odi Library
Overseas Development Institute
0 4. JUL 96
Regent's College
Inner Circle
Regent's Park
London NW1 4NS
Tel: 0171 487 7413
FOR REFERENCE ONLY

IRRIGATION MANAGEMENT NETWORK

NEWSLETTER

October 1991

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 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 ODI Irrigation Management Network is sponsored by:

The Overseas Development Administration (ODA), 94 Victoria Street, London SW1E 5JL, UK; and

The Ford Foundation, 320 E 43rd Street, New York, NY 10017, USA.

ISSN: 0951 1881

IRRIGATION MANAGEMENT NETWORK NEWSLETTER

Contents | *Page*

***New Series* - Network Papers in this set:**

Newsletter

1 *Groundwater Development on Madura, Indonesia: Gender Issues in an Irrigation Project* by Margaret Casey.

2 *Development of Water User Associations on the Madura Groundwater Irrigation Project, Indonesia* by Robert Jackson.

3 *National Pump Irrigation Study: Material Developed During Inception Activities, January 14 - 8 February* by Effendi Pasandaran; *Assessment of Conjunctive Use in Maharashtra Minor Irrigation Systems* by T S Sheng, et al.

4 *Conjunctive Water Use for Irrigation: Good Theory, Poor Practice* by Linden Vincent and Peter Dempsey.

5 *News from the Field - Groundwater Development and Lift Irrigation* from Tunisia, Mali, Sub-Saharan Africa, Bangladesh and South India.

Credits

Amanda Barton, Secretary, Irrigation Management Network

Linden Vincent, Editor, Irrigation Management Network

IRRIGATION MANAGEMENT NETWORK NEWSLETTER

1. NEWS FROM THE IMN

This Network edition is christened a 'New Series', as we experiment with a format that can carry short commentaries on *News from the Field* as well as longer papers. We hope this will encourage more members to send in their experiences, as we know that writing a longer paper can be difficult for busy officials and those for whom English and French is a second language. Very short items of information and replies to letters will continue to be carried in the Newsletter. *Please note the new numbering system which we are also introducing.*

Our first *News from the Field* summarises some of the material received in response to a recent mailshot calling for information on groundwater development and lift irrigation (including water lifted from surface water supplies).

Please write in with comments on your work or on the papers. Do not worry if you feel your English is poor. We can also handle correspondence in French and Spanish.

The IMN has held four Lunchtime Meetings for UK members. The first, in collaboration with the Social Forestry Network at ODI, IIED and Arid Lands Information Network (ARIN) of OXFAM, was given by Will Critchley, a consultant from the Free University, Amsterdam. The meeting launched a book and video entitled *Looking After Our Land: Soil and Water Conservation in Sub-Saharan Africa* (see Section 5, Publications Received).

Harald Frederiksen, Asia Technical Department/Agricultural Division, of The World Bank, gave a thought-provoking talk on *Construction Quality: A Cause of Underperformance in Irrigation Projects* in July. This looked both at construction quality problems and the challenges to national and international organisations in achieving better stamdards of work in irrigation schemes.

In September, Anthony Bottrall, former IMN Research Fellow, attracted a large audience and gave a talk on *Water and Agricultural Development in South Asia: Limitations of an Irrigation Management Perspective.*

Our most recent Lunchtime Meeting in October was given by Robert Wade of Institute of Development Studies, University of Sussex, and Rien Jurriens of International Institute for Land Reclamation and Improvement (ILRI), Wageningen, on *Prospects for Large-Scale Irrigation in the 1990s: Case Studies from South India.* This longer meeting enabled an important exchange of ideas on a 'European scale', with a good overview of the problems and options in large-schemes, especially those where groundwater cannot be extensively developed.

Due to forthcoming evaluation of the Irrigation Management Network, and to ensure that details on our mailing list are not obsolete, we will soon be mailing a Registration Form to all IMN members. Please ensure that you fully complete the form and return by the date specified! Failure to do this will mean that your name and details will be deleted from the mailing list.

2. NEWS FROM NETWORKERS

Network Papers for Discussion

The papers in this edition looks at irrigation schemes based on groundwater development for irrigation, and at prospects for evolution of conjunctive use between surface and groundwater resources in irrigation schemes. We have put together three papers from Indonesia to show the scope of planning and development which has recently been taking place there in groundwater-based irrigation.

In *Groundwater Development on Madura, Indonesia: Gender Issues in an Irrigation Project*, Margaret Casey looks at the role of women in agriculture and the impact of tubewell developments on production and social relations. The paper looks at some of the failures in research design and execution in the various phases of the project. She also makes a number of recommendations for improving extension services to women.

In paper 2, Roger Jackson writes about the *Development of Water User Associations on the Madura Groundwater Irrigation Project, Indonesia.* He documents the initiatives made to encourage formation and evolution of these WUAs, which are seen as an essential component for the success of groundwater development. He looks at the differential success of evolution of WUAs in different parts of the island and summarises key elements of support to encourage improved performance of WUAs. His paper looks at the same project as that of Margaret Casey, and read together, the two papers show the range of research and planning required to promote groundwater development.

Paper 3, consists of two shorter presentations. Effendi Pasendaran continues the focus on Indonesia, with a description of the *National Pump Irrigation Study: Material Developed During Inception Activities, January 14-18 February 1991*. This programme is designed to study the existing scale of groundwater development, and related costs and benefits, in order for further investments to be planned and implemented effectively. The research programme links up a wide range of government staff (technical and administrative) with social researchers.

The second paper in the set, by the authors M M Sawant, R E Barrett, D J Molden and T S Sheng, switches discussion into conjunctive use. Their paper on *Assessment of Conjunctive Use in Minor Irrigation Systems in Maharashtra* looks at the real prospects of improving water availability in these small commands. Opportunities are restricted given the limited prospects for systematic groundwater development, and the range of government organisations involved. The best administrative options lie in developing the interests of the irrigation department, and working to review and develop existing irrigation legislation.

Paper 4 is a literature review on the same topic by L Vincent and P Dempsey, *Conjunctive Water Use for Irrigation: Good Theory, Poor Practice*. This considers the different objectives behind the current interest in 'conjunctive use', which often do not systematically encourage optimal water development. Three different areas of research are reviewed, none of which really gets to grips with the policy developments required. A case is made for improved institutional analysis to see how 'joint use' of resources can be developed more successfully in itself, and also to achieve more optimal mobilisation of resources.

Paper 5 is a new departure for the Network, carrying a number of short items received from Network members on the subject of groundwater development and lift irrigation. Contributions cover resource management issues in Tunisia (Madame Al'atiri Boutiti Raqya), Bangladesh (M S

Talukder, M Ahmed and M A Mojid), and South India (D S K Rao and R K Sivanappan). Richard Carter summarises the technology options for groundwater mobilisation in Sub-Saharan Africa. Souleyman Dembeley writes about village lift irrigation schemes in Mali, and V Ratna Reddy and B C Barah summarise their research on water markets in Andhra Pradesh.

Design of Irrigation Structures for Hilly/Mountainous Areas: Call for Examples. IIMI (International Irrigation Management Institute) is collecting examples of irrigation structures designed for hilly/mountainous irrigation systems. Emphasis is on identification of design products that allow effective system management. A small workshop is planned for January 1992 to review the examples for publication as a handbook of experience.

Most irrigation design manuals are based on conditions found in large systems in the plains. Irrigation developers, and especially engineers with long experience in designing and constructing irrigation systems in hilly terrain, have learned to change these design norms to fit local conditions. Unfortunately, those with the most practical field experience often move into administrative roles and their rich design experience is lost. New staff must learn from their own mistakes that textbook solutions are not always appropriate in the hills. The purpose for a 'handbook experience' is to shorten the time it takes each of us to develop our own unique solutions.

Dr Robert Yoder is coordinating the collection of examples and cases and will be organising the workshop to review them. A draft outline of the handbook has been prepared as well as several case examples. For further information contact Dr Robert Yoder, 325 E 6th Street, Ames, IA 50010, USA, Tel: 1(515)-232 7183, Fx: 1(515)-294 0907 (Attn: R Yoder, CIKARD, Room 324, Curtiss Hall).

Do you work in the Asia-Pacific Uplands? A new Newsletter has been launched to look at environmental and development problems in these areas, especially tropical uplands of moderate elevation. The first edition has looked at the interaction of ecology and farming systems in Guizhou Province, China, and carries notes on workshops held in China and Vietnam. For more information, contact Dr R D Hill, Department of Geography and Geology, University of Hong Kong, Hong Kong.

Doug Vermillion (IIMI, Sri Lanka) has recently compiled a discussion paper on *The Turnover and Self-Management of Irrigation Institutions in Developing Countries*. This paper summarises the literature available to date, and important hypotheses about turnover, and sets out some of the key areas of administrative concern when agencies become involved in such initiatives. The future programme of research at IIMI is also summarised. For a copy of the paper, write to Douglas Vermillion, IIMI, PO Box 2075, Colombo, Sri Lanka.

Richard Palmer-Jones will be undertaking research on Deep Tubewells (DTW)/ Force Mode Tubewells for irrigation in South and South-East Asia in 1992 (funded by The Overseas Development Administration). The aim is to try to assess the efficiency of use of DTW in different hydrological, agronomic, economic and social circumstances, as a means of identifying the role of management in determining performance. At present the intention is to focus on Pakistan, India, Bangladesh and Indonesia. Richard Palmer-Jones would be most grateful for contacts with people, anywhere in the world, who have been involved in or know of DTW irrigation in these or other areas, which may contribute to this research. Write to him at: School of Development Studies, University of East Anglia, Norwich NR4 7TJ, UK.

A new journal of abstracts of *Women, Water and Sanitation* has been launched by the IRC (International Water and Sanitation Centre) to improve information exchange in this area. For more details, write to IRC, PO Box 93190, 2509 The Hague, The Netherlands.

The Center for Indigenous Knowledge for Agriculture and Rural Development (CIKARD) has been compiling material that illustrates gender differences in indigenous knowledge. 'Indigenous knowledge' refers to traditional knowledge that is unique to a particular culture. Only recently have people begun to realise the importance of recording indigenous knowledge for development purposes. Unfortunately, the knowledge recorded is most often men's, while women's contributions are overlooked! Kristine Schwebach of the Center has begun compiling an annotated bibliography focusing on how gender differences are reflected in decision-making processes, indigenous organisations, and indigenous approaches to creativity, experimentation and development. If you would like to contribute towards this bibliography, please send relevant materials to Ms Kristine K Schwebach, CIKARD, 324 Curtiss Hall, Iowa State University, Ames, Iowa 50011, USA.

A new newsletter has been launched listing UK and international events in environmental policy. If you are interested to obtain this, contact the South-North Centre for Environmental Policy, School of Oriental and

African Studies, University of London, Thornhaugh Street, Russell Square, London WC1H 0XG.

Following research funded by ODA at the Water, Engineering and Development Centre (WEDC), Robert van Bentum and Ian Smout have prepared *Guidelines on Design and Construction of Buried Pipe Distribution Systems for Surface Irrigation.* Please contact WEDC if you wish to receive a copy: WEDC, Loughborough University of Technology, Leicestershire LE11 3TU, UK. Tel: 44(0509)-222885; Fx: 211079; Tx: 34319 UNITEC G.

John Merriam has sent in a set of recent papers on flexible supply scheduling. These examine both the theoretical prospects for replacing rigid rotation schedules with 'on-demand' farmer requirements, and some practical results in Pakistan, Sri Lanka, India and Egypt. The work covers reorganisation in canals or with pipelines. The farmers greatly appreciate the changes, but it is planners, bureaucrats, engineers and funders that still need to be convinced. If you are interested to receive these papers, write to: John Merriam, California Polytechnic State University, San Luis Obispo, CA 93407, USA.

Are you aware of the magazine *Food Matters Worldwide*, for farmers, agricultural colleges and concerned consumers? A Quarterly magazine, providing information and a forum for discussion on issues affecting global agriculture, and in particular, concerned with the effects that different agricultural policies and technologies have on poor farmers in developing countries. In Issue 12/July 1991, the Educational Supplement focused on 'irrigating rice in The Gambia', looking at the Jahally Pacharr Rice Project. In Issue 13/October 1991, the Educational Supplement looks at 'traditional' and 'modern' irrigation in the Tropics, using case studies from Muang Faai irrigation system of Northern Thailand, and drip irrigation in Hawaii's sugar cane industry. Editorial address: Food Matters Worldwide, 38-40 Exchange Street, Norwich NR2 1AX, UK. Tel: 44(0603)-761645/Fx: 765434. Subscription Address: Farmers' World Network, Arthur Rank Centre, NAC, Stoneleigh, Warks CV8 2LZ, UK.

Two recent papers from the IRRI (International Rice Research Institute) summarises some important new trends in rice production for the 1990s:

1. Evidence from the Philippines and Southeast Asian countries indicates that there is a trend towards stagnation and/or a decline in irrigated rice yields when intensively cultivated, even under scientific management on

experimental stations. The important point here is that the more recent varieties have started off with a lower yield potential than the earlier varieties such as IR 8.

2. Longterm productivity declines could be due to: (i) lack of significant breakthrough in the yield ceiling of modern varieties; (ii) decline in irrigation investments, especially for maintenance leading to unreliable water supply; (iii) degradation of the paddy environment due to increased pest pressure, rapid depletion of soil micro-nutrients, and changes in soil chemistry brought about by intensive cropping and the increased reliance on low-quality water. Our results imply that the rate of growth degradation of the paddy environment is greater than the rate of growth in yield potential, hence we have been observing a longterm declining trend in the highest experiment station yields.

3. Given current rice technology, there is a minimal yield gap between the experiment station and the top third irrigated farms. If the current yield frontier does not shift outwards the longterm prospects are for stagnation and/or a decline in the top third farm yields.

4. The current yield gap is not between the farmer and the experimental potential but rather between farmers themselves, the top third and the remaining two thirds. This 'between farmer' yield gap can be explained by

differential farmer ability and differential access to irrigation water, rather than by differences in input use.

5. Productivity gains in the post-green revolution era will come from more efficient use of existing inputs to exploit the genetic potential for existing varieties. These 'second generation technologies' (such as better fertiliser incorporation technologies, integrated pest management, etc) are more knowledge intensive and location specific than the modern seed-fertiliser technology that was characteristic of the green revolution. Productivity gains accrue to farmers who: have the ability to learn about the new technologies; discriminate among technologies offered to them by the research system; adapt the technologies to their particular environmental conditions; and provide supervision input to ensure the appropriate application of the technology.

6. The first priority for rice research ought to be the breaking of the current irrigated yield ceiling. If the current stagnation in experiment station

yield is not broken the implications for future national production trends and to the economic viability of rice production are serious.

7. Our results suggest that the yield gap between farmers can be reduced by carefully targeted extension-training programmes. Such training programmes become particularly important as the incremental gains in productivity are achieved by adopting increasingly knowledge-intensive technologies. However, there are costs associated with such programmes and analysing the benefit-cost ratio of such efforts is beyond the scope of this paper.

It is important to determine the magnitude of the different contributions to productivity decline, in order to define an effective strategy to combat it. An irrigation administration can tackle rehabilitation, but other causes of soil and water degradation can only be tackled by coordination between agencies involved in agriculture and conservation.

Taken from IRRI Social Science Papers: *The Post-Green Revolution Blues in Asian Rice Production*, (90-01) by P L Pingali, P F Moya, and L E Velasco, and *Philippine Irrigation Infrastructure: Degradation Trends for Luzon, 1966-89* (90-03) by P Masicat, M Victoria De Vera, and P L Pingali. For more information, write to the authors at the Social Science Division, International Rice Research Institute, PO Box 933, Manila, Philippines.

R Duari has written in on the *Management of Water Resources in Drought-Prone District with Special Reference to the District of Purulia, West Bengal.* He would like to exchange experiences with Network members working in similar environments. We have summarised points from two papers sent to us on the water resources potential of Midnapore, Bankura and Purulia districts, and drought-proofing initiatives in Purulia district:

I am writing to supply some water resources information in the south-west corner of West Bengal, where conditions are very different to the Indo-Gangetic plain.

We feel the effect of drought in almost every year during the dry period of most years. When general drought conditions prevail over the country, its impact in this region of West Bengal can easily be imagined. With the shortage of water in the aquifers, economic set-backs and general sufferings in the public life of these areas become acute. All schemes to mitigate the situation are dependent on the water resources in some way or another, so we must find some means to conserve run-off water drained out uselessly during rains, to create subsoil water potential, and means to utilise this at times of acute scarcity.

It is our common experience that, due to the steep slopes of these areas as well as due to topography, rainwater quickly runs off leaving little time for infiltration. Whatever water percolates after precipitation, and also tends to flow away quickly because of the nature of the soil and the steep gradient of the underground watertable. Above all, due to aridity, whatever surface water is left stored also quickly evaporates well ahead of the onset of the summer months.

Reservoirs created by detention dams at the head reaches of a water course can act as the perennial source to recharge underground water in the downstream catchment of the rivulets, maintaining adequate watertables in adjoining areas situated at lower levels around the year. This will greatly facilitate installation of RLI stations with cofferdams downstream and construction of dug wells or tube wells.

Radical changes of overall hydrological conditions and remarkable improvements of subsoil water table in the localities situated at lower elevations have already been seen after construction of reservoirs under the following irrigation schemes:

1. Jhalda Pat Jhalda M I Scheme in Jhalda, Purulia done by Agricultural Engineering Directorate;

2. Saharjore Irrigation Scheme, Purulia, implemented by Irrigation and Water Supply Department.

Large-scale schemes for construction of special reservoirs involve gigantic resources of expertise, materials and labour, and need planning to be continuous, with phasing of work on a longterm basis. But these smaller schemes, though simpler, will demand a radical change of outlook in the prevailing practices of the minor irrigation administration (or most schemes), in order to support the time-consuming work of extensive survey of the command area. The economics behind framing such schemes are presently determined as per the prescribed ceiling limit in terms of cost per acre irrigated. In the case of proposed special reservoir schemes, the determining factor should be the cost per acre feet of water accumulated or stored in the reservoir.

Some of these prospects and problems can be summarised through a picture of irrigation development in Midnapore district.

A. Minor Irrigation Structures/Schemes:
(based on the Census of Minor Irrigation Structures, 1988)

Type of Structures or means of irrigation	Number	Area Irrigated (ha) 1987-88
deep tubewells	304	9092.70
mini deep tubewells	20	155.00
shallow tubewells	43,789	1,11,096.21
dug wells	26,328	15,668.17
surface flow irrigation schemcs	22,675	48,395.47
surface lift irrigation schemes	68,076	56,525.41
Total area irrigated in 1987-88	-	**241,472.96**

B. Irrigation Projects/Schemes:

	Name of Project/Scheme	Length/No	Area Irrigated (ha)
1.	Kangsabati Reservoir Project	354 km canal	139,995.00
2.	High Level Midnapore Canal System	100 km	35,929.00
3.	Minor (gravity flow) Irrigation schemes	12 Nos	1,611.00
	Total area irrigated		**177,535.00**

In Midnapore, dug wells predominate, typically irrigating 0.2 hectares, excavated 10-15m, with a diameter of 3-4 m. Shallow tubewells, which are only possible near river courses, irrigate around 2 hectares.

We now distinguish two types of 'deep tubewells'. 'Light Duty' (mini) tubewells occur in the east, and have depths 300-350 ft (90-106 m). 'Medium duty' (deep tubewells), are also only found in the east, and are drilled to depths of 450-650 ft (136-197 m), with an average command area of 20 hectares.

It would be very helpful to exchange information with other networks on watershed management in this kind of terrain, the economics and operation of small dams, recharge experiences from small dams, and operational experiences on these deep tubewells.

Mr R J Duari is TA to the Superintending Engineer (Agri Mech) in Midnapore, and can be contacted at IIT, Midnapore, West Bengal, India.

3. INFORMATION EXCHANGE ON AFRICAN AGRICULTURE

COTA (Collective on Exchange for Appropriate Technology), an NGO set up in 1979 by Belgium NGOs, is a service centre tackling technical problems in Africa, Asia and Latin America, working in the areas of: information and training; research and study; consultancy and technical support. COTA publishes research papers a quarterly information bulletin *Echos due Cota*. Contact COTA, 18 rue de la Sablonnière, 1000 Bruxelles, Belgium. Tel: 32(2)-218 18 96.

The Center Sahel promotes information gathering, exchange of ideas, and research, as well as scientific and technical collaboration, with the countries of the Sahel. The Centre also publishes a large number of research papers. Contact Centre Sahel, Pavillon Charles-de Koninck, Université Laval, Cité Universitaire, Québec, Canada G1K 7P4. Tel: 1(418)-656 5448; Fx: 656 7461; Tx: 051-31621.

