matter will be obligatory to both the parties herein.

9. As per clause number 10 and 11 of the Notification of the Irrigation Water Rate Ordinance the irrigation charge is fixed as follows for tubewells with and without a constructed distribution system. The due date for payment of the irrigation charge is 31st December of each year, i.e. on expiry of 45 days from 31st December the beneficiaries are to pay Taka 3/- per acre as penalty. The farmers will cease to have the right to irrigation facilities in the next irrigation season if they are in continuous default.

10. It is obligatory for the Water User Association to follow any directive made by the Assistant Engineer/Executive Engineer of the Barind Project or canal officer of any other rank as per the Irrigation Act, 1876 as amended on the 31st May 1977 for the better operation and management of the irrigation system.

IRRIGATION CHARGE: WITHOUT WATER DISTRIBUTION SYSTEM

	Discharge of the well (cusec)	Minimum command area (acre)	Applicable irrigation charge (Taka)	Applicable irrigation charge. Up to 31 Jan incl. 20% rebate	Applicable irrigation charge. Up to 15 Feb incl. 10% rebate	Remarks
1	2	3	4	5	6	7
1.	1.20-1.50	45	10,135/-	8.100-/-	9,121/-	at the
2.	1.51-1.75	54	12,150/-	9,720/-	10,935/-	rate of
3.	1.76-2.0	60	13,500/-	10,800/-	12,150/-	Tk. 225/- per acre

IRRIGATION CHARGE: WITH WATER DISTRIBUTION SYSTEM

1.	1.20-1.50	60	13,500/-	10,800/-	12,150/-	at the
2.	1.51-1.75	80	18,000/-	14,400/-	16,200/-	rate of
3.	1.76-2.00	100	22,500/-	18,000/-	20,250/-	Tk. 225/- per acre

Note: The irrigation charge is fixed by Government decision and in practice if the command Area of a deep tubewell increases then the amount of irrigation charge also increases in proportion.

11. The group leader can under no circumstances collect or receive a larger irrigation charge than that fixed by the Project Authority. If he does such an act then it will be punishable under the penal code. It is obligatory on the part of group leader to submit the balance sheet of income and expenditure as per the by-laws of the association at the end of each year.

12. If the cost of repair exceeds 33% of the deposited amount of the irrigation charge of a deep tubewell operated on the irrigation charge basis, then the Barind Deep Tubewell Water Users' Association must bear the extra cost of repair above 33%. The cost of spare parts supplied by the "Barind Integrated Area Development Project" will be considered within

the 33% of the amount of irrigation charge deposited. The second party will be held responsible for any theft of engine, pump, gearhead, motor or its spares from the installed and operating deep tubewell.

13. For those tubewells operated on the irrigation charge basis, it is obligatory on the second party to deposit the handle and spicer shaft of the deep tubewell to the relevant Assistant Engineer (Zonal Office) at the end of irrigation season. If the Water Users' Association fails to deposit the handle and spicer shaft in time then the second party will not raise any objections when the Authority of the Barind Project dislodges these accessories. The second party can receive the handle and spicer shaft from the office of the Assistant Engineer after paying the due irrigation charge before the next irrigation season starts.

14. If due to wrong operation or indiscriminate use of the deep tubewell the engine, pump, gearhead, motors, etc, are damaged beyond repair by the Barind Deep Tubewell Water Users' Association or its representative then 35% of the cost of such damaged parts or accessories will be borne by the Association.

15. The second party may pay the depreciated cost of a tubewell operated under an irrigation charge basis, when purchasing either in cash or through a bank loan.

16. If we, the second party deviate or fail in the above noted stipulations then the Authority of the Barind Project herein the first party or relevant authority has the right to take appropriate measures as provided in the PDR act (Public Demand Recovery Act) or has right to take measures under any relevant law in order to realise the cost of the deep tubewell or the irrigation charge.

17. Attached to this deed of agreement is the description of plots of land of the members of the "Barind Deep Tubewell Water Users' Association" described in 'Form A', and a copy of its by-laws. All these papers are considered to be the part of this deed of agreement. Subject to the above legally binding obligations, we the second party .... on behalf of the "Barind Deep Tubewell Water Users' Association" put our hand and seal on this Deed or agreement in order that Cooperative Society is registered.