The African Institute, Italy, conducts research on aspects of African development (including the links between food security and urbanisation in Niger, food security and peasant strategies in Burkina Faso and rural cereal markets in Senegal), and runs short courses on African development. Its Research and Documentation Centre specialises in African development, particularly in agricultural development and food security, rural development and macro-economic issues, producing a bi-annual review of the international press and providing a photocopying service. For further information contact, Istituto Italo Africano, Via Aldrovandi 16, 00197 Rome, Italy. Tel: 39(6)-879746.

4. COMMENTS ON NETWORK PAPERS

Mr Hervé Plusquellec, Irrigation Engineering Adviser, The World Bank, has written in with comments on a past Network paper:

I would like to comment on the Network paper 90/3b (*Interactions Between Technical Infrastructure and Management*) prepared by Professor L Horst. Professor Horst questions the (very slow indeed) trend towards automatisation of modern irrigation schemes. He also suggests to adapt the technologies to the management capabilities where skill shortage persist through simplification of structures requiring fewer manual adjustments and fewer measurements, such as on/off and division structures.

I agree with Professor Horst that gradually adjustable technology requires a large number of skilled and dedicated field staff which are difficult to recruit in both developed and developing countries. A case in point is the design frequently used by most consulting firms in Indonesia where cross-regulators are equipped with sluice gates and offtakes with Rominj (weir) type gates. This is the worst combination of structures resulting in hydraulic instability and large variations of water released to farmers, as discussed in another paper of Professor Horst's (*Irrigation Systems - Alternative Design Concepts*, 7c, 1983). Such systems are nearly unmanageable because they amplify any flow variations from the headworks.

However, I challenge the recommendations of Professor Horst to downgrade the design and, subsequently, the performance of irrigation systems in terms of flexibility of water delivery. The very objective of automation is to simplify operation, and therefore to adjust to the skill gaps of field staff. Design of automated systems in most cases is more complex, but operation should be simpler. The combination of a duck-bill weir with an orifice offtake (or better with a constant flow baffle distributor) resolves most of the problems faced in operation of conventional design systems.

Of course use of most advanced automatic systems, centralised, computer-assisted, require higher skills. However, a great deal of improvement can be achieved with proper selection of control structures and use of hydro-mechanical equipment before adoption of these sophisticated technologies suitable for very large systems.

Professor Lucas Horst, (Department of Irrigation & Soil & Water Conservation, Wageningen Agricultural University, Nieuwe Kanaal 11, 6709 PA Wageningen, The Netherlands) has replied to these comments by Mr Plusquellec:

I have the feeling that the crux of the discussion lays in the sentence: "I challenge the recommendation of Professor Horst to downgrade the design and subsequently the performance of irrigation systems in terms of flexibility of water delivery".

First of all I would like to refer to an earlier paper (*Choice of Irrigation Structures, the Paradox of Operational Flexibility*[1]). In this paper I argued that systems designed with the aim of being highly flexible and efficient through relatively sophisticated technological means, without taking into account operational capabilities and farmers participation, might lead to situations with little flexibility at farm level and overall efficiencies lower than expected. In other words high flexibility and good performance do not necessarily go hand in hand.

Secondly, I supposedly recommend to *downgrade* the design (by advocating simplification where possible). This statement contains the assumption that adoption of a higher level of technology means a *superior* design. I cannot agree here, e.g. I consider drip irrigation in rice fields inferior to flooding; a moveable weir inferior to a fixed weir if there is no absolute assurance of operation; in case of shortage of staff (in numbers and skill) Romijn gates or constant head orifice inferior to inflexible proportional division, etc, etc.

In other words, design is superior if *all* conditions are fulfilled to make it work - it has nothing to do with superior or inferior technologies or with downgrading.

Dr R K Patil and K R Datye, of The Centre for Applied Systems Analysis in Development (c/o K R Datye, Flat No 2, 133/134 Vasumati Apartments, Banner Road, Aundh, Pune 411 007, India), have also submitted comments:

The Network Paper on *Equity Considerations in the Modernisation of Irrigation Systems* by Gilbert E Levine and E Walter Coward Jnr (89/2b) considers important issues related to designs and their relationship to equity. However, one more aspect of equity has not been explicitly stated. In

---

[1] L Horst, Irrigation Design for Management, Asian Regional Symposium 1987.

certain situations, equity can be interpreted as provision of opportunities for equal benefits to all. This may violate the principle of equal supplies on area/family basis, or level of contribution the user made to the construction of the system.

The methodological sequence enumerated in section 4 of the paper are equally applicable to this type of equity. However, operationally this is a difficult task in the developing countries, more especially in the Indian sub-continent, where the dominance of engineers in irrigation bureaucracy is paramount. How to dent (as it is impossible to eliminate) the engineer-bureaucracy and bring it in tune with social reality is a problem.

In discussing 'operating schedules', an elegant and concise classification of systems into 'administered' and 'managed' types has been made. Though the categories are presented in a neutral sense as 'either/or', the nomenclature suggests 'managed' is to be preferred to 'administered', though this is not explicitly stated.

However, later in the section on 'Make Design Decisions' (4.8), both the rules are presented as equally attractive, leaving the decision to farmers (?) and bureaucracy. It is difficult to accept this position, as these rules are constrained by certain environmental factors, peculiar to certain situations, which make it necessary to adopt one or the other without any choice. In other words, a supply systems and a demand system are not options, as there are constraining factors limiting such an open choice.

To illustrate, Warabandi, which is an outstanding example of an 'administered' system, has a fair success in the Punjab (both India and Pakistan) due to the following factors:

(a) The water allowance from canal is just a fraction of what the crops required. Thus, it is only 1.8 mm/day at the head of the water course, which is highly inadequate for crop growth. However, if this much amount is given, there is no fear of waterlogging or excess water supplies;

(b) Though the canal water allowance is insufficient for raising the crops, the farmers have the opportunity of supplementing it through tubewell waters, as the geology and topography (alluvial soils) is excellently suited for groundwater recharge. It has been rightly observed that warabandi does not guarantee a specific amount of water. This weakness is more than compensated by the availability of tubewell waters. Hence, the almost strict equity in canal water distribution that results from warabandi does not affect the productivity.

In Western Maharashtra, and maybe at other locations where the geological conditions do not favour a large-scale uniform underground storage, adoption of Warabandi in all its rigours becomes wasteful and damaging to productivity.

It is necessary, therefore, to understand the environmental specifics where a supply system would fail. A brief narration of these specifics follows:

Soils:

The soils in Maharashtra and most of the Indian peninsular are heterogeneous. The soils not only change in different sub-commands but within the outlets and at times within one holding.

Crops also change from soil to soil. Generally, a very high frequency of irrigation is essential for light soils, but low frequency is tolerable in black soils. The deep black soils pose considerable problems in irrigation. Due to high moisture holding capacity and high wilting coefficient, these soils need soaking from rains or a very high dose of irrigation in kharif, as the soils develop cracks during the summer. These soils heave and therefore need a dry spell after irrigation/rains to make the surface workable for sowing/cultivation operations.

For kharif crops, a pre-soaking irrigation is essential in the last week of May or first week of June, which give sufficient drying period in June, when rains are not intensive or continuous. Otherwise sowing is not possible until September as continuous rains occur in July, August and the first half of September. Thus, in rainfed conditions, or if sowing is planned after replenishment of the soil reservoir and in the rains only, *either* one late kharif *or* an early rabi crop only can be raised in these soils, if early irrigation is not planned from the carry-over of the previous year. With one such irrigation, kharif crops can be successfully taken with marginal irrigation before the traditional rabi crop sowing period. As the moisture is extracted by kharif crop, the rabi crops do need irrigation against the late kharif crop or the single rabi crop which can be reared on residual soil moisture.

In light/medium soils, sowing of kharif crops can be done after one or two light showers. These soils need irrigation in rabi and therefore can take full advantage of irrigation.

Groundwater:

The groundwater availability in these regions is erratic and uncertain. Groundwater is generally available and can be economically exploited in areas underlaid with murum or decomposed rocks, close to a canal network. In areas with solid rock underlying, groundwater is accessed by chance, if the well or bore strikes a fissure or crack in the rocks strata. In very deep black soil availability of water is poor and cannot be pumped out economically due to very low recuperation. Generally well water in such soils is not suitable for irrigation due to the high salt content.

In the public delivery systems it is always desirable to extend the benefits, i.e. water resources, to a large number of farmers and larger areas. It is also aimed to attain more production per unit volume of water. To enable this, certain restrictions are imposed on growing high water consuming crops like paddy/sugarcane, banana. Secondly, the water deliveries from the public delivery systems cannot be effected with very high frequency needed for very shallow soils and also for crops like vegetables and flowers.

The farmers who have access to groundwater have a tendency to utilise it for growing high value cash crops, which are either prohibited on canal waters or could not be grown under low frequency. In such a favourable situation, the farmers either do not demand canal waters or demand for only a part of the area for crops permitted under the canal rules.

Size of Holdings:

The holding pattern in Maharashtra is also not uniform. Some operational holdings are so large that the farmers do not have either the financial capacity or manpower to utilise the full area as per the cropping pattern under irrigated crops, whereas in the same locality medium and small farmers can take irrigated crops over larger areas in the recommended cropping pattern.

Uniform supply of water to the entire command with equitable distribution based on holdings may not lead to equitable production per unit area or per unit volume of water. The alternatives in this case could be:

1. Delivering water at high frequency in small doses to light soil;

2. Scheduling water supply at different periods to light, medium and heavy soils as per the crops and cropping sequences.

3. Supplying water to meet:

   (a) full demands where groundwater is not available or exploitable;
   (b) partial demands where partial groundwater is available;
   (c) no supply where groundwater is plentiful.

4. Allocating water for high intensity of irrigation to small and marginal farmers so that they can get enough production or income from their holdings.

5. Allocating relatively less water per unit area to large holdings, so that the benefits from public delivery systems are judiciously made available to a weaker section on priority.

6. Restricting or cutting down supply of water to areas prone to waterlogging/salinity in order to maintain the health of the soil and further reduce the burden on drainage or reclamation of soils.

Due to all these vagaries in soils, groundwater availability, crops and size of holdings, land use for irrigated crops on surface canal water cannot be uniform. Similarly, the irrigation water demands are not uniform or proportionate to holdings. The farmers who do not have groundwater, demand water for more areas compared to those who have wells. Similarly, the light soils demand water more frequently than the deep soils. The cropping patterns are distinctly different in kharif and rabi according to the soils and the sowing of crops. Consequently, the crop stages are also different and it is not possible to organise deliveries with the consideration of uniform cropping pattern in the entire command area.

In these circumstances a demand system (or rule No 2) is the only answer. The rule of strict proportionality (supply-based) with fixed outlets will lead either to crop starvation or excess water supplies (waste of water). Adjustable, variable turnout gates are more appropriate in this sort of a situation. This is just not a theoretical point. In the Mula project (Maharashtra), under World Bank sponsorship, the Irrigation Agency decided to redesign a branch canal and its tertiary system (command area

12,000 ha) to the warabandi system as prevalent in Punjab. Fixed outlets (APMs) were installed giving the discharge proportionate to the area to be irrigated.

On system operation, the farmers found, to their dismay, that they have no way to control the waters. Further, as there was a mixed cropping pattern with crops having variable demands, farmers were at a loss to find the ways in which to stop the water when not required. A sorghum crop requires only 3-4 waterings, while wheat in the same season requires 6-7 waterings. With the fixed outlets, waters were flowing in the field when the distributary was running. Sorghum does not need waters at this stage, as excess watering leads to lodging. The only thing farmers did was either to tamper with the fixed outlets or put bunds to prevent the water flow. In this area, about 60% of the outlets were damaged by the farmers for legitimate reasons. A purist advocate of warabandi would say that if the farmers do not need water, let them put it into drains. That is, allow wastage for the sake of operation of warabandi. In a water-scarce area this would be a foolhardy suggestion.

The conclusions that could be arrived at from this experience are:

1. Whether to meet the equity, productivity and efficiency criteria, the decision on the quantum of water allowance is crucial. It could be anything from 1.8 mm/day to, say, 8-11 mm/day, depending on evapotranspiration rates. Any amount less than ETo can be fixed provided supplementary water resources are available. However, due account has to be taken of the proper segment of the farmers who cannot afford the luxury of exploiting supplementary water sources, even if available. Warabandi, in an environment of the type described is likely to do violence to social equity.

2. In the absence of availability of sizeable alternate water sources in the command, water allowance (canal waters) has to be nearer the ETo rates. In times of canal water scarcity (season/year), the allowance could be reduced. If prior intimation of reduction is made available, farmers can decide the crops and the area that could be irrigated within the reduced quota. This should serve the equity principle as well.

3. From what has been said above, in such environmental conditions the supply-based operational system is clearly inadvisable. It is likely to

lead to water wastage or to crop starvation (if allowance is reduced). The only solution is to operate the system on demand basis, with adjustable gates. In passing, it may be mentioned that the efficiency criterion is also affected by the principles that govern the Main System Management (MSM). If MSM is based on downstream control, efficiency and productivity objectives are better served.

Finally, a comment on warabandi may be made. While extolling the virtues of this system, a claim has been made that the available water is shared equitably between each farm inlet authorised to receive irrigation and there are no head and tail problems. At the concept level, this is true; operationally it is otherwise. Thus, a study made by Hydraulics Research shows that there is a general decline in delivery from head to tail[2]. An analyst may dismiss these facts as aberrations/exceptions, but their persistence should lead to a further in-depth analysis of the problem.

There cannot be any disagreement on the main theme of the paper; it has been put neutrally and in the fine academic tradition. But in the hands of irrigation bureaucracy, the article would be interpreted as designating options which are both equally attractive. As the bureaucracy is fond of 'administering', the choice would invariably fall on rule No 1. This option is construction-oriented, which the engineers love. The second option, though complex for implementation, has long run beneficial effects on productivity, equity and efficiency and is in the interests of the farmers and the total economy. The bureaucracy favours possibilities and not probabilities. Thus, if farmers tamper with fixed outlets, they are termed as obstinate and adamant. What surprises one is that The World Bank is party to force anti-farmer policies through the instrumentality of irrigation agencies. To rationalise this behaviour, it would be said that they have opted on the choice of equally attractive alternatives, presented in this paper. Our submission is that choice is not a free one, but situational. In certain situations, as illustrated above, supply-based delivery systems will do damage to efficiency, equity and productivity criteria.

---

[2] I M Makin, 1987, *Warabandi in Punjab India*, Hydraulics Research, Wallingford. Similar data are presented in the studies conducted by Dr David Freeman.

Mr Bhanwar Dan Bithu (Chief Engineer, Command Area Development, Indira Gandhi Nahar Project, Bikaner, Rajasthan, India) comments on M Akhtar Bhatti and Jacob W Kijne's Network paper *Irrigation Allocation Problems at Tertiary Level in Pakistan*, 90/3c:

This paper touches many problems and interventions within the Indira Gandhi Nahar Project. The canal system provides irrigation water to the fine, wind-blown sandy soils in the arid desert region under rotational irrigation scheduling (warabandi), now practised over three decades. It has, however, been observed that under the warabandi system the irrigators in the head reaches, and even in the near-waterlogged lands, tend to irrigate and utilise their turn to depress the salts as a land management programme despite the lack of flexibility and absence of a trading practice. Also in this area, the canals cross sloping lands with geological barriers. This tends to develop high perched ground watertables at the tail ends, affording skimming wells at the Canal tail ends.

It has also been observed that under the warabandi system, unlike scientific irrigation scheduling, cotton, wheat and other crops are either under-irrigated or over irrigated at certain stages of growth resulting in below-optimal production.

The authors, M Akhtar Bhatti and Jacob W Kijne, can be contacted at IIMI, 1 A/B Danepur Road, GOR I, Lahore 54000, Pakistan.

5. PUBLICATIONS RECEIVED

Critchley, W., (1991) *Looking After Our Land: New Approaches to Soil and Water Conservation in Dryland Africa*, OXFAM, Oxford, UK.
This book is about the main lessons to be learnt from new approaches to soil and water conservation in sub-Saharan Africa. It presents six case studies, two each from Burkina Faso, Kenya and Mali, where soil and water conservation, based on the participation of the local people, has resulted in some success. The book brings out the essential ingredients of a successful soil and water conservation project and provides a set of questions which should be asked before embarking on such a programme - not a fixed list of steps to take, but some important points to remember.

The fieldwork for the book was carried out during 1990, and descriptions of project work and progress relate to the projects at this stage.

It is written expressly for development workers in arid and semi-arid Africa, on whose experience it is based. Together with the accompanying video (90 mins) it is suitable for use in workshops or discussion groups as well as being of more general interest to a wider audience concerned with environmental issues. It also stands on its own as a useful reference tool. Both the book and the video are available in French and English. If you want more information about the book and video, contact Olivia Graham, OXFAM, 274 Banbury Road, Oxford OX2 7DZ, UK.

International Institute for Environment and Development, (1991) *Wetlands in Drylands: The Agroecology of Savannah Systems in Africa*
This three-part publication is aimed at providing a broad overview of the role of 'valley bottom' wetlands in savannah agroecosystems in Africa. The work consists of two volumes providing overviews, and a set of case studies. Volume I gives an overview of ecological, economic and social issues, and Volume II presents a study of soil and water processes. Case studies cover: fadamas in northern Nigeria; 'bas-fonds' in Burkina Faso; the wadis of north Kordofan in Sudan; the Khor Baraka in Sudan and Eritrea; dambos in Zambia. For further information, contact Ian Scoones at IIED, 3 Endsleigh Street, London WC1H 0DD, UK.

Sivakumer, M V K ., Wallace, J S., Renard, C., and Giroux, C., (1991) *Soil Water Balance in the Sudano-Sahelian Zone*, IAHS Publication 1991
This internal workshop was held at Niamey, Niger, 18-23 February 1991. The book contains over 50 papers, some in English and some in French, grouped under five headings: (1) Current Research and Future Implications; (2) State of the Art of Soil Water Balance Research; (3) Soils of the Sudano-Sahelian Zone; (4) Soil Water Balance Studies in the Sudano-Sahelian Zone; (5) Operational Applications of Soil Water Balance Monitoring and Prediction.

In addition to soil moisture studies, problems and models in rainfall and evapotranspiration studies are included, together with studies on water uptake by various vegetation types and crops. Models and research papers predominate, although a handful of papers do look at the impact of soil conservation approaches. Some papers do provide an overview of the entire region, but most case studies are from West African countries. The papers represent a definitive overview of soil studies in the region, and their references a tremendous academic resource. For more information, contact the International Association of Hydrological Sciences Press, Institute of Hydrology, Wallingford, Oxfordshire OX10 8BB, UK. If you wish to obtain the Newsletter published by IAHS, write to Mr J H Colenbrander, Secretary-General IAHS, CHO-TNO, PO Box 6097, 2600 JA Delft, The Netherlands.

Caldwell, R., (1991) *Land Resource Management in the Sudano-Sahelian Belt of West and Central Africa: A Practical Review*
This report summarises the environmental challenges in land resource management, and the opportunities for sustained management systems. Interventions in soil conservation, water conservation, improved cropping systems and forestry initiatives are reviewed. The text provides an overview of issues rather than detailed case studies. For more information, write to Mr Richard Caldwell, Office of Arid Land Studies, The University of Arizona, Tucson, Arizona, USA.

Abdalla Abdelsalam Ahmed (ed) *Proceedings of the Conference on Irrigation Management in the Gezira Scheme, Wad Medani, 15-17 May 1989*, Khartoum University Press
The central theme of this conference was 'towards a better utilisation of irrigation water use in the Sudan'. The conference papers include results from some ten field research programmes, covering engineering, agronomy socio-economic and anthropological aspects. The papers include examination of water scarcity problems and water losses in the system, water distribution and equity problems and optimisation of water allocation, and surveys on farm-level water management. There was much discussion around the gap between the 'rule-book' and management priorities versus farmers' needs, and which should have priority in both research and operation. Recommendations reflect the need for more, and better, maintenance and changes in delivery methods.

Chilton, P J., et al (1990) *Collector Wells for Small-Scale Irrigation*, Technical Report WD/90/20
Lovell, C J., Batchelor, C H., and Murata, M., (1990) *Development of Small-Scale Irrigation using Limited Groundwater Resources*, Second Interim Report, Report ODA/11/90
These two reports continues documentation of research in Zimbabwe to study the feasibility of using shallow basement aquifers as a source of water for small-scale irrigation. The first paper documents continuing investigations of these aquifers, and appropriate well excavation and pumping techniques. The second paper compares new drip technologies with traditional flood irrigation practices, and also investigates sites in neighbouring communal areas for potential pilot sites. For more details,

contact Mr Henry Gunston, Institute of Hydrology, Wallingford, Oxfordshire OX10 8BB, UK.

Peter, D., and Prudhomme, P., (1989) *Village Water Supply and Groundwater Resources/Hydraulique Villageoise et Ressources en Eau Souterraine*, Ministère de la Coopération et du Developpement, Paris
In view of the increasing discussion on groundwater in Africa, we would like to remind Networkers about this useful collection of abstracts focused on west and central Africa, published in French and English. Although primarily focused on water supply programmes, it includes very useful information on water resource regimes and pump studies. For more information on this and other publications related to water, contact La Documentation Francaise, 29-31 Quai Voltaire, 75340, Paris Cedex 07, France.

Irrigation and Rehabilitation/La Réhabilitation des Périmètres Irrigués, (1991) Editions du Gret
This work presents the findings of the working group on irrigation and rehabilitation, set up in 1989 by the Network Recherche-Développment at the request of, and funded by, the French Ministry of Cooperation and Development. This group dealt with seven case studies on irrigation and rehabilitation: three in sub-Saharan Africa - the village irrigation system of Matam in Senegal, the Retail Project in Mali and the rehabilitation of Onaha in Niger; two in Madagascar - rehabilitation of Somalac and small-scale irrigation works on the uplands; two in Haiti - the Plaine de l'arbre and the Jarson Jarde Project.

Rehabilitation is not simply upgrading dilapidated infrastructure. Essentially it is a reworking of the whole irrigation project, leading to new relations between the producers and government bodies. The gradual handover of management responsibility to producer group often goes hand in hand with the withdrawal of the state. The central questions of this book are, under what conditions and at what rate is the turnover best achieved?

Shukla, L., and Gurfar, R K., (1991), *Canal Irrigation Management: Problem of Time and Use Relationship*, Agricole Publishing Company, New Delhi
This study of the Indira Gandhi Canal of Rajasthan examines the impact of water availability on cropping patterns and uses, looks at responses of farmers to the improvement of water management, and suggests measures for more efficient water use. This scheme is one of the largest in the world. Infrastructure to serve 505,000 ha has already been completed, over the

period 1974-87, with a further million hectares to be served in Stage II. Stage II is currently suffering from severe under-utilisation following lack of settlers in a harsh environment, and the traditional occupations of local people in livestock herding. Intensities of irrigation envisaged with this water are low (80% - 110%) and water releases have been based on the 'warabandi' system, but there have been additional problems of the release of water up to theoretical requirements across State boundaries.

This study encapsulates virtually all the problems that we know about large-scale irrigation schemes, especially the often inappropriate use of warabandi systems, also described by Patil and Datye in the 'Comment' section of this Newsletter. However, it also includes a brief study of the effect of settlers on the traditional inhabitants, and the disruptive effects of inadequate water distribution. The book ends with a short review of possible interventions in both farmer organisation and technical improvements, but one is left wondering the extent to which these can help without sustained bureaucratic reform. Can we suggest a dialogue starts with advice from other large schemes in India, and from further abroad?

Brooks, K N., Ffolliot, P Fl, Gregersen, H M., and Thames, J L, (1991) *Hydrology and the Management of Watersheds*, Iowa State University Press
It has long been a tradition of hydrology and water resources text to combine chapters describing physical processes and measurement techniques with economic modelling techniques. However, this book provides a very thorough and readable text book on both fronts, providing a wider coverage of topics than in many other texts. This is primarily an undergraduate text, and does anticipate a grasp of algebra and mathematics, but the text is very readable, and helped by many good simple diagrams. The reference material is somewhat dated but is well-discussed. The role of forests in watershed management is the main theme of the text, although other landuse systems are considered. The book is written for training in 'Western' planning procedures, and sometimes has a mechanistic and technocratic flavour. Sadly very little is written about people, and how to get decisions debated, accepted and implemented. The book does summarise some of the problems of tropical ecosystems, but the review of land management issues and options is sketchy. Overall, however, this is a good undergraduate text for Western countries, especially where there is academic back-up for a fuller discussion of issues raised in the text.

Bagchi, K.S., (1991) *Drought-Prone India: Problems and Perspectives*, Agricole Publishing Academy, New Delhi
This book is a compendium of information on the droughtprone districts of India, covering both physical information on climate soils and runoff as well as agricultural data. Unfortunately, most of the agricultural statistics are either undated, or are from the 1970s and early 1980s. The book does include a section on various agricultural recommendations from different states, but does not provide any critique of policies, planning methods or agricultural practices in the droughtprone areas. A list of NGOs and voluntary agencies is given for each state. The main users of this text will be administrators involved in drought work, for whom this book summarises salient features across India, and particular recommendations.

Ansari, N., and Pradhan, P., (1991) *Assistance to Farmer-Managed Irrigation Systems: Experiences from Nepal*
This collection of ten papers evaluates work in FMIS in Nepal from developing sector-funding programmes, and experiments in funding and construction approaches with farmers, through to actual experiences on particular programmes. The papers were presented at the Seminar 'Improving Farmer-Managed Irrigation Systems: Experiences of Different Agencies and Organisations', 27 June 1990. It is published by the Planning and Design and Irrigation Division, Department of Irrigation, Ministry of Water Resources, Kathmandu, Nepal.

The Worth of Water: Technical Briefs on Health, Water and Sanitation, *Intermediate Technology Publications*, (1991)
Pictorial illustrations are an important means of communicating ideas and designs. This book collects together the technical briefs which have been published in the journal *Waterlines* in recent years. Each edition has carried four pages of concentrated information and advice for field workers and decision-makers which people have found invaluable. This collection covers the entire spectrum of water programme needs, from discharge measurements and intake works, disease information, water quality control, standpipe and latrine design, to making soap. If you are involved in water supply, get this for yourself and fellow field workers. For more information, contact IT Publications, 103-105 Southampton Row, London WC1B 4HH.

Meizen-Dick, R., and Svensen, M., (1991) *Future Directions for Indian Irrigation: Research and Policy Issues*, IFPRI
This publication contains 14 papers dealing with four broad categories of concern in Indian irrigation, raising issues rather than suggesting definitive

solutions. Firstly, the important issues facing the sector are discussed, especially the water resources base, development options for the future, and the need for greater efficiency of operation. Secondly, the performance of existing systems is examined, with emphasis on the options to improve the generally poor performance without extensive physical modification. Thirdly, prospects for introducing and sustaining managerial improvements are debated. The last section looks at some of the special problems of Eastern India, which, although once possessed of a productive and prosperous agricultural sector, now lags behind many other areas. The final chapter addresses research needs for the future. The papers stem from a workshop held in Ootacamund in 1988. The authors can be contacted at IFPRI (International Food Policy Research Institute), 1776 Massachusetts Avenue, NW, Washington DC 20036, USA.

Tyagi, N K., Joshi, P K., Gupta, R K., and Singh, N T., (eds) (1990) *Management of Irrigation System*, Central Soil Salinity Institute, Karnal, India
This book collects the 38 papers presented at the National Symposium on Management of Irrigation Systems, Karnal, 27-28 February 1988. It thus contains a wealth of material, particularly on technical aspects. The six technical sessions cover papers on (1) water delivery, application and disposal; (2) soil-water-plant relations; (3) land drainage and conjunctive use; (4) use of saline water and management of salt affected soil; (5) irrigation project planning and evaluation.

Sundar, A., (ed) (1990) *Promoting People's Participation in the Rehabilitation of Tanks in Karnataka*
This collection of seven papers looks at various aspects of the history of tank operations in Karnataka. Papers look at village practices in sharing water at times of scarcity (*damoosi*), the work of local councils, and initiatives in rehabilitation.

Sundar, A., (1990) *Managing Public Irrigation Systems*
This report collects a number of papers by the author on irrigation management. It covers many aspects of management structures and performance, as well as information for M&E, training and extension needs.

Both of the above papers can be obtained from Wamana Consultants, 601 Lingapur-la-builde Complex, Himayatnagar, Hyderabad 500 027, India.

Venkata Reddy, M (1990) *Impact of Irrigation and Multipurpose Projects on Economic, Social and Environmental Conditions: A Study of Ghataprabha Command Area, Karnataka*
This study looks at changes in the Ghataprabha Command Area, comparing the conditions in 1986-87 with a Benchmark Survey of 1975-76. The area has seen major changes in cropping activities. Farmers have moved from traditional sorghum production into maize and sugar cane, although sorghum still occupies third place in the crop selection. However, hybrid varieties are still not widely cultivated. Large farmers violate crop recommendations more frequently. However, large farmers have lower irrigation intensities than smaller farmers because of labour shortages, and there is potential for mechanisation. Intensities have not changed much at all over the decade. Yields of most crops have increased, but sugar cane is declining (in spite of increasing area of cultivation). The value of output per irrigated acre is six times that of rainfed crops, with big increases in output and use of inputs in the zones with good water supply. There is inequitable distribution of benefits, and caste plays a major role in determining access to land, water and inputs. Increases in income varies across the scheme, but everyone has gained. Saving ratios have increased, and are positively related to land size, but labourers and marginal farmers have limited savings. Farm debt has increased significantly, largely due to crop loans for cultivation of commercial crops, but there has been drastic decreases in non-farm debt, except for labourers. Recommendations stress that problems from violation of cropping patterns must be addressed, and consider better use of water (especially to use the water flowing at night which is often wasted), and needs to tackle environmental problems.

6. SHORT REPORTS AND JOURNAL ARTICLES

Received from the Research and Development Network (GRET, 213 rue la Fayette, 75010 Paris, France, Tel: 33(1)-40 35 13 14; Fx: 40 35 08 39; Tx: 212890), report on the meeting of 6 May 1991 of the working group on irrigation from GRET and FAO networks. It focused on the 'place and future of peasant organisation in three large-scale irrigation schemes', namely, Lac Alaotra, Madagascar; Office due Niger, Mali; and Yagona, Cameroon).

Vaishav, T., (1991) Training Engineering Supervisors for Small-Scale Irrigation Development in Nigeria, *Waterlines 9(4): 20-22.*

Fujisaka, S., (1991) Agro-Ecosystems and Farmer Practices and Knowledge in Madagascar's Central Highlands: Towards Improved Rice-Based Research Systems, *IRRI Research Paper 143*, International Rice Research Institute, PO Box 933, 1099 Manila, Philippines.

Karnik, S S., (1990) Women in Sub-Saharan Africa: A Select Annotated Bibliography, *African Currents No 11: 92-109.* (*African Currents* is an journal published by the Centre of East African Studies, University of Bombay, Vidyanagari, Kalina, Bombay 400 098, India.)

Dike, E., (1990) Problems of Large-Scale Irrigation Schemes in Nigeria, *Science, Technology and Development 8(3): 245-252.*

Lloyd, J W., (1990) Groundwater Resources Development in the Eastern Sahara, *Journal of Hydrology 119: 71-87.*

Mankarious, W., Gates, T K., and Rady, M A H., (1991) Irrigation of Small-Level Basins in Egypt, *Journal of Irrigation and Drainage Engineering 117(3): 361-376.*

Carter, D C., and Miller, S., (1991) Three Years Experience with an On-Farm Macro Catchment Water Harvesting System in Botswana, *Agricultural Water Management 19: 191-203.*

Degoutte et al., (1990) Etude de Variantes Techniques dans le Domaine des Petitis Barrago en Afrique De L'Ouest, *Bulletin de Liaison du Comité Inter-Africain d'Etudes Hydrauliques No 81 (July 1990): 19-32.*

Pearce, F., (1991) Africa as a Watershed, *New Scientist (23 March 1991): 34-40.*

Siltation Problems in the Gezira Irrigation Scheme, Sudan, *ODU Bulletin (1991) No 21.*

Small-Scale Irrigation Development in Africa, *ODU Bulletin (1991) No 22* For more information on the *ODU Bulletin*, contact Hydraulics Research, Wallingford, Oxfordshire OX10 8BA, UK.

Morgan, P., and Chimbunde, E., (1991) Upgrading Family Wells in Zimbabwe, *Waterlines 9(3): 10-12.*

Sexton, B., and Garman, P., (1991) Water Current Turbines for Sudan: Using the Energy in the Nile, *Waterlines 9(3): 30-32.*

Alam, Mahmood., (March/April 1991) Problems and Potential of Irrigated Agriculture in Sub-Saharan Africa, Technical Paper, *Journal of Irrigation and Drainage Engineering 117(2): 155-172.*

Knoth, Jocher., (1989) Wassernutzerorganization und System Management (Water User Groups and System Management), in *Der Tropenlandwirt (Journal of Agriculture in the Tropics and Sub-Tropics), Vol 41.* Thesis, with fieldwork from Senegal.

Lee, M D., and Visscher, J T., (1990) Water Harvesting in Five African Countries, *Occasional Paper 14,* IRC International Water and Sanitation Centre, The Hague, The Netherlands.

Rizk, Z S., and Davis, A D., (April 1991) Impact of the Proposed Qattara Reservoir on the Moghra Aquifer of Northwestern Egypt, *Groundwater 29(2): 232-238.*

Wells, N A., Andriamihaja, B., and Solo Rakotovololona, H F., (1991) Patterns of Development of Lavaka, Madagascar's Unusual Gullies, *Earth Surface Processes and Landforms 16: 189-206.*

Simon, B., and Anderson, D., (June 1990) Water Auctions as an Allocation Mechanism in Victoria, Australia, *Water Resources Bulletin 26(3): 387-395.*

Tsur, Yacov., (May 1990) The Stabilisation Role of Groundwater when Surface Water Supplies are Uncertain: The Implications for Groundwater Development, *Water Resources Research 26(5): 811-818.*

Nickum, J E., and Easter, K W., (1990) Institutional Arrangements for Managing Water Conflicts in Lake Basins, *Natural Resources Forum 14(3): 210-221.*

Pandey, Sushil., (1990) The Economics of Water Harvesting and Supplementary Irrigation in the Semi-Arid Tropics of India, *Agricultural Systems 36(1991): 207-220.*

Bartarya, S K., (July 1991) Watershed Management Strategies in Central Himalaya: The Gaula River Basin, Kumaun, India, *Land Use Policy 8(3): 177-184.*

Brand, A., and Bradford, B., (1991) Rainwater Harvesting and Water Use in the Barrios of Tegucigalpa. Available from Bernt Aasen, UNICEF, Apartado Postal 2850, Teguciagalpa, Honduras.

Mase, T., (1990) A Study of Water Users' Associations for Irrigation in Asia, *Irrigation Engineering and Rural Planning 18: 5-16.*

Small, L E., and Svendsen, M., (1990) A Framework for Assessing Irrigation Performance, *Irrigation and Drainage Systems 4: 283-312.*

Ishag, K., Thornton, D., Tiffen, M., and Upton, M., (March 1991) Farm Location and Farmers' Performance on the Hamza Minor Canal, *Water Resources Development 7(1): 2-15.*

Long, R B., (March 1991) Short Run Marginal Returns from Irrigation Water, *Water Resources Development 7(1): 39-44.*

Khan, L R., (March 1991) Impacts of Recent Floods on the Rural Environment of Bangladesh: A Case Study, *Water Resources Development 7(1): 45-52.*

Awadalla, S., and Noor, I M., (March 1991) Induced Climate Change on Surface Runoff in Kelantan, Malaysia: A Preliminary Assessment, *Water Resources Development 7(1): 53-59.*

Chaudhry, M Aslam., and Young, R A., (1989) Privatization of Scarp Tubewells: Some Economic Considerations, *Special Report Series No 15*, Pakistan Economic Analysis Network (EAN) Project, in collaboration with Ministry of Food, Agriculture, and Cooperatives, Government of Pakistan.

Chaudhry, M Aslam., (1988) Rationalization of Irrigation Water Charges in Pakistan: Answers to Some Policy Questions, *Special Reports Series No 9*, Pakistan Economic Analysis Network (EAN) Project, in collaboration with Ministry of Food, Agriculture, and Cooperatives, Government of Pakistan.

Mallorie, E., (1988-90) Definition of Recommendation Domains for Wheat in Sindh, *Pakistan Journal of Agricultural Social Sciences Vols 3 and 4(Nos 1 and 2)*, Bi-Annual Journal of Pakistan Agricultural Research Council, Islamabad.

van Immerzeel, W H M., (April 1991) Field-Irrigation in the Peruvian Andes, *Waterlines 9(4): 5-8.*

Jurriens, M., and Landstra, W., (1990) Tungabhadra Irrigation Pilot Project: Final Report, Conclusions and Recommendations, Vol 1 (Main Text and Annexes), International Institute for Land Reclamation and Improvement, PO Box 45, 6700 AA, Wageningen, The Netherlands.

Jurriens, M., and Landstra, W., (1990) Tungabhadra Irrigation Pilot Project: Final Report, Conclusions and Recommendations, Vol 2 (Figures and Tables), International Institute for Land Reclamation and Improvement, PO Box 45, 6700 AA, Wageningen, The Netherlands.

Lynch, B D., (1991) Women and Irrigation in Highland Peru, *Society and Natural Resources 4: 37-52.*

7. FUTURE CONFERENCES AND WORKSHOPS

4-10 November 1991, Cairo, Egypt
Congress on 'Soils and Water Management for Sustainable Productivity'. Details from Prof Dr A M Elgala, Faculty of Agriculture, Ain Shams University, Shobra El-Khaima, Cairo.

18-23 November 1991, Bangkok, Thailand
8th ICID Afro-Asian Regional Conference on 'Land and Water Management in Afro-Asian Countries'. Contact Secretary-General, International Commission on Irrigation and Drainage, 48 Nyaya Marg, Chanakyapuri, New Delhi 110 021, India. Tel: 3016837; Tx: 031 65920 ICID IN.

20-24 November 1991, Shanghai, China
Regional Conference on development and water pollution control 'Asian Water Quality'. Details from Huangpu River Research Department, 1 Nandan Road, Shanghai, China.

26-31 January 1992, Dublin, Ireland
International Conference on Water and the Environment. Details from WMO/UNEP.

30 August-12 September 1993, The Hague, The Netherlands
15th International Congress of ICID. The general theme of the Congress is 'Water Management in the Next Century'. Contact Secretary-General, International Commission on Irrigation and Drainage, 48 Nyaya Marg, Chanakyapuri, New Delhi 110 021, India. Tel: 3016837; Tx: 031 65920 ICID IN.

8. TRAINING COURSES

Louis Berger have compiled a reference document on all irrigation-related teaching around the world in 1991 and scheduled for 1992, *The Compendium of International Short-Courses, Workshops and Conferences.* You should also inform them of any new teaching developments you are involved with. Contact Tom Kajer, Louis Berger International Inc, 213 Ansal Chambers II, 6 Bhikaiji Cama Place, P K Puram, New Delhi 110 066, India.

CEFIGRE (organise courses in French and English) have several courses running which will be of interest to engineers, water management and environmental protection executives. CEFIGRE is conducting these activities mainly in the fields of water resources, urban water supply and sanitation, rural development (water, sanitation, irrigation), environmental management, and institutional development. Countries hosting their courses include: Thailand, Cote D'Ivoire, Burkina Faso, Niger, Cameroon, and France. For details, write to: CEFIGRE, Sophia Antipolis, BP 113, 06560 Valbonne Cedex, France. Tel: 33(92)-945800; Tx: 461 311 F; Fx: (93)-654402.

For courses run by the Water, Engineering and Development Centre (WEDC), please write direct to them at Loughborough University of Technology, Leicestershire LE11 3TU. Tel: 44(0509)-222885; Fx: 211079; Tx: 34319 UNITEC G.

Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England.
Telephone: +44 71 487 7413
Telex: 94082191 ODIUK
Fax: +44 71 487 7590

odi

IRRIGATION MANAGEMENT NETWORK

THE LIBRARY
OVERSEA... INSTITUTE
REGENT'S ... PARK
INNER CI...
LONDON NW1 4NS

GROUNDWATER DEVELOPMENT ON MADURA, INDONESIA: GENDER ISSUES IN AN IRRIGATION PROJECT

Margaret Casey

Network Paper 1

October 1991

Papers in this set:

1 *Groundwater Development on Madura, Indonesia: Gender Issues in an Irrigation Project* by Margaret Casey.

2 *Development of Water User Associations on the Madura Groundwater Irrigation Project, Indonesia* by Robert Jackson.

3 *National Pump Irrigation Study: Material Developed During Inception Activities, January 14 - 8 February* by Effendi Pasandaran; *Assessment of Conjunctive Use in Maharashtra Minor Irrigation Systems* by T S Sheng, et al.

4 *Conjunctive Water Use for Irrigation: Good Theory, Poor Practice* by Linden Vincent and Peter Dempsey.

5 *News from the Field - Groundwater Development and Lift Irrigation* from Tunisia, Mali, Sub-Saharan Africa, Bangladesh and South India.

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

Linden Vincent
Editor, Irrigation Management Network
Overseas Development Institute
Regent's College
Inner Circle
Regent's Park
London NW1 4NS

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

The opinions represented are those of the author and do not necessarily reflect the policies of the Overseas Development Institute, or any other organisation with which the author is connected.

GROUNDWATER DEVELOPMENT ON MADURA, INDONESIA: GENDER ISSUES IN AN IRRIGATION PROJECT

Margaret Casey

Contents **Page**

Margaret Casey is a freelance research consultant. She can be contacted at her home address: 80 Ponsonby House, Bishop's Way, Bethnal Green, London E2 9HS (Tel: 081-980 7496).