Signature

1st party

2nd party

Witnesses

1.

2.

3.

APPENDIX C

IRRIGATION WATER RIGHT CARD

Dear Sir

You are one of the farmers of the Project of BIADP/ BADC as described before. You are a claimant for irrigation water throughout the year for various crops under different seasons as per rules and regulations described hereto. You are welcome as one of the model farmers, entitled to irrigation water from your Deep Tubewell sunk under BIADP, on condition of observing the rules and regulations listed below. The rules and regulations are subject to variation by the competent Authority.

Project Director

BIADP, Rajshahi

REGULATIONS

1. The irrigation charge fixed per bigha of land is to be deposited with the group leader at the beginning of each cropping season who shall give a receipt for the money.

2. The fixed yearly allowances for the group leader, tubewell driver and drainman shall be deposited once at the beginning of the Boro/Irri season along with irrigation charge to the group leader in return for a money receipt.

3. The cost for diesel, lubricant, grease, gear oil etc, shall be deposited with the group leader in advance.

4. The irrigation charge per bigha of land for the different seasons, the maintenance cost of the tubewell (diesel) lubricant, gear oil, etc, shall be paid at the rates as given below:

Rate per bigha	Rate fixed according to crops			
	Irri/ boro	Irri/ aus	T.Aman	Wheat potato others
Allowances for staff	67/-	-	-	-
Maintenance cost (diesel, lubricants, grease, etc)	298/-	170/-	80/-	98/-
Irrigation charge	35/-	30/-	30/-	20/-
Total amount fixed per bigha	400/-	200/-	90/-	188/-

Remarks: The above rates are established assuming the total command area under one DTW is 60 acres. The rate will be reduced or increased if the command area is increased or decreased.

5. It is compulsory to purchase diesel and lubricants from BADC's store in return for a money receipt.

6. BADC will not either maintain the engine and pump or guarantee the irrigation water until a minimum of Tk. 6000/- (six thousand) is deposited by the farmers from a tubewell as irrigation charges for one year. So at the beginning of each cropping season the irrigation charge is to be deposited. For non-payment of irrigation charge the spicer shaft of the engine will be disconnected.

7. The Government of the People's Republic of Bangladesh has paid a large subsidy to the cost of the deep tubewells in order to develop the Project area. Thus to keep the land under the Project idle is a crime. The main duty of the group leader is to supply water for irrigation after paying the necessary irrigation charge, the allowances and the maintenance cost. It is the right of all the farmers in the command area of a tubewell to use the water for irrigation. This tubewell is not anybody's personal property.

8. Every farmer under the command area of a tubewell should know that:

a. The allowance of a group leader is Tk. 1200/- per month, but he is not entitled to more than Tk. 5000/- per year. The group leader is elected by the votes of the farmers of the command area, and he may be removed from his charge if he is not re-elected;

b. The monthly allowance of a tubewell operator is Tk. 1000/- but will not exceed Tk. 4000/- per year. The tubewell operator will be appointed by the farmers of the command area from amongst their dependants. The educational qualification of a tubewell operator is to be a minimum of Class VIII;

c. The monthly allowance of a drainman is Tk. 700/- but will not exceed Tk. 3000/- per year. All these appointments are to be made by the Upazila Project Committee on the recommendations of farmers of the command area.

9. Those farmers who do not possess this card or who have not paid the dues or irrigation charge, will not be entitled to irrigation water from the DTW.

10. Please contact the officer of BIADP, BADC located at the Head Quarters of each upazila under the Project for more information.

DESCRIPTION OF YOUR LAND UNDER THE COMMAND AREA OF DTW

No.	Plot No.	Area of land in bigha	Remarks

Total land in bigha. 3 bigha = 1 acre.

IRRIGATION MANAGEMENT NETWORK

INFORMATION SHEET - IRRIGATION WATER CHARGES

If you have discussed or implemented any of the ideas presented in the IMN Papers on irrigation water charges, please can you summarise your actions on this sheet.

NAME ....

ORGANISATION ....

ADDRESS ....

....

DATE ....

PAPERS USED, IF KNOWN ....

....

DETAILS OF ACTIONS ....

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5 PRI JR

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