GROUNDWATER DEVELOPMENT ON MADURA, INDONESIA: GENDER ISSUES IN AN IRRIGATION PROJECT

Margaret Casey

1. INTRODUCTION

This paper examines the impact of a groundwater irrigation project upon women in Madura, Indonesia. Madurese women are traditionally responsible for many aspects of agricultural production, i.e. as primary producers, farm managers, processors of foodstuffs, and traders. They are also prominently involved in off-farm enterprises and those reproductive activities which are commonly subsumed and hidden under the blanket terms 'housework' and 'childcare'.

Technological changes may have complex and differential effects on the men and women within a given society. Thus, it is essential during the initial planning stage to gain a systematic understanding of those factors which may be pertinent to the future implementation of a project. The information which was available on gender and intra-household variables on Madura at the time the project was introduced was scant. Over the years the need to involve women in the extension programme has been stated, as will be described below, but it was not until 1989 that a qualitative analysis of Madurese women in agriculture was conducted. This study (Casey, 1989) concluded that the involvement of rural women in the decision-making process concerning agricultural matters was being adversely affected by their virtual exclusion from the extension programme.

The aim of the paper is to emphasise the necessity of understanding how a given farming system operates, particularly the complex inter-relationships which exist between men and women before a development project is implemented. It also reviews issues in the design of relevant research initiatives to establish gender-related concerns which may influence the outcome and benefits of an irrigation project. It has to be appreciated that farmers and households are not homogeneous and that distinctions prevail between individuals in their access to and control of resources. In short, the economic, social and political disparities which exist in a given locale have to be identified from the inception of a project. Those findings then have to be incorporated into the design, implementation and appraisal of the project.

2. AGRICULTURAL DEVELOPMENT AND THE MADURA GROUNDWATER IRRIGATION PROJECT

Madura, which lies off the north-east coast of Java, is traditionally known within Indonesia for the proud character of its inhabitants, for its hot, dry climate and barren soils, and, more recently in the context of the tourist industry, for its bull races (*kerapan sapi*). The island is some 160 km long, up to 38 km wide, and covers an area of 4,382 square km. It is rugged and hilly but not mountainous, the highest point being 470 m above sea level. A limestone formation, 50 to 300 m thick, outcrops as prominent escarpments to the north and south. The limestone soils offered only marginal potential for agriculture in the past. However, the limestone formation holds the only real potential for groundwater abstraction for irrigation. To the north and south of the limestone ridge lie alluvial plains.

The climate is tropical, but Madura has a more pronounced dry season than neighbouring Java, with droughts lasting between four and six months. Dry Season I falls between April and July, whilst Dry Season II falls between August and November. The Wet Season falls between December and March. However, the length of the seasons may fluctuate from year to year and from one area of the island to another. Rainfall varies significantly between different parts of the island, generally increasing away from the coast and from east to west. Mean annual rainfall varies from 1250-1750 mm in the east, to 1750-2100 mm in the western inland area.

Madura belongs to the administrative provincial unit of East Java. The island is divided into districts; from west to east, Bangkalan, Sampang, Pamekasan and Sumenep, which constitute 4 of the 29 administrative districts (*kabupaten*) of the province. The population is over 2.7 million (1980 census); average population density is 557 persons per square km. The fairly low growth rate (1%) is partly explained by permanent and seasonal out-migration to Java and beyond.

The majority of the population is dependent on subsistence level agriculture, the size of the average land holding being 0.1-0.2 ha. A 1982 land-use survey pointed out that only 14.1% of all land in Madura was used for wet rice (*sawah*) cultivation, while the corresponding figure for the province of East Java was 28.5%. Agricultural output is generally low due to relatively infertile soils, lack of water and other inputs. The staple crops in the traditional subsistence systems are rainfed rice and maize. Tobacco production is important in the eastern districts of Sumenep and Pamekasan, and there are a few industries, such as tiles, bricks and textiles, in the centrally located villages of Sumenep. Animal husbandry, fishing, and salt production are also important throughout the island. Compared to the rest of the province, Madura has a low level of education, literacy rate, per capita income and development.

The Regional Development Plan of East Java for the period 1979-1984 (Indonesia's Third Five-Year Plan) gave high priority to Madura. The Indonesian government, with the assistance of international agencies, directed its efforts to the development of the island. It is in the context of Madura's poverty and lack of resources that the Madura Groundwater Irrigation Project (MGIP) has been developed. The original aim of the project was to increase agricultural production, mainly of wet rice. Soils were classified according to their suitability for wet rice and results assumed to indicate a general suitability for irrigated development. This emphasis on rice production was in accordance with the policy aim of the Indonesian government to achieve national self-sufficiency in rice at that time.

One of the main changes envisaged as a result of groundwater development on Madura was the conversion of unirrigated land (*tegal*), previously supporting a rainfed cropping pattern of dry-land rice (*padi gogo rancah*) and/or maize, to land suitable for wet rice. The aim was to grow two irrigated wetland rice crops per year. Such a change in land use was expected to result in a very large increase in agricultural production and be one of the major benefits of groundwater development.

The project was implemented through the Indonesian Directorate General of Water Resources Development (DGWRD) by the Directorate of Irrigation II (DOI II). The executing agency within the DOI II is the Groundwater Development Sub-Directorate (PAT) which has Groundwater Development (P2AT) office at provincial level and in the actual areas of operation. As P2AT is a government agency, it has to work through the existing apparatus of civil administration, from district (*kabupaten*) to sub-district (*kecamatan*) to village (*desa*). The Madura project comes under the jurisdiction of the East Java Groundwater Development Project Executive Board in Surabaya (BP P2AT Jawa Timur), which oversees all the groundwater projects in the province.

Following reconnaissance studies and investigations from 1972 to determine the scope for development, the MGIP has been implemented in three Phases since 1979 (discussion of the history of the project as a whole may be found in Casey 1991 and Smout 1986 and 1990, and in various annual reports). By the end of the project, some 4672 ha will be irrigable and 126 tubewells will have been constructed, mainly in the southern half of the island. Typically a tubewell serves a command area of between 20 and 45 ha. It has been one of the key aims of the extension programme to form and develop water users' associations (*Himpunan Petani Pemakai Air*, usually known by the acronym *HIPPA*), made up of the farmers (*petani anggota*) in the command area. Support is recognised to be essential in areas such as Madura, where farmers have little or no experience of irrigation. From amongst their number, and with the assistance of the village head (*klebun*), the farmers select a committee. This committee consists of a chairperson (*ketua HIPPA*), a treasurer (*bendahara*), tubewell operator, water bailiff (*ulu-ulu*) and a secretary (*sekretaris*). Each block is headed by an elected person known as *ketua kelompok*, whose responsibility it is to liaise between block members and the HIPPA officials. Charges for irrigated water are levied by the hour or by number of plants, and are payable to one or other of the HIPPA officials depending on village preference. It is the aim of the project to hand over the running of the wells to the individual HIPPA and the local government after two years of support (i.e. for costs of diesel and the operator's salary) from the project, although this has not always been possible.

Financial support has been provided from the ODA (for the services of the principal consultants), from the European Community (for the services of local consultants, technical assistance programmes, procurement of equipment and construction contracts), and also from the Government of Indonesia (GOI). Liaison is maintained with the EC and ODA mainly at Directorate General and Directorate level. Responsibility for the project was handed over from the EC delegation in Bangkok to the Delegation in Jakarta on 28 November 1986. The principal consultants were British while the local consultants were Indonesian.

3. THE SOCIOLOGICAL COMPONENT OF THE MGIP

Gender issues in agricultural development received increasing attention during the 1980s (see, for example, Dey 1982, Nelson 1981, and Poats, Schmink and Spring 1988). However, it has often proved difficult to incorporate a meaningful research input in the feasibility and design stages of project development. Although time is a major constraint, agreement of research priorities both within a social research team, and also between social and technical staff, is frequently a source of debate, and sometimes serious controversy. This section reviews the methodology proposed for social research in the early stages of the MGIP.

The original proposals for social research in the MGIP suggested a three-month period to gauge farmer response. This proposal was subsequently modified after a pre-feasibility visit for work to cover selection of sites, water charges, extension, and to clarify the effect of land tenure, cropping patterns and institutions on farmer response. Under these modifications, a sociologist or anthropologist would undertake this work over a six-month period.

The sociology programme was established in April 1985 with the appointment of an expatriate Sociology Adviser (male) and two Indonesian sociologists (also male). The Adviser made three inputs during 1985-86, while the two local sociologists were in post for twelve months. One local sociologist then remained on the project for a six month period. Following further recommendations from the funding agency, the sociologists focused upon the planning and design of new tubewell irrigation systems on the island. Take-up of tubewell irrigation facilities had been poor, particularly in west Madura and it was in response to this problem that the new programme of village studies and meetings was developed.

The research procedure agreed for farmer participation in new systems was for a short social study of two to three days in each location. Data would be collected on village social structure, on the importance of kinship patterns and settlment units, and on the identification of influential groups and individuals. This study would be backed up by three consultative meetings in each village during the planning process at which the views of farmers would be sought. Before these meetings were set up, a visit would be made to each village head to explain the objectives of the project, and it would be the responsibility of the village head to invite 'relevant farmers' to the meetings. Officials at higher administrative levels - the district and sub-district - plus the Agricultural Service (*Dinas Pertanian*) would also be contacted.

The purpose of the first consultative meeting was to introduce the ideas and practices of tubewell irrigation to farmers (since it was a new phenomenon to Madura), to discuss the proposed timetable of development activities and provisions for land compensation, and to consult with the farmers about the extent and boundaries of the proposed command area. The focus of the second and third meetings was to discuss with farmers the alignment of canals, the division into blocks, and the positioning of outlets. It was also the general aim to cover such issues as land ownership, sharecropping, marketing, migration, the attitudes of farmers to tubewell irrigation, and to discuss any special requests farmers might have.

In implementing these social studies and consultative meetings in the villages it was hoped that all parties and interests might be consulted from the beginning of tubewell development and that any social factors which ought to be incorporated into the design of irrigation systems would be identified. The village studies were to be the responsibility of the local sociologist alone while the consultative meetings were to be undertaken by the local sociologist and members of the P2AT staff. The Sociology Adviser was to be responsible for reviewing the results of the programme, dealing with any problems occurring after the installation of pumps, and for report writing. It was expected that the sociology team would cooperate with the Design, Water Management and Agriculture sections of the project.

The procedure of village social studies and consultative meetings had been instituted too late to be incorporated into the 1984-85 programme. It was used in an abbreviated form during the 1985-86 programme in those villages where some work had already been undertaken. The procedure was scheduled to be implemented in full in 1986-87 for the Phase 3 drilling programme. However, it seems that the village social studies were frequently not undertaken and the consultative meetings were in practice limited to two. Besides participating in the programme of site selection and evaluation, the sociologists were heavily involved in those areas where take-up of tubewell irrigation facilities had been poor. This involved the sociologists in the use of agricultural demonstration plots, videos and posters in an effort to increase farmer interest and involvement in new schemes, plus the physical rehabilitation of irrigation systems (i.e. lining tertiary canals, defining irrigation blocks, and so on).

The initial pre-feasibility visit had pointed out the need for an extension strategy which incorporated women. Whilst recognising that time constraints might make this difficult, it was suggested that a 'small supplementary study' might be considered for the future. However, the recommendations concerning the study of the impact of tubewell irrigation on women were not taken up.

The primary aim of the sociology programme, as stated in the MGIP annual report of 1986 (1986:154), was to ensure:

> that all the parties and interests may be consulted ....
> avoiding the alienation or exclusion of some elements from tubewell development at an early stage.

However, it seems that the contribution of Madurese women to agricultural production was not considered a priority. The possibility that women might be farmers, farm labourers and farm managers, and as such should be incorporated into the procedure of meetings outlined above, was not taken on board. Given that considerable efforts were directed to encourage farmers to take up the irrigation facilities and to perceive the project as their responsibility rather than an external imposition, the failure to involve women was a double omission.

Subsequently, however, certain members of the project staff, increasingly came to feel that women were not sufficiently integrated into the development project. A brief survey of women in agriculture was undertaken by the local sociologist in October 1987 on the north coast of Bangkalan. The ensuing report raised many more questions than it answered. It was eventually agreed that a further study should be undertaken, focusing on women's roles in decision-making and production. A farming systems-style survey of an informal nature was conducted in 1989, with a focus on specific areas of technical interest. The latter included land ownership, production arrangements, women's roles in marketing produce, in seed selection, storage and purchase, and women's attitudes and decision-making influence in the adoption of cash-cropping and irrigation.

Four villages were selected for fieldwork. These villages spanned the island, from the drier eastern areas where tobacco is an important cash crop, to the wetter west, where migration is more prevalent and where efforts are being made to establish *polowijo* crops (in the Madurese context, foodcrops other than rice, i.e. maize, soya bean, melons, etc), as cash crops. A week was spent in each village conducting informal discussions with women. Efforts were directed to meeting women wherever they happened to be - transplanting rice seedlings, weeding tobacco plants, finding fodder for cattle, planting groundnuts, performing the myriad of tasks subsumed under the label 'housework', and so forth. The interviews were generally conducted in Madurese, largely because most women did not speak

Indonesian but also because it was the language they were most familiar with.

The study included women from different areas of each village, of different age groups, marital status, and with varying access to land and income-earning activities. It proved possible to focus on particular topics as and when they arose, which would have been difficult if we had been administering formal questionnaires. Such topics typically concerned issues of local interest; thus in one village discussions frequently centred around tobacco, while in another women were keen to talk about *polowijo* crops. In the west, male migration and the opportunities to earn additional, non-agricultural income proved popular topics of conversation, while animal husbandry was much discussed in the fourth village. Thus key topics were identified by the women themselves and subsequently explored within the specific context of each village study.

A problem encountered in all four villages was that of persuading men that we wished to talk with women. Wherever we went, men would appear, intent on telling us "what we really wanted to know". Men were keen that we should receive the "right" answers to our questions and obviously felt that their womenfolk might misinform us and that this would have dire consequences for the village as a whole. A satisfying discussion with a woman would often come to an abrupt end when a man appeared because the women seemed reluctant to talk freely with men present (although there were exceptions). We wanted to spend as much time as possible with women without alienating or antagonising men, since this might have unfortunate consequences for the women concerned and also for the future success of the extension programme. This meant that sometimes we had to exercise a great deal of patience, which, given the time constraints, was not always easy.

To sum up this section, it can be said that the sociological component of the MGIP was introduced rather late in the day. At the time the consultation procedure for new sites was drawn up, the planning and survey of many Phase 2 systems was already well advanced. The Sociology Adviser noted in 1986 that in many of the cases where consultation had not taken place, substantial revisions to the command area boundaries and to layout proved necessary. It may be the case that the contributions of technically trained team members - hydrogeologists, soil specialists, engineers and agriculturalists - are usually perceived to be more tangible than those of a sociologist. Once a budget has been drawn up and the inputs from various specialists have been allocated, the working schedule is often difficult to re-arrange. In the case of the MGIP, as we have seen, sociological inputs were only introduced in 1985, six years after Phase 1 of the project commenced. The problems then facing the sociologists were considerable: trying to coordinate a procedure of meetings in abbreviated form in some villages, in full in new sites, revising command areas in other villages, in addition to participating in demonstration plots, the presentation of extension materials, and assisting other sections in work concerning irrigation charges, for example. They were hampered still further by staff shortages and time constraints. It was in this context that the issue of gender was effectively shunted to one side. The lesson to be learnt from the MGIP case is the need to incorporate a sociological element in the initial planning and early implementation of a project with adequate inputs for the work and an agreed set of work targets. The MGIP also reveals the importance of greater sensitivity to gender issues on the part of all team members, including the sociologists.

4. THE MULTIPLE ROLES OF MADURESE WOMEN

The village case studies established that Madurese women make a central contribution to various stages of agricultural production. All the women interviewed named farming as their principal source of income. Farming in Madura is based around the *tanean*, a settlement unit which consists of one or more houses, kitchen(s), cattle sheds and a prayer house. It is a semi-autonomous unit, occupied by an extended family who are linked not only by kinship ties but also by bonds of economic and social inter-dependence and cooperation. According to Madurese custom (*adat*), men are perceived to be the head of the household while women are traditionally associated with cultivating the land, becoming wives and mothers, and holding the *tanean* together. This is reflected in the fact that a daughter may, in some areas, inherit twice as much as a son, because as a man the latter is free to leave the village and find work elsewhere. Land may be held in a variety of ways, sometimes simultaneously; it may be inherited, worked on a share-cropping basis, rented, or pawned. Of course, not all women have access to land, and some are employed as waged labourers.

Men usually prepare the land (i.e. ploughing, hoeing and harrowing the soil) for crop cultivation, while women are generally responsible for many of the ensuing activities. Whether it is rice, tobacco, maize, or other *polowijo* crops which are cultivated, the labour inputs for planting, sowing, transplanting, weeding and harvesting are supplied by women. Men may also assist in weeding the tobacco crop and in carrying sheaves of rice from the fields. The application of fertilisers and insecticides may be undertaken by either sex. Further processing (drying, threshing and winnowing) is done by women. The tasks of storing grain for home consumption and as sowing seed for the following year, plus the marketing of surplus crops, fall to women.

Both men and women provide labour under the *gotong-royong* system, whereby family members and neighbours come together and work as a group on each person's land in rotation, with no wage involved. This is an important form of labour for many small farms since a large group of labourers may be assembled and the work completed in a short span of time. In the wetter west of the island, where animal husbandry is of greater importance, adults and children of both sexes are involved in the collection of fodder for stall-fed cattle.

Since both men and women within a household may own land, and given that women traditionally control household financial resources, decisions concerning agricultural production have traditionally been taken jointly. However, as will be discussed in the next section, this is changing. In their capacity as farm managers, individual women may be responsible for renting or sharecropping land, hiring waged labourers, providing food and drinks for labourers, paying their wages, arranging credit and so forth. In areas such as the west of Madura, where seasonal migration of males has been prominent, many women are used to being responsible for decisions concerning the family farm. Widows and divorcees take sole responsibility for decision-making.

A significant proportion of women in the village studies participated in other income-earning activities, in addition to the roles discussed above. These activities varied according to local topographical conditions and proximity to market centres, and included the trading of fish, fruit and other goods, making a variety of snacks, and working as masseuse and dressmakers.

Women are also household managers, responsible for the day-to-day running of the household, a fact which is directly related to the cultural association of women with food. Most women are involved in non-productive activities. It falls to women to prepare and cook food, obtain water for bathing and cooking, collect firewood for cooking, to care for children, keep the house and yard swept clean, and so forth. Women often cultivate kitchen gardens to supplement their household's diet.

5. THE IMPACT OF THE MGIP ON MADURESE WOMEN

The introduction of tubewells and the adoption of new farming technology has had a significant impact on traditional cropping patterns in Madura. With the availability of irrigation water it is now possible to grow three crops a year in many of the command areas. Tobacco has flourished as a cash crop in the drier east and has spread to central Madura, where there is now a greater diversity of cash crops, including tobacco, chilli, cucumber, shallot, water melon and soya bean. In west Madura, the cultivation of rice, groundnuts and maize, together with small amounts of mung bean, cow peas, sesame seed and sweet potato, is combined with animal husbandry.

These changes in agricultural practice have affected women in a number of ways. In the past, Madurese women learnt farming techniques and practices from their parents so that there was a smooth transition of skills and knowledge from one generation to the next. Women were intimately involved in the various stages of decision-making and production, and, since their menfolk were often absent from the village in search of work, they were directly responsible for all aspects of farming. The method of acquiring knowledge from first hand experience still exists, but it would seem that women are being denied access to the information needed to operate the new technology because they are not included in the extension programme. The institutionalisation of information - on the use of tubewell water, new strains and crops, credit arrangements, and so on - seems to have brought about a sharper differentiation of 'male' and 'female' spheres of activity and influence.

Women have traditionally been involved in small trading. The expansion of tobacco production in east and central Madura has meant that the dynamics of economic networks have changed from a range of local, personal contacts to a hierarchical structure which extends beyond the local and interlocal markets. Agents of the large cigarette companies from East Java often buy the tobacco crop whilst it is still in the field, thus cutting out the small trader altogether. Sometimes an individual will make arrangements to buy the tobacco crop of a number of villagers, and then sell to the agent. However, with the availability of irrigated water in central Madura there is now a greater diversity of *polowijo* crops such as chilli, cucumber, shallot, water melon and soya bean, coupled with proximity to the town of Pamekasan (the administrative capital of the island). Women have been able to establish themselves as petty traders in these crops.

Although the Indonesian government is keen to establish a comparable *polowijo* crop as a cash crop in the west of Madura, the failure to do so to date has meant that women have maintained and in some cases expanded their traditional trading roles. Intercropping is common in west Madura. Farmers commented that when rice is inter-cropped with the maize variety Ardjuna (a high yielding strain which the government is promoting), the rice crop is often poor because Ardjuna absorbs a lot of water. When Ardjuna is inter-cropped with groundnuts, the yield from the groundnut harvest is low because Ardjuna absorbs more nutrients from soil than the local variety of maize. Women are reluctant to give up planting maize because it is a staple food crop. On the other hand, they also wish to continue planting groundnuts because the latter is an important source of cash. Some women have attempted to solve the problem by intercropping the local variety of maize (which is a much smaller plant) with groundnuts in the main body of their plot of land, and planting small amounts of Ardjuna around the perimeter of the plot. The Ardjuna cobs are then sold whilst the local maize is stored. Many women farmers informed us that the seed from Ardjuna does not store well. Further, the taste is not liked. Maize is a staple foodstuff in Madura, traditionally eaten mixed with rice. The problems surrounding indigenous ideologies of food, and the risks involved in planting a new variety or new crop, are difficult to pin down. The presence in Madurese kitchens of *lumbung* and *jurung*, large containers used to store rice and maize respectively, are indicative of the value placed on storing agricultural produce for the forthcoming year.

Migration by men is still a feature of life in the western part of the island. Proximity to the port of Kamal and to East Java and the unsuitable climate for tobacco production means that many men still look to migration for their livelihood. In east and central Madura, however, it is no longer imperative for men to find work elsewhere since the growth of tobacco as a cash crop has opened up new opportunities for income-earning. In one of the villages studied, in central Madura, a number of men had given up their jobs as pedicab (*becak*) drivers, *sate* sellers and street hawkers (*kaki lima*), and become actively involved in the choice of new strains and crops, fertilisers and insecticides, methods of cultivation and in demonstration plots. Prior to the installation of the tubewell the previous year, their wives had been responsible for the various aspects of agricultural production.

The extension programme is inadvertently skewed in its approach to farmers. Services have been directed toward men, who have been identified as effective farm managers, and the knowledge which men acquire (or have access to, since not all men fully understand the extension messages) does not seem to filter through to women easily. Women are at a distinct disadvantage because they do not have ready access to the knowledge on which to base their choices. For example, a number of women in the survey did not know very much about pesticides because their husbands took care of this aspect of production. Although women were observed applying pesticides in the field, when questioned they did not know the brand name, the costs involved, or the optimum amount to use. Other women informed us that they did not use pesticides because they were afraid of damaging the crop and of poisoning themselves and their livestock (the leaves from various crops are used as fodder). They preferred to let any infestation take its natural course. Yet others were reluctant to plant new crops because they had not received any advice on growing techniques and marketing. That women have continued to participate in the decision-making process, albeit on a diminished scale, is a measure of their tenacity and enthusiasm in picking up information despite being virtually ignored by the extension programme.

It has been noted above that the family unit has traditionally been an important source of mutual help and cooperation for its members. It is from within the cluster of *tanean* that an individual may seek interest-free loans to buy seed, draw labour under the *gotong-royong* system, and so forth. However, with the introduction of tubewell irrigation, the new crops and varieties of rice and maize require greater expenditure on chemical fertilisers and pesticides. Traditional kinship networks are no longer always adequate to provide the cash flow required. This has meant that in some villages small farmers (both male and female) have had to turn to wealthy individuals for loans to purchase seed, fertilisers, to pay water charges, and so forth.

These individuals may also be prominent in buying up quantities of agricultural produce from small farmers. This was illustrated well in one of the villages where haji who bought up a high percentage of the chilli crop (known locally as *lombok*) was nicknamed *"haji lombok"*. Wealthy individuals may also be the proprietors of village shops (*kios*) which sell seed, fertiliser, pesticides, farming tools, and a variety of household items such as sugar, soap, oil, etc. The *kios* undoubtedly provide a convenient service, making it possible for small farmers to purchase inputs and goods on a credit basis. However, at the same time, small farmers are increasingly enmeshed in a patron-client relationship, becoming ever more dependent on a handful of individuals for inputs, credit and the marketing of produce. It would be extremely difficult for small farmers to disentangle themselves from this situation.

It would appear, then, that the establishment of tubewell irrigation systems, together with the introduction of high-yielding rice and maize varieties, new cash crops, and the availability of fertilisers and insecticides, has altered the balance of power between men and women. By making men the target for extension messages (even in areas where they were absent from the village for long periods) they have been elevated above the *tanean* milieu in which they exist.

6. OBSTACLES TO WOMEN'S INVOLVEMENT

The extension services exist to disseminate technical assistance, to advise farmers on land preparation, on the availability of alternative crops and new seed varieties, the use of fertilisers and so forth. It is clear that the extension programme is missing a significant proportion of farmers because it is not reaching women farmers. Extension messages have been targeted at men. Why should this be so? It has been ascertained that women make a substantial contribution to agricultural production and that many of the new technologies being promoted are related to the tasks they traditionally perform. What are the barriers to women's participation in the extension programme?

One of the major obstacles in involving women in the extension programme is in making direct contact with women. Women are not generally represented in village level institutions. As a consequence of this isolation, women have had little opportunity to develop leadership skills. The village head (*klebun*) is always a man, and negotiations concerning the irrigation project within a village begin with him, as has been mentioned above. He is responsible for contacting farmers to discuss the proposed areas to be irrigated, on possible canal alignments and block boundaries. The *klebun* only invites men farmers to these meetings, even when women are landowners in the proposed command area. When data has been collected on farmers in the command areas, the names of male heads of households have been noted down rather than the names of landowners. These usually include men and women. Following on from the preliminary consultative meetings, it is men who are subsequently invited to form the HIPPA committee. In the four villages studied, there were no women officials on the HIPPA committee (chairperson, treasurer, water bailiff, secretary, operator). The heads of the irrigation blocks (*ketua kelompok*) were also all men.

Invitations to meetings with Agricultural Field Assistants are usually also only extended to men. A considerable number of women farmers said they they had never met or spoken with an extension worker, either from P2AT or the Agriculture Service. In discussions with the Agriculture Field Assistant in one village it was apparent that he was aware of the gap in the extension service as regards women. However, he felt that he could not approach women farmers as a group. When developing and adapting the existing extension programme, the various cultural constraints which women face must be acknowledged.

Videos have been produced by P2AT (on tubewell agriculture and water users' associations) and shown in villages as part of the HIPPA training programme. Few women had seen these videos, despite the fact that in a rural area the showing of a video would be quite a social event (but see Smout, 1986:16). Women did not feel that they could simply turn up when they had not been invited. It seems that the only women who are at liberty to attend meetings are divorcees, widows, and those whose husbands are incapacitated. Even within this minority group, few actually attend because they feel uncomfortable attending what is, in effect, a gathering of men.

Although posters have been produced and displayed in the villages, the fact that many Madurese women are illiterate means that the extension messages may often go unheeded. Literacy in Madura has improved dramatically over the last two decades due to the increasing number of schools in rural areas. However, for financial and cultural reasons girls tend to cease attending school at an earlier age than boys, and consequently the illiteracy rate is higher among women. In addition, when posters are displayed at the pumphouse they frequently go unread, since access to the pumphouse is often restricted for safety and security reasons.

Thus, right from the beginning, women are excluded from the project. The reasons for this discrimination are partly associated with cultural norms; Madurese men and women rarely come together in groups outside the family. Further, given that women are often involved in multiple activities - both on and off-farm, as household managers and child carers - it is physically difficult for them to attend meetings which are held in the morning or evening. Ray (1990:25) has pointed out that a recent study has shown that many Madurese women of reproductive age are under-nourished and energy deficient. Consequently, they may have to spend more time than is usual in nursing underweight sickly babies and have less energy to participate in activities beyond their normal working day. This problem might be tackled by arranging meetings at a time which fits in with women's work patterns and by encouraging participants to organise a creche during meetings.

Another reason is that the planners of the project did not advise the different levels of government organisation that concerted efforts should be made to incorporate women into the MGIP from the initial survey and planning stages onwards. One assumes that this occurred because the role of women in Madurese agriculture was not sufficiently understood. Consequently, the advantages of involving women, and the barriers which existed in the programme, were not appreciated.

The failure to integrate women into the MGIP may also be partially explained by the fact that research into women's roles and status has entered the development sphere rather late. This is changing. The ODA has recently published a Checklist for the Participation of Women in Development Projects which is being circulated to ODA and consultative staff. It is to be hoped that its use will help to avert the unwitting exclusion of women from future development projects.

In 1990 the ODA drew up terms of reference for an adviser to make a one-month input to the MGIP to consider the ways in which the agricultural extension strategy should be modified by integrating the needs of women into the project. It was recommended in the subsequent report (Ray, 1990) that a substantial Women In Development (WID) programme should be included in the proposed Phase 3 Extension to the MGIP. A one year extension had been sought largely because delays in equipment supply had put back the commissioning of 20 wells and, in turn, had delayed the associated training programmes. The extension was granted and commenced in November 1990. It included a six month input by an expatriate WID Adviser. The Adviser's brief was to establish a programme for the greater involvement of women in project activities, with particular attention being given to HIPPA activities and demonstration plots. The overall aim is to work alongside the Department of Agriculture, since when P2AT withdraws from the project all future extension work will be the responsibility of this Department.

7. CONCLUSION

The finding that Madurese women are active participants in many aspects of agricultural production, but have not generally been consulted in the planning or implementation of the MGIP, is predictable enough and not peculiar to Madura. During the past two decades many authors have documented similar situations in various parts of the world (see, for example, Dey 1982; Nelson 1981; Poats, Schmink and Spring 1988). In my report (1989) I concluded that the scope of the MGIP should be broadened to incorporate the roles of women in agricultural production and decision-making, since the extension programme would obviously be much more successful if directed toward both men and women. If men continue to be singled out as recipients of the extension services there will be a corresponding loss of socio-economic status for women. Suggestions were made on how the extension methods might be communicated to women as a group.

As a preliminary to implementing any measures aimed at involving women in the extension programme it would be useful to ascertain the numbers of men and women employed as Agricultural Field Assistants by the Agriculture Service. Efforts will have to be made to recruit more women staff, with priority being given to Madurese speakers, who may then be trained and deployed to work with rural women. Of course, hiring more women as project staff members will not guarantee success, since the gender of a researcher is no guarantee of the requisite analytical skills. However, women staff have a better understanding of the problems which women farmers face. As a corollary to this, men extension workers should receive some re-orientation training to make them more explicitly aware of the scope of women farmers' activities and problems. The Agriculture Service possesses the infra-structural capabilities of reaching village women and working with them, and efforts should be made to encourage administrative officials to put pressure on, and support, the Agriculture Service in mobilising its undoubted potential to maximum effect.

In the drive to increase contact with women farmers, women should be invited to special explanation meetings, they should be integrated wherever possible into the water users' associations (HIPPA), and women's farmer groups should be set up. If information is to travel beyond a small number of women, then contact groups must be set up with precise objectives. Efforts should be made to involve more women in demonstration plots, so that they may learn at first hand about new crops and strains, recommended cropping patterns, inputs, water management and irrigation practices. Greater use should be made of extension materials. Since the majority of women in the survey did not appear to have seen the P2AT videos it would be helpful to show the videos in selected areas at times which suit women. Posters should have a greater impact if displayed at various points around the villages, and not just at pumphouses. A likely site would be rice mills, which are a popular congregation point for women. It was suggested that a poster be designed, specifically targeted at women, to emphasise the fact that tubewell irrigation is not the preserve of male farmers but is there for the benefit of the whole community.

Existing women's organisations might prove useful in making contact with women. Family welfare programmes (PKK) have focused on the centrality of women's roles within the family, on health care, on the preparation of food and so on. However, those who might benefit most from such programmes do not have the time to participate and often feel that the subject matter is irrelevant to their lives. If programmes were initiated which cover the other side of women's roles, i.e. their involvement in farming activities, it might be possible to involve more women. A woman speaker from the Agriculture Service or P2AT could, for instance, discuss the extension literature and posters (which would also help to bridge the problem of illiteracy). An example of what might be possible in the future is provided by the family planning programme; strong grass-root level organisations have developed as a consequence of the visits to PKK meetings by family planning specialists.

There are obviously different perceptions concerning the utility of tubewell irrigation. This is particularly apparent in the wetter west of Madura, where the effects of tubewell irrigation have been less dramatic than in the drier east. The original aim, that rainfed land (*tegal*) would be converted to irrigated land (*sawah*) so that two irrigated crops of rice would be grown each year, has not been fulfilled. It is now acknowledged that since much of this *tegal* land had already been developed for *polowijo* crops it is unlikely that conversion is either practicable or economic. The government has now prioritised the production of *polowijo* crops and is keen to find an alternative cash crop for the west, comparable to tobacco in the east. As part of this programme it has promoted new higher yielding varieties of maize which do not conform to villagers' requirements, as has been mentioned above. Farmers in the west of Madura tend to see irrigation water as a means of ensuring that they are self-sufficient in foodstuffs. Only when this basic need is satisfied will the possibility of cultivating cash crops be explored. Many express a natural anxiety that if they switch to new crops or varieties they may face disaster if the crops fail. Though intercropping is traditional in the west, not much emphasis has been given to date to demonstrations of intercropping. Part of the answer would seem to lie in directing the extension programme to those who are directly involved in producing, storing, preparing, and marketing agricultural produce, - that is, women farmers.

ACKNOWLEDGEMENTS

This paper is based on consultancy work undertaken in Madura in 1989. I would like to acknowledge the help and support I received from members of the British and Indonesian teams, P2AT, and the Agriculture Service. I would also like to thank all those villagers who gave freely their time and knowledge.

REFERENCES

Casey, M., (1989) Sociological Study of Women in Agriculture in Madura, Madura Groundwater Irrigation Project, Groundwater Development Consultants (International) Ltd, Cambridge.

1991 Development in Madura: An Anthropological Approach, in Johan Pottier, ed., forthcoming volume to be published by the School of Oriental and African Studies, London.

Dey, J., (1982) Development Planning in The Gambia: The Gap Between Planners' and Farmers' Perceptions, Expectations and Objectives, in *World Development 10(5): 377-396.*

Groundwater Development Consultants (International) Ltd, 1986 Madura Groundwater Irrigation Project Annual Planning Report, Cambridge.

1987 Madura Groundwater Irrigation Project 1986/87 Annual Report/Workplan, Volume I Main Report, Cambridge.

Nelson, N., ed, (1981) African Women in the Development Process, Frank Cass and Co Ltd.

Poats, S V., Schmink, M., and Spring, A., eds, (1988) Gender Issues in Farming Systems Research and Extension, Westview Special Studies in *Agriculture Science and Policy*, Westview Press, Boulder. Published in cooperation with the Women in Agriculture Development Program, University of Florida.

Ray, D., (1990) Proposals for Integration of Women Farmers in Agricultural Extension, Madura Groundwater Irrigation Project, Groundwater Development Consultants (International) Ltd, Cambridge.

Smout, I., (1986) Training Programmes for Irrigation Farmers, *ODI-IIMI Irrigation Management Network Paper 86/1e*, Overseas Development Institute, London.

Smout, I., (1990) Farmer Participation in Planning, Implementation and Operation of Small-Scale Irrigation Projects, *ODI-IIMI Irrigation Management Network Paper 90/2b*, Overseas Development Institute, London.

Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England.
Telephone: +44 71 487 7413
Telex: 94082191 ODIUK
Fax: +44 71 487 7590

IRRIGATION MANAGEMENT NETWORK

THE LIBRARY
OVERSEAS DEVELOPMENT INSTITUTE
REGENT'S ...
INNER CIRCLE, REGENT'S PARK
LONDON NW1 4NS

DEVELOPMENT OF WATER USER ASSOCIATIONS ON THE MADURA GROUNDWATER IRRIGATION PROJECT, INDONESIA

Roger Jackson

Network Paper 2

October 1991

Papers in this set:

1 *Groundwater Development on Madura, Indonesia: Gender Issues in an Irrigation Project* by Margaret Casey.

2 *Development of Water User Associations on the Madura Groundwater Irrigation Project, Indonesia* by Robert Jackson.

3 *National Pump Irrigation Study: Material Developed During Inception Activities, January 14 - 8 February* by Effendi Pasandaran; *Assessment of Conjunctive Use in Maharashtra Minor Irrigation Systems* by T S Sheng, et al.

4 *Conjunctive Water Use for Irrigation: Good Theory, Poor Practice* by Linden Vincent and Peter Dempsey.

5 *News from the Field - Groundwater Development and Lift Irrigation* from Tunisia, Mali, Sub-Saharan Africa, Bangladesh and South India.

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

Linden Vincent
Editor, Irrigation Management Network
Overseas Development Institute
Regent's College
Inner Circle
Regent's Park
London NW1 4NS

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

The opinions represented are those of the author and do not necessarily reflect the policies of the Overseas Development Institute, or any other organisation with which the author is connected.

DEVELOPMENT OF WATER USER ASSOCIATIONS ON THE MADURA GROUNDWATER IRRIGATION PROJECT, INDONESIA

Roger Jackson
Groundwater Development Consultants Ltd
Demeter House, Station Road, Cambridge CB1 2RS, UK.

Contents **Page**

DEVELOPMENT OF WATER USER ASSOCIATIONS ON THE MADURA GROUNDWATER IRRIGATION PROJECT, INDONESIA

Roger Jackson
Groundwater Development Consultants Ltd

ABSTRACT

The establishment and training of Water User Associations (WUA) has been a crucial aspect of the Madura Groundwater Irrigation Project, East Java Province, Indonesia. The long-term sustainability of tubewell irrigation depends on the capability and motivation of the WUAs to operate and maintain their systems based on adequate water charge collection and sound financial management. This paper describes the procedures used in the WUA development programme, and discusses further measures that will need to be taken at local government level to build on the considerable progress that has been made by the Project.

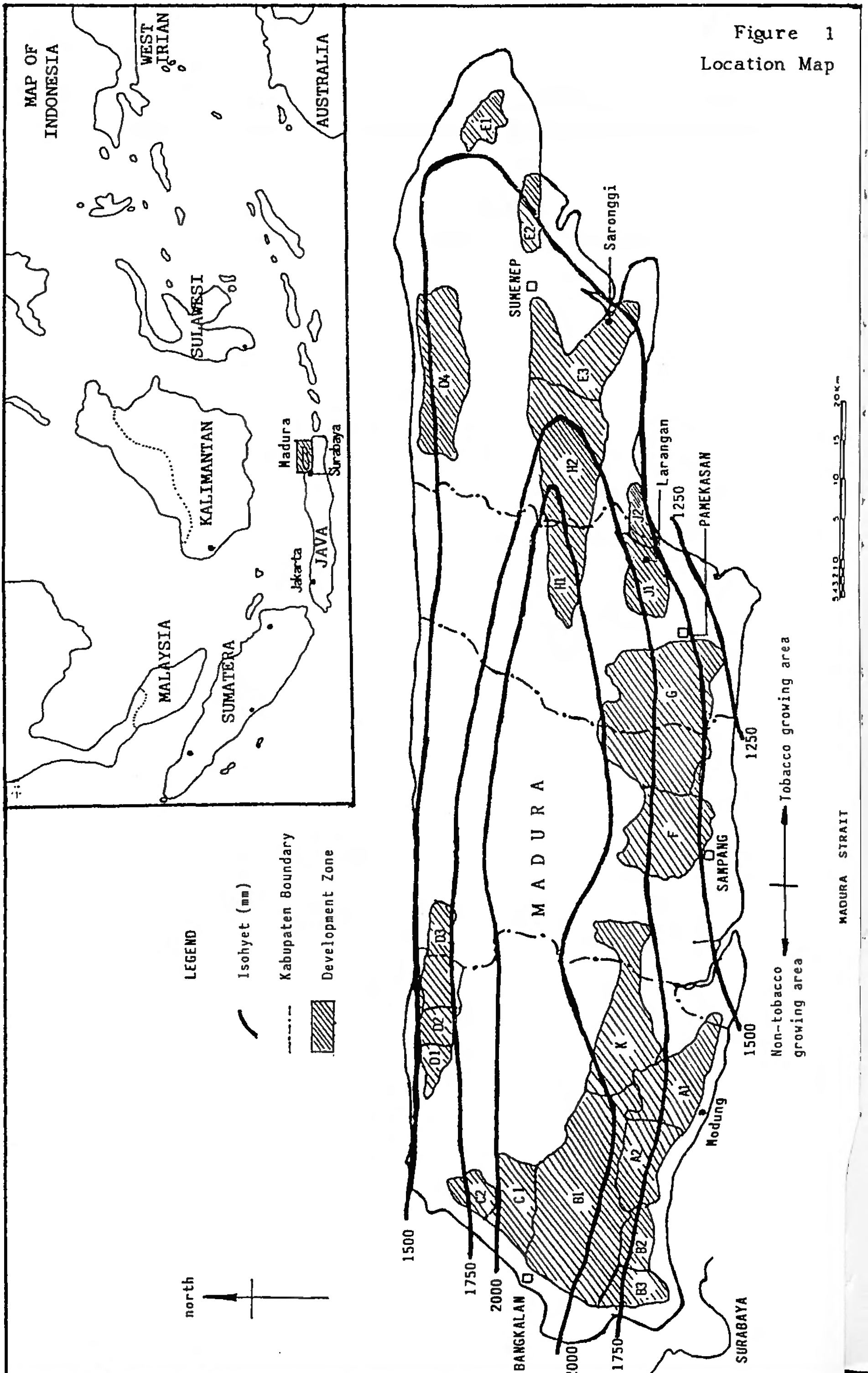
1. BACKGROUND

1.1 Introduction

The main objective of the Madura Groundwater Irrigation Project was the development of groundwater resources for the irrigation of previously rainfed land to increase the production of food and cash crops, and to improve the incomes and welfare of farming families. A crucial aspect of the Project was the establishment and training of Water User Associations (WUA) to enable the primary beneficiaries of the Project - the farmers - to be actively responsible for the operation and management of the tubewell irrigation system serving their land. This aspect was considered to be of great importance in an area like Madura where the farmers have little or no experience of irrigated agriculture.

The WUA development programme is in line with the national policy of handing over of small-scale irrigation schemes (up to 500 ha) for operation by the farmers themselves (*Penyerahan Irigasi Kecil*).

Figure 1
Location Map



The groundwater resource (limestone aquifer) was developed by means of tubewells with diesel-driven deepwell pumps. WUAs are particularly important for tubewell systems since the water will only flow if the pumpset has fuel and is well maintained - this requires some degree of organisation and cash flow management.

Water charges were introduced to cover operation and maintenance costs, and to give a sense of value to the water to encourage better water use. It was hoped that as the farmers benefited financially from the increased production of crops, they would have a feeling of commitment to the tubewell systems and thereby ensure the continued operation of the systems.

1.2 Project Description

The Project is located on Madura Island, East Java Province, Indonesia (Figure 1). Madura is noted for its dryness, having a more pronounced dry season than neighbouring Java, and the resilience and toughness of its people. The Madurese are known for their strong adherence to Islam, and their independent spirit and reluctance sometimes to accept central government authority.

As a result of the relatively harsh environment and lack of opportunities on the island, the Madurese have long migrated to mainland East Java and other parts of the Indonesian archipelago in search of work and a better life.

Agricultural output is low due to drought, poor agricultural inputs and, compared to Java, relatively infertile soils. The most important cash crop is tobacco in central and east Madura, and cattle form an essential part of the farming economy and the basis of the main cultural event on the island - the annual bull races or *Karapan Sapi*. The traditional food staple is maize. Rice is limited to the relatively few areas with surface irrigation. The main constraint to improving the welfare of the predominantly agricultural population of the island is the availability of water for irrigation and domestic supply.

As part of its programme to increase agricultural production in the 1970s and 1980s, particularly of rice in order to achieve self-sufficiency, the Indonesian government did not wish to leave out politically important, but economically less developed, areas such as Madura in the general development drive. Where suitable aquifers were known to exist, groundwater development was seen as the quickest and most feasible way of providing irrigation water and improving social conditions in the rural areas.

From 1972 preliminary studies were carried out to identify potential development areas on Madura, and the Project proper was implemented in three phases from 1979 to 1990 (Phase 1: 1979-1984; Phases 2 and 3: 1984-1990). Tubewell development zones (A1 to K) were selected on the basis of groundwater and land resource potential for irrigation, and were grouped according to rainfall distribution and cropping pattern type into the following areas:

Areas	**Rainfall**	**Cropping**	**Zones**
West Coastal	1500-1750 mm	Non-tobacco	A1,A2,B2,B3, D2, D3
West Inland	1750-2000 mm	Non-tobacco	B1,C1,C2,K
Central and East	1250-1500 mm	Tobacco	D4,E1,E2,E3, F,G,H1,J1,J2.

The main physical works consisted of the construction of 126 tubewell systems with a total design command area of 4630 ha (average command area 37 ha per tubewell). Command areas were divided into seven day-rotation blocks which were supplied by concrete-lined open channels.

A base workshop was established in Pamekasan, the capital of Madura and the Project Headquarters, and field workshops were built at Sumenep and in *Kabupaten* (district) Bangkalan to serve the tubewells in the east and west respectively. However, generally the mechanical support service has been constrained by poor management and low staff motivation, particularly in the base workshop, and it is important that improvements are made to ensure the continued operation of the tubewells for the future (this is discussed further in Section 4).

The number of beneficiary farmers is about 18,800, i.e, about 150 farmers per tubewell system.

Tubewell operation was initially subsidised by the Project to enable the WUAs to accumulate a cash fund from the collection of water charges so that operations could be financed after the removal of the subsidy and handover from the Project. Cropping pattern demonstrations were held on selected farmers' plots at each tubewell during the first year of operation to introduce new varieties (particularly *palawija* crops), crop management and irrigation techniques, as a way of extending new information to farmers who previously had little or no experience of irrigated agriculture. Cooperation from the farmers was achieved by guaranteeing them a minimum return, while the inputs of seed, fertilizer, agrochemicals, etc, was provided by the Project. Generally, the demonstration programme has been successful, and has been particularly important in western Madura, where tobacco is not grown (because of the risk of rainfall in the dry season) and alternative cash crops need to be promoted. The uptake of new technologies by farmers in areas such as Zones B3 and A1 (Figure 1) is one of the major successes of the Project.

The development schedule of a typical tubewell system is illustrated on Figure 2.

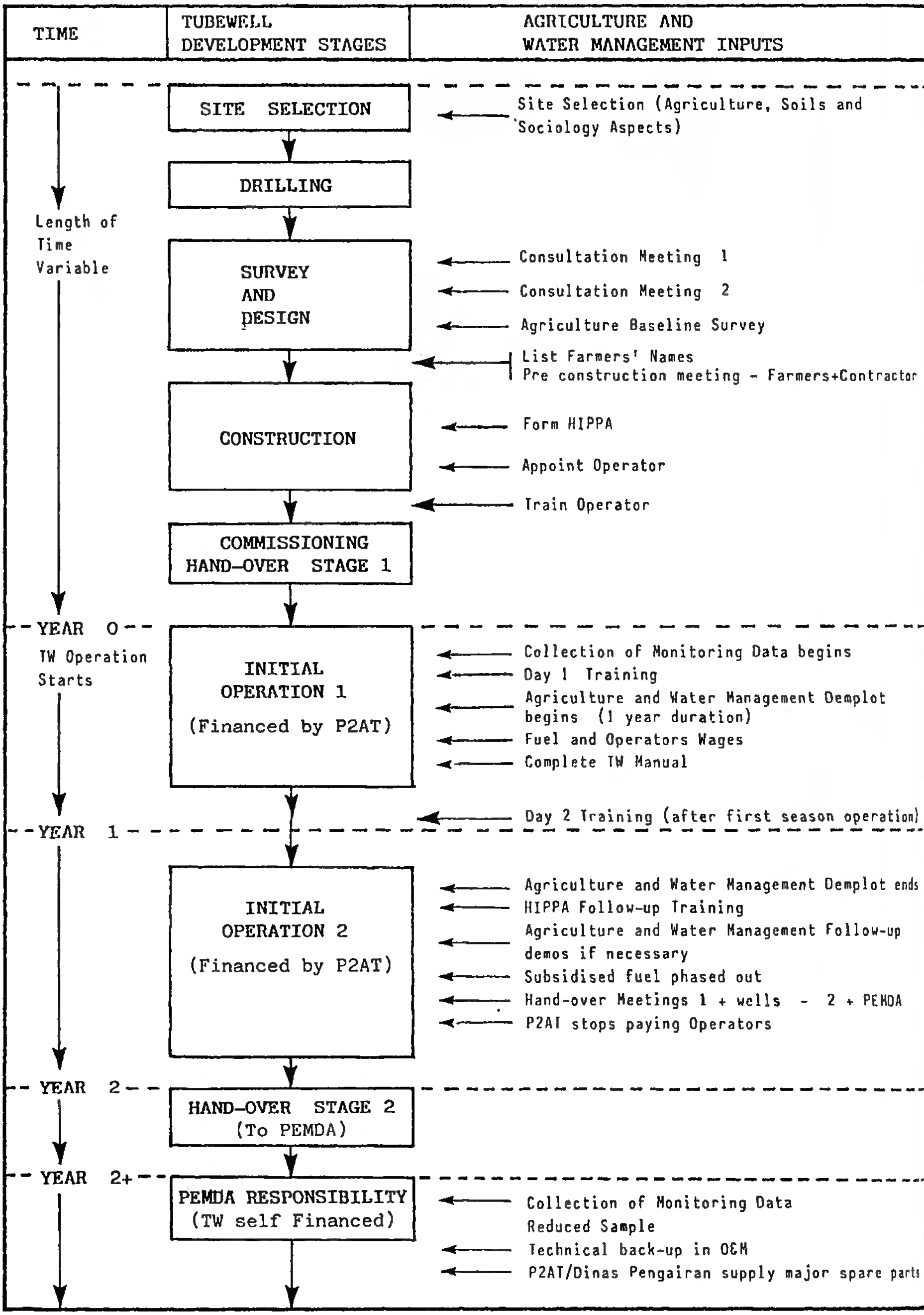
Financial assistance for the Project was provided by grants from the Overseas Development Administration (ODA) of the British government (all phases), and the Commission of the European Communities (Phases 2 and 3 only). The Project was implemented by the Directorate General of Water Resources Development (DGWRD), Ministry of Public Works, Government of Indonesia, and the executing agency was the Groundwater Development Project (P2AT) of the DGWRD's Directorate of Irrigation II.

1.3 Social Influences on Development

During the early part of Project implementation it became apparent that there were considerable differences in economic and social issues between western and eastern Madura, which had a direct bearing on the eventual performance of the WUAs and success of tubewell operations. Sociological studies became increasingly important in the tubewell site selection process to assess whether social conditions in the villages under consideration were likely to be conducive to supporting a tubewell irrigation system. Factors considered included the attitude and influence of the village head and religious leaders in the village, extent of migration and share-cropping, land ownership, and general attitude to irrigation development. Particular attention was also paid to village boundaries and to ownership of land by

FIGURE 2

DIAGRAM OF DEVELOPMENT OF TYPICAL TUBEWELL
INCLUDING AGRICULTURE AND WATER MANAGEMENT INPUTS



persons from other villages in order to avoid the problems encountered at some of the earlier sites. The role of women in farming and village society also emerged as an important consideration, as reported by Casey (1991).

Generally, the area east of Pamekasan has fewer economic and social dilemmas and there has been a positive response to tubewell development. Tobacco is the dominant cash crop in this area, and the effect on farmer incomes has been significant. WUAs have taken root and have responded well to project guidelines concerning water charges, financial control and responsibilities for canal and pumpset maintenance.

In the western part of Madura, however, social structure is far less cohesive, and conflict and feuding between factions led by powerful individuals is a feature of rural life. Migration to mainland East Java and other areas is high. Tobacco is not grown in this part of the island, and farmers have had few incentives to introduce alternative cash crops. There has been resentment to external intervention, and this sentiment is taken advantage of by those, who for their own reasons or because of vested interests, do not want to see particular government-sponsored projects implemented.

Given this background it is hardly surprising that WUAs at some of early (Phase 1) tubewells, sited purely on hydrogeological and land resource grounds without regard to social and economic considerations, failed to function once the initial Project operational subsidy was removed.

Sociological studies were introduced soon after the start of Phase 2 and were principally focused on western Madura. As a result of these studies a programme was developed for farmer participation in the planning, survey and design, and construction of all new tubewell irrigation systems. Attempts (albeit belated) were made to redress the exclusion of women's involvement. The programme was introduced in order that the Project should be perceived as something in which the farmers had an interest and responsibility, rather than being externally imposed. The programme centred around two New System Meetings (Consultation Meeting 1 and Consultation Meeting 2 in Figure 2) which were held at critical stages in the planning and design process, when farmers' views were sought. During the last year of construction (1989/1990) a Pre-Construction Meeting between the farmers and contractor was also held, to explain the requirements for good construction. These meetings were generally successful in ensuring that the irrigation systems were acceptable to the farmers and could be operated by the WUAs.

As the Project progressed the picture became less bleak in western Madura. Market forces from nearby Surabaya (the second largest city of Indonesia) and elsewhere encouraged the irrigation of marketable fruit and vegetable crops in the dry season, and the programme focused on villages where intervention had made headway. The process was helped by the appointment of more motivated village officials and the active participation of the local government extension service (*Dinas Pertanian*) in the Project's cropping pattern demonstration and vegetable trial programmes. More attention has also been given to contacting women.

Zone A1 (Figure 1) in particular has developed well. A further boost to the demand for tubewell produce should be provided by the bridge linking Surabaya to western Madura planned for completion in the mid-1990s.

However, it must be expected that many farmers will wait until they have seen a few years of examples of effective irrigation and good yields before they are prepared to make their own commitment of time and resources. Many of these farmers exist on marginal incomes and cannot reasonably be expected to take such a risk unless they are convinced that the irrigation system will work well and reliably, and good yields will be obtained. This is particularly true of those who would otherwise spend the dry season working in Surabaya or elsewhere. It is particularly important during these early years to maintain the impetus of the cropping demonstrations and WUA training work.

2. WATER USER ASSOCIATION FORMATION AND TRAINING

2.1 Introduction

Very little WUA work was carried out during Phase 1 of the Project. The need for improving the performance of WUAs was seen as an urgent task for Phase 2, and a decision was made to develop a training programme for each tubewell, following training methods formulated for the East Java Irrigation Project (EJIP) which provided a useful local model. The training programme was designed to deal with the following topics:

- WUA organisation and officers' responsibilities;
- Financial aspects of tubewell management;
- Improving water management;
- Increasing the area irrigated and the cropping intensity.

2.2 Formation

Water User Associations (generally known in East Java by the Indonesian acronym HIPPA - *Himpunan Petani Pemakai Air*) were set up for each tubewell through the Village Community Organisation (*Lembaga Masyarakat Desa*) in accordance with the East Java Governor's Decree Nr 201 of 1987. The guidelines contained within the Decree are mainly concerned with establishing the structure of the WUA (appointment of officials, formation of committees, etc), and are too general for any practical application to the running of WUAs. Although the guidelines are primarily for surface water (gravity fed) irrigation schemes, it is reported that most WUAs on surface water schemes exist in name only and their function is not clearly defined since the supply and distribution of water is generally in the hands of the local government irrigation service (*Dinas Pengairan*). However, since WUAs are crucial to the successful operation and management of pumped tubewell schemes, the Madura Project devoted a lot of effort to formulating practical guidelines for WUA training and strengthening, and it is hoped that the experience gained can be applied to other groundwater projects in Indonesia and elsewhere.

The organisation structure of the WUAs as set up on Madura is shown in Figure 3.

WUA formation took place during the construction of the irrigation system (Figure 2) and consisted of the following activities:

- Marking the names and landholdings of the farmers on the command area map;

- Listing the farmers in each irrigation block;

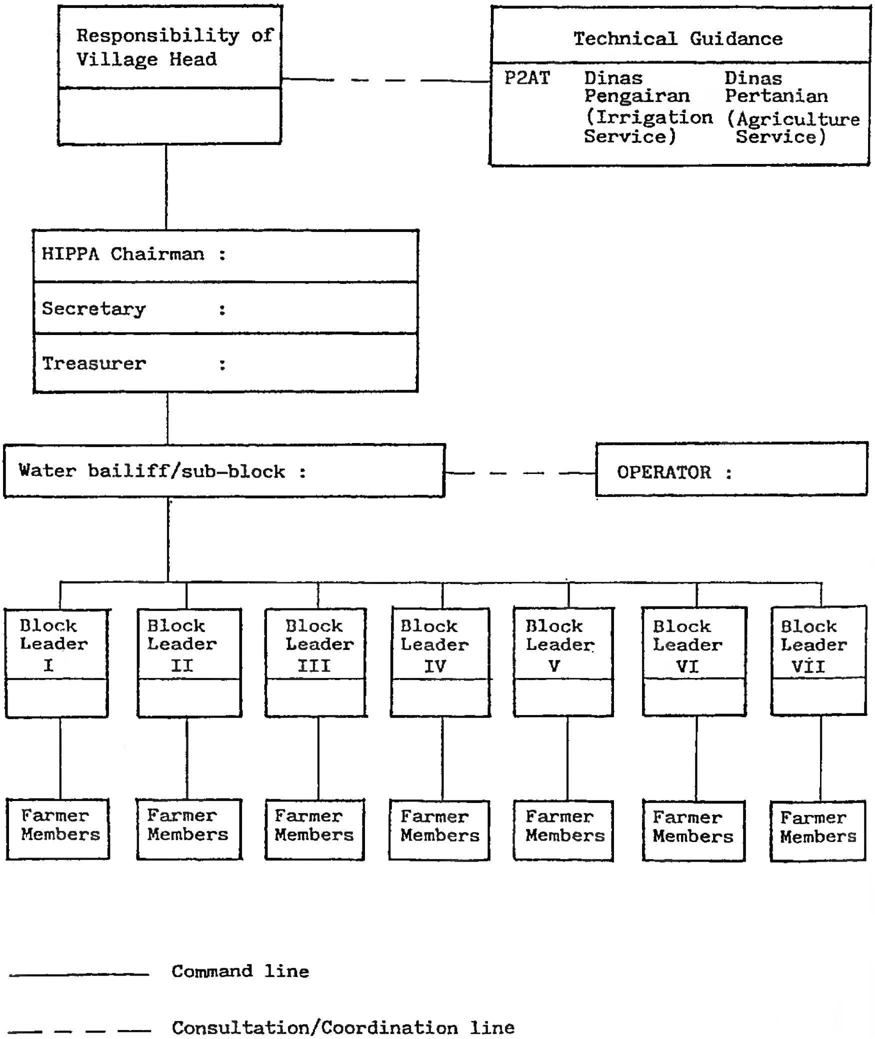
- Discussing the formation of the WUA with the village head and sub-district (*camat*) officer;

- Organising an official meeting of the farmers at the village to inaugurate the WUA - this involved an explanation about the role of the WUA and the election of WUA officers.

At some locations there was a tendency to appoint all the WUA officers from a particular interest group or family. This was usually unsatisfactory, and substitutions had to be made at subsequent training sessions in order to

FIGURE 3

STRUCTURE OF WATER USER ASSOCIATION (HIPPA)



ensure a more balanced representation. Nevertheless, it is inevitable that the water users with the most influence (which may include the village head) usually have the greatest role to play in WUA activities.

Around the time of pumpset installation (the final physical works before the tubewell scheme can be used), the pumpset operator was appointed and trained. Once the tubewell was ready for use a commissioning ceremony was held, and the WUA training sessions got underway. Experience showed that for maximum impact these activities were best done as a compact package.

2.3 Pumpset Operator and Training

The pumpset operator is a key member of the WUA, and needs to be carefully selected. The operator normally works full-time on a tubewell scheme whereas other WUA officers are much less active. The operator can therefore have a strong influence on the use of the system, extending much further than basic mechanical operation and maintenance.

P2AT asked the village head to nominate a number of candidates, and a selection was made on the basis of criteria such as age, education, literacy, landownership and nearness of house to the tubewell. In 1987 the criteria for operator selection was tightened up: potential operators were required to have studied to high school level and belong to an active farming family. This meant that although many of the newer operators were young, they were at least literate and more mechanically minded than some of the operators appointed earlier in the Project.

Successful operator appointment depended very much on interaction and discussions with the village head, and disagreements did arise where individuals were uncertain of the Project and had strong convictions about personnel. However, problems of this nature primarily occured in villages west of Pamekasan, where there were both economic and social challenges in adopting new irrigation technology and institutions, and were reduced by sociological research and dialogue.

Experience showed that the selection process generally took a long time and needed to be started well in advance of the pumpset installation and commissioning programme.

Table 1: HIPPA Training Programme - Phase 2 Tubewells

Day 1 (one month before commissioning)

	Programme	Equipment Requirement
1.	Introduction	Transport: 2 x LWB L/R; Overhead projector (OHP); Flip-chart.
2.	Video (Pertanian dan Sumur Pompa)	Video cassette recorder
3.	Cost and charges	OHP; Flip-chart
4.	Irrigation system and tubewell operation - layout - rotation - cropping patterns before/after extension messages (OHP)	OHP; Flip-chart
5.	Group photo	Camera
6.	Lunch	
7.	Visit to operating tubewell - discussion with HIPPA - agricultural - demonstration	2 x LWB L/R
8.	Walk the command area - discussing components and operation (PA system); Return and arrange meeting for Day 2	
9.	Supper	

Day 2 (one season after commissioning)

	Programme	Equipment Requirement
1.	Report on problems and experiences of operation	Transport 1 LWB L/R OHP and Flip-chart
2.	Field inspection of system	Clip-board, Layouts
3.	Record and charges - progress report	OHP, Flip-chart
4.	Video 'HIPPA and Sumur Pompa' and Maintenance Video	Video cassette recorder Video cassette recorder
5.	Lunch	
6.	Summary of conclusion and agreements - operation and maintenance	
7.	Explanation of Tubewell Manual	
8.	Presentation of certificates and TW Manual	Certificates and TW Manual

After selection the operator attended a training course in pumpset operation and maintenance organised by the Project's Mechanical Engineering Division (MED).

2.4 Commissioning Ceremony

After the installation of the pumpset and training of the operator, a commissioning ceremony was held at the tubewell in the presence of the *camat*. The commissioning represented the start of operations and the first stage of the handover process from the Project implementing agency to the local government authorities. However, the official handover formalities were not usually completed until several years later.

An attempt was made to try and commission new wells before the start of the dry season, particularly for the tobacco crop in central and eastern areas (mid - late May).

Commissioning ceremonies were important occasions since the introduction of tubewell water represented an important step in the participation of the village community in formal development, and spearheaded later developments such as the provision of all-weather access roads and domestic water supply facilities.

2.5 Water User Association Training

WUA training consisted of a two day programme: Day 1 was normally held around the time of the commissioning ceremony, and Day 2 sometime later. Initially Day 2 was held one month after commissioning, but in 1988 this was changed to one crop season later in order to give the farmers time to accumulate experience and to see one crop demonstration through to harvest. The contents of the training programme are given in Table 1.

The main messages of the Day 1 training concerned the operation of the tubewell and the importance of setting, paying and collecting water charges. For this it was necessary for the MED to give an accurate account of fuel consumption in order to calculate pump operating costs. The session ended with a walk around the command area when all the components of the system were explained.

Day 2 training was concerned with maintenance and water management. It was usual for problems concerning construction and layout of the system to be raised at this time, which enabled P2AT to make provisions for modifying the canal network for possible later rehabilitation works.

As many farmers as possible were encouraged to attend the training sessions, and usually about half the command area total did. This meant that there was usually a number of farmers representing each irrigation block.The main training aids used were video films and cartoons illustrated by overhead projector. Two video films were specially produced by the Project, '*Pertanian dan Sumur Pompa*' (Agriculture and the Tubewell) and '*HIPPA dan Sumur Pompa*' (Water User Association and the Tubewell), shown on Days 1 and 2 respectively. Both films took the form of a socio-drama with local actors and actresses playing the roles of pump operator, WUA officials, farmers, etc. The '*HIPPA dan Sumur Pompa*' video emphasised the need for a strong WUA and good farmer cooperation for the water to be used effectively. The video ended with a summary of the four major points needed for a successful tubewell:

- The WUA organisation must be strong and active;
- Different irrigation blocks should work together;
- Farmers within blocks should work together;
- Pumping charges must be paid.

Generally the videos were considered useful and enjoyable by the farmers. However, there were some objections to a fight scene involving a farmer caught stealing water, and some mild flirting between the operator and one of the female characters[1]. A flashback scene, where a returning migrant remembers the "dry, bad old days" before the tubewell, was rarely understood. In contrast to fears that fight scenes might encourage more aggression in the real situation, farmers suggested that bad water management practices should be shown and highlighted as such, rather than the film showing recommended practices only.

Operation and maintenance manuals were prepared for each tubewell, and presented to the WUA during the Day 2 training. The manual covered the following main topics:

---

[1] Women (and some male operators) may have wanted this issue discussed, to show difficulties and fears over social interaction on both sides. As Margaret Casey shows, women were not invited to the video presentations. New technologies often require men and women to talk to each other in new contexts, and women need to negotiate for work to be done. This can be threatening to existing stereotypes and gender controls. *Editor's Note.*

- Description of tubewell, pump and engine;
- Description of irrigation system;
- Recommended pumping charges;
- Recommended irrigation programme and water scheduling;
- WUA responsibilities;
- Pump operator's responsibilities;
- Government responsibilities.

However, it was found that tubewell manuals were largely left unread, and it was unusual to find them at the pumphouse or with the operator. The problem seemed to be that the WUAs found the manuals too long and complex even though every effort had been made to make them as straight forward as possible.

Posters illustrating important points such as the collection of water charges, and what the revenue is to be used for, were better understood. These posters were displayed at the pumphouse, village office and wherever possible near mosques and other public gathering places.

2.6 Monitoring and Follow-Up

During the first year of operation regular contact was made with the WUAs through the cropping pattern demonstration programme, and the monitoring of accounts.

Follow-up meetings were generally held towards the end of this period to try and sort out any organisational, financial or technical problems the WUAs may have experienced, and to prepare the WUAs for the removal of the Project's operational subsidy and handover of the tubewell system.

At several sites WUAs were reformed because of ineffective or irregular management of water charge proceeds or due to popular request. Problems of WUA fund management were common to many tubewells and in 1989 it was decided to hold a series of two day training courses in book-keeping and accountancy for WUA chairmen and treasurers. The response from the participants was generally good, and the training was considered to have been very worthwhile.

In 1990 a WUA Newsletter (*Berita HIPPA Sumur Pompa*) was introduced to speed up the spread of information to the WUAs and to encourage dialogue between the WUAs. The newsletter has been published on average every two months, and has proved to be a valuable means of communicating with the WUAs. Articles in the first three editions covered the following topics:

- WUA institutional development proposals;
- Field workshop operation, duties, service, etc;
- Dry season monitoring programme;
- Women in development;
- Selected tubewell profiles;
- Payments to WUA officials;
- Preparations for an Open Day for farmers at the experimental garden near Bangkalan.

3. WATER USER ASSOCIATION FINANCES AND PERFORMANCE

3.1 Water Charges

The WUA has to agree to charge its members (the farmers) for irrigation water received from the tubewell to cover all costs of operation. The level of charge is recommended by P2AT as part of the initial training, and is reviewed during subsequent monitoring and follow-up.

The charge is levied from the time the tubewell system is commissioned. Because operating costs (diesel and pump operator's salary) are subsidised by the Project for the first two years of operation, the revenue from the water charge accumulates to form a cash reserve to enable operations to continue after the subsidy is removed and the tubewell is handed over.

Operation and maintenance costs are made up of pumping costs (diesel, oil, battery water, etc) which are incurred while the pump is running, and system costs incurred whether the pump is running or not - these consist of the operator's salary, maintenance of the irrigation system and pumphouse, pumpset service and repair, payments (honoraria) to WUA officials and miscellaneous expenses (travel, etc).

After the removal of the P2AT operational subsidy, the WUA is responsible for all operational costs except heavy maintenance and repairs to the pumpset - this will eventually be borne by the Irrigation Service (*Dinas Pengairan*) after the Project has been handed over to the local government or, in the more progressive areas, by a mutual WUA fund administered at *kecamatan* (sub-district) level (this is discussed more fully in Section 4).

There is a distinction between the way of paying for pumping charges between tobacco (paid by the number of plants) and non-tobacco crops (paid by the hour). This is because each tobacco plant is individually watered by hand (by filling semi-circular buckets from small reservoirs along the canals), and farmers know exactly how many tobacco plants they have in their fields - paying by plant for this high value crop is felt to be a fairer system.

In 1990 average recommended charges were Rp 1950/hour (US$ 1.1) for non-tobacco crops and Rp 2100 for 1000 tobacco plants (US$ 1.2). Although at most sites there is broad agreement between recommended and actual levels, there are cases of considerable disparity, particularly at tobacco-producing wells where higher level charges for tobacco are used to allow a discount on rice and *palawija* crop payments (*palawija* crops are non-rice food crops such as maize, groundnut, soybean, etc). The undercutting of rice and *palawija* payments is to encourage farmers to use water for these less profitable crops.

However, overall there were considerable problems with water charge collection and processing of funds, and in 1989 special training courses were held for WUA chairmen and treasurers to try and improve accounting practices. It is believed that as the WUAs gain more experience in operational practices the situation will improve - indeed, this is already happening in some areas.

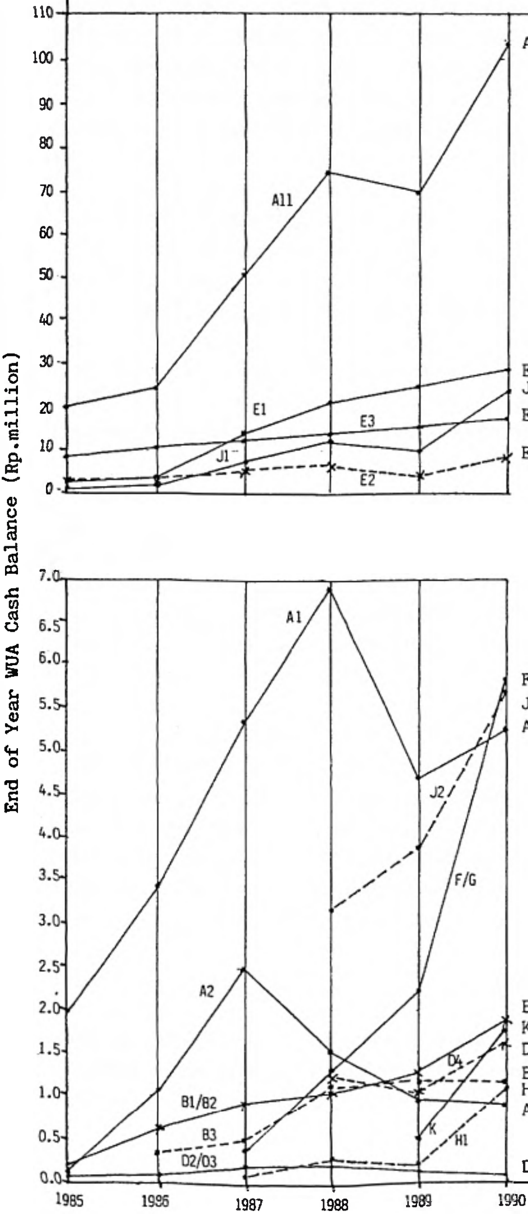
At many wells, particularly those in the west of the island, there is a strong psychological barrier to paying more than about Rp 1500 an hour for water, especially where poorly prepared plots can take 6-8 hours to irrigate. Further training and guidance is needed to convince farmers that the full cost of water charges has to be met, especially since water costs are normally less than 10% of total production costs (seeds, fertilizers, pesticides, etc, are far more expensive).

3.2 Water User Association Accounts

The balances in each tubewell's WUA accounts are monitored monthly, and provide a convenient indicator of how the WUAs are performing. End of year balances for each tubewell development zone are shown in Figure 4.

FIGURE 4

WUA CASH ACCOUNTS



Zone	Kecamatan	Average Cash Balance/Well 1990
All tubewells		1.06
E1	Dungkek	5.66
J1	Larangan	2.62
E3	Lenteng	0.83
E2	Gapura	1.06
F/G	Proppo	0.58
J2	Pragaan	1.89
A1	Modung	0.59
B1/B2	Tragah	0.27
K	Blega	0.36
D4	Ambunten	0.84
B3	Socah	0.28
H1	Pakong	0.35
A2	Kwanyar	0.13
D2/D3	Tanjung Bumi	0.01

Generally balances have risen steadily since 1985 (when monitoring began), with spectacular increases in the tobacco zones east of Pamekasan. Growth has also been good in Zone A1 in the west, where major efforts made on WUA strengthening and agricultural extension for *palawija* crops have been very successful. Average cash balances per well increased from Rp 0.78 million at the end of 1989 to Rp 1.06 million at the end of 1990. For most wells in the tobacco growing areas and in Zone A1 there has been no discernable drop in WUA balances after the removal of the Project operational subsidy and handover.

An effort has been made to get the WUAs to deposit their funds in village savings accounts, and most WUAs in the tobacco growing areas have complied. However, since WUAs are officially viewed as 'social organisations' they are not empowered to open bank accounts in the name of the WUA itself (only cooperatives or *Badan Usaha* at village level are able to do this), and accounts have to be registered in the name of a WUA official, usually the treasurer. There are obvious dangers in this, and legislation is needed to elevate the status of WUAs to enable them to open accounts in the name of the WUA and to perform similar functions as that of a cooperative or *Badan Usaha* - this forms the basis of a pilot institutional development programme being carried out at three sub-districts (*kecamatan*) during an extension to the Project in 1991 (see Section 4).

WUAs generally lack the necessary experience in fund management and accounting, and the Project devoted considerable effort to trying to improve the situation. As mentioned previously, in 1989 a WUA chairman and treasurer training programme was successfully undertaken to improve accounting and book-keeping practices. In five separate sessions a total of 94 WUA officials attended the training (98 were invited).

Although the size of the WUA balance is a reasonable indicator of the health of a WUA, the reported figures need to be viewed with some care. The WUAs with large balances quite often do not actually have all the cash readily available, as part of it is sometimes loaned for the purchase of cattle, motorcycles and other consumer items; it is felt this is a more secure way of protecting financial assets against inflation and the occasional collapse or default of village savings banks. Although there is an obvious danger of abuse of WUA funds with these measures, regular monitoring by the Project coupled with local community pressure has prevented the build-up of any widespread problems. In the few cases where extensive abuse of WUA funds has occurred, the intervention of the *camat* (who will be taking

Table 2: <u>WUA Performance - 1990</u>

Climate/ Crop Area	Groundwater Zone	No. Good WUAs	No. Satisfactory WUAs	No. Poor WUAs	No. Failed WUAs	Total
West Coastal	A1	2	5	2	-	9
	A2	-	1	5	1	7
	B2	-	1	-	-	1
	B3	-	1	3	-	4
	D2	-	-	1	1	2
	D3	-	-	3	-	3
	Sub-Total	2 (8%)	8 (31%)	14 (54%)	2 (8%)	26
West Inland	B1	-	2	3	3	8
	C1	-	-	-	2	2
	K	-	1	4	-	5
	Sub-Total	0	3 (20%)	7 (47%)	5 (33%)	15
Central and East	D4	1	1	-	-	2
	E1	5	-	-	-	5
	E2	3	4	1	-	8
	E3	8	7	7	-	22
	F	-	1	-	-	1
	G	2	2	5	3	12
	H1	-	1	2	-	3
	J1	8	1	-	-	9
	J2	3	-	-	-	3
	Sub-Total	30 (48%)	17 (26%)	15 (23%)	3 (5%)	65
	Grand Total	32 (30%)	28 (26%)	36 (34%)	10 (9%)	106

over the monitoring role from the Project) was generally sufficient in ensuring that corrective measures were taken. Eventually, it is hoped that WUA accounts will be audited by the *kecamatan* or *kabupaten* offices on a regular basis, and training in this aspect is being given in the Extension to Phase 3 in 1991 (Section 4)

3.3 Water User Association Performance

Although not perfect, the WUA account balance is a convenient yardstick to rank the performance of WUAs, and can used to define the following categories:

Good WUA	cash balances of more than Rp 1.0 million (US$ 570) have been achieved after removal of Project operational subsidy and handover;
Satisfactory WUA	cash balances of Rp 0.5 - 1.0 million (US$ 285-570) have been achieved;
Poor WUA	cash balances have not exceeded Rp 0.5 million (US$ 285);
Failed WUA	cash balance fell to zero after subsidy removal and handover.

Using these financial criteria, WUA performance for the period 1985-1990 is summarised on Table 2. Most of the good and satisfactory WUAs occur in the central and eastern zones, where tobacco is the dominant cash crop. However, WUAs in these categories also predominated in Zone A1 in the west where the Village Community Council (*Lembaga Masyarakat Desa*) is particularly active and farmers have responded well to the benefits of irrigation in the dry season. The worst WUAs occur in the west, particularly in the inland area which has the highest proportion of failures (Zones B1 and C1), and in parts of Zone G; these socially difficult areas are characterised by strong personalities at village level who have used WUA cash to their own advantage.

Overall, however, the majority of WUAs (56%) are either good or satisfactory, and it is believed that as the WUAs at some of the newer tubewells gain more experience the proportion of poorer WUAs will decrease. Also, the move towards vegetable production replacing traditional earners in Zones A1 and B3, and the practice of growing two rice crops in B3, should be reflected in stronger WUA accounts in these two areas in the future.

4. FURTHER DEVELOPMENT OF WATER USER ASSOCIATIONS

The long term sustainability of tubewell operation ultimately depends on the support given to the WUAs by the local government irrigation services (*Dinas Pengairan*) after the P2AT team has pulled out, and on the capability of the workshops to respond quickly to breakdowns and maintenance requirements. Discussions and investigations have been carried out with local government since 1989 to formulate concepts for WUA strengthening, and steps are being implemented on a pilot basis in 1991 during an extension to the Project. Three *kecamatan* were selected for this work to represent the main tubewell areas - Modung in the west, Larangan in the centre and Saronggi in the east (Figure 1).

Although the WUAs collect water charges and keep cash accounts for routine operational expenses, the big worry for the future concerns the financing for major repairs, engine overhauls (estimated cost Rp 3 - 5 million or US$ 1715 - 2860) and eventual pumpset replacement (estimated cost up to Rp 14 million or US$ 8000). Economic studies have shown that wells in tobacco areas, and the better well-schemes in the west (if cropping intensities are further improved) are able to create net annual benefits of at least Rp 40 million (about US$ 23,000) which should be sufficient to cover these major equipment costs. The main aim of the work at Modung, Larangan and Saronggi is to develop WUA organisation and financial resources so that these major operating expenses can be covered in the future.

As a result of extensive discussions between P2AT and local government planning and technical service agencies, the following programme is being implemented:

(a) Formation of a steering committee in the provincial local government planning agency (BAPPEDA) to coordinate activities, and a P2AT working group to assist the steering committee;

(b) Formation of irrigation committees at *kabupaten* and *kecamatan* level in line with the East Java Governor's decree Nr 232 of 1988, to coordinate WUA development activities and to act as a channel for disseminating government policies on water and irrigation matters;

(c) Adoption by the WUAs of the basic principles that village-based organisations should adhere to, the *Anggaran Dasar - Anggaran Rumah Tangga* (AD-ART);

(d) Legislation to enable WUA groupings at *kecamatan* level to operate as cooperatives (*Badan Usaha*), with the right to open bank accounts in the name of the organisation and to have access to official credit facilities. A concept that has been proposed is for a WUA Mutual Fund to be established, that WUAs would pay into on a regular basis (and earn interest) and be able to borrow from when the need arises. A higher rate of interest would be paid on borrowed money to cover administrative costs;

(e) Formulation of measures to enable the workshops to operate on a cost recovery basis, including a mechanism for the procurement of spare parts and their sale to the WUAs.

The response from the local government officials and WUAs in the pilot areas has been very good, and the programme is so far running well. Some degree of legislation has already been passed to enable the WUAs to have more control over their finances, and cooperation amongst the WUAs is improving. However, the most difficult aspect of the programme is the development of the workshops since a suitable mechanism enabling a public sector facility to be run along commercial lines has not yet been established by the DGWRD or the local government irrigation service; it seems likely that some degree of privatisation will be needed to maintain the custom of the WUAs.

5. CONCLUSIONS

The establishment and training of WUAs has been a crucial aspect of the development of tubewell irrigation on Madura. The WUAs were formed to enable the primary beneficiaries of the Project - the farmers - to be actively responsible for the operation and management of the tubewell systems serving their land.

Most of the WUAs established on Madura are managing to operate the tubewells reasonably effectively, and the benefits of the Project are clearly apparent. However, the concept of WUAs is still relatively new, and, as project implementation draws to a close, the local government will need to take a more active role in providing support and encouragement to sustain WUA performance in the future.

Invaluable experience has been gained on the Madura Project in developing suitable procedures for WUA establishment, training and follow-up, and this experience could be applied to other projects of a similar nature. The main conclusions from the WUA work on Madura are summarised below:

(a) Much time and effort is required for effective WUA formation, training and follow-up, and close consultation with village officials and key farmers is essential to ensure that the aims and responsibilities of WUAs are properly understood. Well trained and motivated project staff with good communicative skills are needed for this work;

(b) The personalities and motivation of key officials need to be taken into account when forming WUAs. At some locations there was a tendency to appoint all the WUA officers from a particular interest group or family. This is generally unsatisfactory, and efforts should be made to ensure a more balanced representation. However, it is inevitable that the water users with the most influence (which may include the village head) usually have the greatest role to play in WUA activities;

(c) Pumpset operators are key members of the WUA and need to be carefully selected and trained. Potential operators should have studied to high school level (to ensure literacy) and belong to an active farming family. The selection process can take a long time (several months) and should be started well in advance of the pumpset installation and commissioning programme;

(d) WUA training should be split into two sessions, the first session around the time of tubewell commissioning and the start of operations, and the second session after one crop season in order to give the farmers time to accumulate some operational experience. Video films were found to be very useful, but for maximum impact should be short and to the point;

(e) WUA finances and the importance of maintaining a cash fund through water charge collection need to be stressed during the training programme. Cash flow management is a problem area for most WUAs, and special training should be given to WUA chairmen and treasurers;

(f) In order to get the WUAs off to a good start, the Project should subsidise operating costs (mainly diesel and the pump operator's salary) for at least a year after tubewell commissioning. However, water charges should be collected from the time operations start so that a cash reserve is formed during the subsidy period to enable operations to continue after the subsidy is removed. The WUAs need to be made aware at the outset that they will be responsible for covering operation and maintenance costs once the subsidy is removed;

(g) A regular newsletter is a very useful means of disseminating information to WUAs;

(h) Cash account balances are a convenient way to monitor the performance of WUAs, although the reported figures need to be viewed with some care. WUAs with large balances quite often do not actually have the cash readily available, as it is sometimes loaned for the purchase of cattle, motorcycles and other consumer items; WUAs feel this is a more secure way of protecting financial assets against inflation and the occasional collapse or default of village savings banks;

(i) Efforts should be made to get the WUAs to deposit their funds in village savings accounts. However, since WUAs are officially viewed as 'social organisations' they are not empowered to open accounts in the name of the WUA itself (only cooperatives or *Badan Usaha* at village level are able to do this), and accounts have to be registered in the name of a WUA official, usually the treasurer. There are obvious dangers in this, and legislation is needed to elevate the status of WUAs to enable them to open accounts in the name of the WUA and to perform similar functions as that of a cooperative or *Badan Usaha*;

(j) Most of the WUAs in the eastern part of Madura, where tobacco is the main cash crop, have performed well. A good response has also been achieved in Zone A1 in the west where village communities are particularly active and farmers have benefited from the growing of (non-tobacco) crops in the dry season. However, the economic and social problems in the west have generally resulted in poorly performing WUAs;

(k) The long term sustainability of tubewell operation ultimately depends on the support given to the WUAs by the local government and irrigation services after the P2AT Project team has pulled out, and on the capability of the workshops to respond quickly to breakdowns and maintenance requirements. These aspects are being addressed by further institutional development work during an extension to the Project in 1991, involving local government staff training and the introduction of cost recovery procedures for the workshops.

Many of the problems with WUA development, such as domination of the WUA organisation by particular family or pressure groups, operator literacy, etc, were addressed as they became widely recognised and satisfactory solutions have generally been found. However, longer-term problems involving changes to government policy or legislation, such as the legal status of WUAs and ability to open bank accounts, etc, cannot reasonably to expected to be solved during the period of Project implementation. However, once the problems have been explained to the various parties concerned, and there is sufficient consensus of opinion that changes are required, then solutions to these problems will become possible in the course of time.

ACKNOWLEDGEMENTS

The author would like to thank Ir Tjetjep Sudjana (Sub-Director, Groundwater Project) and Ir Suratmo H S (Project Manager, Groundwater Development Project, East Java) of the Directorate of Irrigation II (DGWRD) and their P2AT Madura team, and acknowledges the considerable effort that was put into the WUA programme. The paper largely draws on material contained within the Phase 2 and Phase 3 Final Report prepared by staff of Groundwater Development Consultants and Indec & Associates, and the author gratefully acknowledges the contributions that these staff made to the report. Particular thanks must be given to Ian Smout[2] who was instrumental in starting the whole WUA programme off at the beginning of Phase 2, and who encouraged the author (the consultant's team leader on the Project from 1986 to 1990) to consolidate the results of the work in the form of this paper; Ian's comments and advice during the preparation of the paper are greatly appreciated. Last but not least the author would like to thank Sa'odah in the GDC office in Pamekasan for all her effort in typing and correcting the manuscript, and to her boss Pak Erdin Nursjaf Tajoedin for drawing the figures.

[2] Now at the Water, Engineering and Development Centre (WEDC), Loughborough University of Technology, UK.

REFERENCES

Casey, Margaret, (1991) Groundwater Development on Madura, Indonesia: Gender Issues in an Irrigation Project, (New Series) - *ODI Irrigation Management Network Paper 1*, Overseas Development Institute, London.

Groundwater Development Consultants (International) Limited in association with Indec & Associates Limited, Phase 2 and Phase 3 Final Report, Madura Groundwater Irrigation Project, July 1990.

Ian Smout, (1986) 'Training Programmes for Irrigation Farmers - An Example from East Java, Indonesia', *ODI/IIMI Irrigation Management Network 86/1e*.

Ian Smout, 'The Management of Irrigation Tubewells' Paper 36, Water Wells - Monitoring, Maintenance, Rehabilitation, 1990.

Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England.
Telephone: +44 71 487 7413
Telex: 94082191 ODIUK
Fax: +44 71 487 7590

IRRIGATION MANAGEMENT NETWORK

THE LIBRARY
OVERSEAS DEVELOPMENT INSTITUTE
REGENT'S COLLEGE
INNER CIRCLE, REGENT'S PARK
LONDON NW1 4NS

NATIONAL PUMP IRRIGATION STUDY: MATERIAL DEVELOPED DURING INCEPTION ACTIVITIES JANUARY 14 – 8 FEBRUARY 1991

Effendi Pasandaran

ASSESSMENT OF CONJUNCTIVE USE IN MAHARASHTRA MINOR IRRIGATION SYSTEMS

M M Sawant, R E Barrett, D J Molden, and T S Sheng

Network Paper 3 October 1991

Papers in this set:

1 *Groundwater Development on Madura, Indonesia: Gender Issues in an Irrigation Project* by Margaret Casey.

2 *Development of Water User Associations on the Madura Groundwater Irrigation Project, Indonesia* by Robert Jackson.

3 *National Pump Irrigation Study: Material Developed During Inception Activities, January 14 - 8 February* by Effendi Pasandaran; *Assessment of Conjunctive Use in Maharashtra Minor Irrigation Systems* by T S Sheng, et al.

4 *Conjunctive Water Use for Irrigation: Good Theory, Poor Practice* by Linden Vincent and Peter Dempsey.

5 *News from the Field - Groundwater Development and Lift Irrigation* from Tunisia, Mali, Sub-Saharan Africa, Bangladesh and South India.

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

Linden Vincent
Editor, Irrigation Management Network
Overseas Development Institute
Regent's College
Inner Circle
Regent's Park
London NW1 4NS

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

The opinions represented are those of the author and do not necessarily reflect the policies of the Overseas Development Institute, or any other organisation with which the author is connected.

NATIONAL PUMP IRRIGATION STUDY: MATERIAL DEVELOPED DURING INCEPTION ACTIVITIES JANUARY 14 - 8 FEBRUARY 1991

Effendi Pasandaran

Effendi Pasandaran is Director, Center for Agro-Socioeconomic Research, Agency for Agricultural Research and Development, Ministry of Agriculture, Bogor, Indonesia.

ASSESSMENT OF CONJUNCTIVE USE IN MAHARASHTRA MINOR IRRIGATION SYSTEMS

M M Sawant, R E Barrett, D J Molden, and T S Sheng

Tom Sheng can be contacted at Computer Assisted Development Inc, 1311 S College Avenue, Fort Collins, Colorado 80524, USA, and will pass on comments to the other authors.

NATIONAL PUMP IRRIGATION STUDY: MATERIAL DEVELOPED DURING INCEPTION ACTIVITIES JANUARY 14 - 8 FEBRUARY 1991

Effendi Pasandaran
Director, Center for Agro-Socioeconomic Research
Agency for Agricultural Research and Development
Ministry of Agriculture, Bogor, Indonesia

1. CURRENT RESEARCH ON PUMP IRRIGATION PROGRAMS IN INDONESIA

While the major rice producing areas of Indonesia have benefitted from irrigation development, the drier areas of Indonesia, where the scope for gravity irrigation is very limited, have not received an equal share of GOI (Government of India) investment. As a result, incomes in areas without irrigation are significantly below those found in the more intensely irrigated areas. An increased concern for eliminating poverty and reducing the income gap in Eastern Indonesia and other bypassed areas, combined with the recognition of the potential for rapid agricultural development through utilization of groundwater supplies for irrigation, has encouraged the government and donors to pursue programs to develop increased irrigation supplies through the introduction of pumps. These pumps can be used to extract groundwater as well as pump available water supplies from rivers, streams and smaller water bodies.

Although relatively speaking, a very small percentage of the total irrigated land in Indonesia is irrigated using pumps, there have been numerous programs developed around groundwater and surface pump irrigation. These programs range from large, deep tubewells serving in excess of 100 ha, to small well points serving less than 5 ha. Similarly, there are river lift schemes ranging between those serving more than 250 ha to small, portable pumps serving less that 10 ha. In general, where the government has taken the lead, the investment has included a large subsidy in capital investment and, in many cases, in operations and maintenance (O&M) costs, as well. In contrast, private investments by the farmers have not involved any subsidies, while programs organized by NGOs have stressed farmer involvement in investment and O&M, although there has usually been some element of implicit subsidy in the capital investment as well as in the services of the NGO staff. Along this spectrum there lies a broad range of other approaches tried by different agencies with funding from a wide variety of sources.

Each of these approaches has had some degree of success, and some have had a high rate of failure. Unfortunately, due to the wide dispersion of the projects, there is at present no overall understanding of the important elements required for a successful pump irrigation project, nor has there been any type of comprehensive survey of the past approaches. An increased concern for the less well developed areas and more emphasis on private sector approaches, appears to be conducive to expanded pump irrigation investment. Yet, there are a number of unanswered questions that need to be addressed before successful expansion of pump irrigation can be ensured. These questions include:

- Technical capacity of government agencies to develop and implement pump irrigation schemes;
- Institutional mechanisms to develop and sustain strong farmer water user associations;
- The economic viability of pump irrigation for rice and non-rice crop production and the agricultural services, including marketing, for non-rice crops;
- Provision of appropriate financing institutions and the ability of the farmers to pay for the capital, as well as the O&M costs for pump irrigation;
- The appropriate role of the private sector and NGOs in the development and rapid expansion of pump irrigation;
- The environmental sustainability of large-scale groundwater development in Indonesia.

2. STUDY FOCUS

As pressure builds for rapid expansion of pump irrigation in Indonesia, there is a danger that the subsidies associated with past pump irrigation programs will be a major part of the new programs. Not only do these subsidies place a burden on the national budget, they also tend to encourage inefficient use of Indonesia's increasingly scarce water supplies. In addition, as has been documented in a number of countries, subsidies often act as a deterrent to the formation of strong water user associations and, thus, encourage a dependency by water users on the government for future assistance.

A better understanding of the necessary and sufficient conditions for successful development of pump irrigation in Indonesia is critical to the planning and implementation of the large investments, both public and private, in pump irrigation that are now being developed for the next decade. Yet, given the many actors involved in pump irrigation and the wide variation in types of systems and institutional approaches, the GOI is not well equipped to learn from past investments. Lack of reliable information on the current state of pump irrigation schemes is a significant constraint on the GOI's ability to formulate pump irrigation programs for the less productive regions of the country. This is particularly crucial with respect to Eastern Indonesia as the GOI develops programs to absorb the poverty reduction funds earmarked by the donors for investment in this region. Given the limited human capital and infrastructure in Eastern Indonesia, it is clear that the area has a severe constraint on its ability to absorb large amounts of new investment. Therefore, there is a clear danger than investment models that have proven successful in Java and the more developed areas of Sumatra and Sulawesi, will be totally inappropriate for Eastern Indonesia.

There are also uncertainties about the technical capacity of the relevant implementing agencies to develop pump irrigation. Questions remain concerning the economic viability of pumping, financing arrangements, sustainable pumping levels, agricultural support services for non-rice crops, and the legal and institutional supports needed for strong farmer water users associations. Without addressing these issues, especially the economic ones, there is a danger that the explicit and implicit subsidies endemic to past public sector promotion of pump irrigation will produce unsustainable practices and/or environmental degradation. Among the possible negative environmental effects of overly subsidized or inappropriate pump development could be declining groundwater levels which impact on village water supplies and lead to increased pumping costs, salt water intrusion from over-depletion of groundwater and river water supplies, and accelerated contamination of water supplies from the increased use of agro-chemicals associated with high value irrigated agriculture. These issues concern long-term aquifer management, and can only be resolved if an adequate base of information is created about both the nature and potential of pump irrigation and about past experiences with the process of developing additional water supplies utilizing pumps.

Understanding these emerging issues will be crucial for the formulation and implementation of large investments in pump irrigation now being planned in the next five years. Yet, there is, however, no known inventory or comparative assessment of the various approaches being used, nor is there adequate monitoring of either the agro-economic benefits, sustainability, or the environmental impact of pump and groundwater irrigation throughout the country. Thus, the GOI has limited reliable information on which to base its planning and its requests to donors for expanded pump irrigation development.

Particularly critical is the GOI's capacity to formulate appropriate pump irrigation activities to absorb the increased funds the state and donors have earmarked for Eastern Indonesia, a region designated as a "neglected area". Increased attention to the problems in Eastern Indonesia is welcome, yet the capacity of much of this part of the country to exploit new technologies and to effectively absorb and use large capital investment, even if dispersed among many small pump sites, is relatively low. And there is the danger that in developing pump irrigation in these regions, there may be a bias toward introducing the "standard" technologies already in use in Java and other more economically integrated and densely populated parts of the country. These technologies, which may not even prove economically viable or sustainable in Western Indonesia, may be transplanted to Eastern Indonesia without careful consideration of their appropriateness or potential impact, and could even prove to be counter-productive in the longer term.

Stemming from these concerns, the National Pump Irrigation Policy Study has been formulated. The Study, to be jointly funded by Ford Foundation (FF) and the United States Agency for International Development (USAID), and to be implemented by the Center for Agro-Socioeconomic Research (CASER) and the Irrigation Support Project for Asia and the Near-East (ISPAN), respectively, has the following objectives.

3. STUDY OBJECTIVES

The main purpose of the National Pump Irrigation Policy Study is to provide an overview and assessment of past and present experiences with pump irrigation throughout Indonesia. The Study is expected to be an important and timely step in assisting the GOI in developing viable policies for development, expansion, and monitoring of pump irrigation and in preparing effective and appropriate proposals for donor assistance in this sector. The Study will:

(a) Seek the approximate extent of existing pump irrigation and pumping capacity throughout the country. Identify the number and extent of different types of pump irrigation, and according to their key features, such as location, size, agro-ecological zone, hydrologic setting, etc.

(b) Identify the range of approaches that have been tried in Indonesia for developing pump irrigation schemes, including those sponsored by government agencies, non-government organisations, and the private sector.

(c) Assess through case studies a representative sample of pump irrigation approaches, identifying the essential elements of each and describing the conceptual and implementation processes used. Examine their suitability and adaptability for various hydrologic and agro-socio-economic contexts. Evaluate their effectiveness with respect to technical, economic, financial, and institutional viability and sustainability. The Study will determine in particular:

- the formation processes and effectiveness of water users' associations (WUAs) in the development and operation of pump irrigation schemes, including the key elements found in successful approaches to organizing and strengthening WUAs in pump irrigation schemes;

- the legal framework and institutional supports needed for successful and sustainable WUAs in pump irrigation systems;

- the relationship between public agencies, the farmers, the WUAs in each scheme, and the extent to which roles, responsibilities, and functions are explicit, understood, and implemented. Assess the potential for expanding the rights and responsibilities of WUAs, and the role of the private sector, including the provision of technical and management services to WUAs;

- the composition of investment (farmer, private business, local and central government, and donor) during the planning, implementation, and operational stages. Determine operation and maintenance costs and funding sources. Assess the economic and financial viability of selected schemes.

(d) Provide assistance in determining and prioritizing critical near- and long-term policy issues for the expansion of pump irrigation throughout the country, particularly Eastern Indonesia.

- identify and assess near-term policy options, and recommend follow-up actions such as environmental and agro-economic monitoring programs, pilot and demonstration projects, and action research needed to evaluate various development scenarios;

- identify long-term policy issues and prioritize steps for future study.

(e) Recommend steps to improve viability and sustainability of pump irrigation systems.

4. STUDY ORGANISATION

As the overall purpose of the Study is to influence future pump investment in Indonesia, particularly new investment in Eastern Indonesia, a steering committee will be created. The committee will be composed of representatives from the National Planning Agency (BAPPENAS), and the Ministry of Agriculture, the Ministry of Public Works, the Ministry of Interior, and the Ministry of Mines and Energy. Recognizing the policy focus of the Study, the steering committee will be chaired by a representative of BAPPENAS.

5. STUDY APPROACH

Given the dispersed nature of pump irrigation in Indonesia, the Study has been designed to combine data of a number of different types collected from a wide variety of sources. The majority of the data will be collected by staff from CASER which has divided itself into three teams: (1) West

Java; (2) Central Java and Sulawesi; and (3) East Java and NTB. As indicated, assistance will be provided by expatriate experts in the fields of irrigation economics and policy, groundwater hydrology and institutional management. In addition, data concerning technical aspects of engines/motors and pumps will be collected by staff from the Faculty of Agricultural Engineering from the University of Gadjah Mada (UGM), Yogyakarta. The five major types of data to be collected include: (1) Development of a database that inventories the extent of pump irrigation in the country; (2) Collection of general agricultural, technical and institutional data specific to selected pump irrigation research sites; (3) Detailed technical data concerning technologies in use at the selected research sites; (4) Collection of structured survey data from farmers, operators and other concerned personnel at the selected research sites; and (5) Using a case study methodology, collection of data that documents how the institutional approach actually functions within the different research sites.

(a) *Inventory Data*-Compilation of available statistics on actual irrigated area served by pumps is complicated by the wide number of agencies and organisations involved in pump irrigation, the complex array of past and present programs and the lack of clearly defined government organisation that is responsible for maintaining this information. As a result, developing an inventory of present pump irrigation requires collection of data from public sector firms such as the Department of Environmental Geology, the Department of Irrigation II-Project for Pumping from Groundwater (P2AT), the Department of Irrigation I, the Department of Agriculture and numerous Local Government Agencies. From the private sector, sugar mills, palm oil plantations and other estate crops are major users of large-scale pump technology, while individual farmers and groups of farmers have made significant investments in small-scale groundwater and river pumping systems. Non-governmental organisations as diverse as Bina Swadaya and CARE have also had a continuing involvement in development of pump irrigation.

(b) *General Agricultural, Technical and Institutional Data*-General data related to each research site, including the surrounding area, is available from a wide variety of sources. This data will be collected by one of the three CASER teams assigned to the different sites. Sources for this data will include:

- Agricultural service (*Dinas pertanian*)
- Irrigation service (*Dinas pengairan*)
- District government office (*Kecamatan*)
- Project office
- Project documents
- Non-government organisations (LSMs)
- Village data.

(c) *Specific Technical Data*-Technical data about each pump, well and engine/motor such as information concerning size, type, age, investment, operation, maintenance and repair costs as well as trend data related to pumping hours, depth to water, drawdown and downtime. This data will be collected by staff from the Faculty of Agricultural Engineering from UGM. Sources for this data will include:

- Project reports
- Data from files in the project office
- Data from water users association records
- Data collected in the field
- Field measurements such as discharge rate and fuel consumption
- Government data series including climatic and river flow data
- Data and information from other local government offices.

(d) *Structured Survey Data*-Socio-economic data will be collected by CASER staff. Interviews of water users in the area using a structured questionnaire will be held on both a random basis and a focused basis, depending on the purpose of the group to be sampled. In research sites, the primary approach of the structured survey will be to select 1/10 to 1/4 of the large pumps and, within the service area of each to pump to select approximately a 15% sample of the farmers. In addition, staff will interview a selected smaller number of farmers in the area that use well points, shallow wells, and open wells for irrigation. The intent of this exercise is to quantify the situation within the command areas of the different pumps. Thus, the primary source of data is:

Structured interviews with farmers and other concerned individuals.

(e) *Case Study Data*-Detailed data collected by an unstructured approach in a limited number of pump command areas. This data will be collected primarily by graduate students from the Institute of Agriculture at Bogor (IPB) who will reside in the area 2-3 months, as required. The approach will be that of a case study with more an emphasis on qualitative understanding than on quantitative documentation. Case study data will be collected over an extended time frame as constant observation and discussion is required to gain a broad appreciation of the personal relationships and actual functioning of the irrigation systems in the area: Sources of data will include:

- Actual observations in the field and at meetings held in the area
- Interviews with farmers, association leaders, and other villagers
- Discussions with P2AT, NGOs, agriculture and local government officials
- Information compiled from irrigation and P3A records and files
- Insights gained from key observers and other individuals
- Measurements taken in the fields
- Data from project documents, evaluations, and other sources.

In order to ensure the data are complete, and to provide a means of cross checking the data, the structured surveys and technical data will be collected on the same set of pumps in each site. Case study data will be collected on a sub-set of these pumps. Thus, there will be technical data available for each pump site where socio-economic data are collected and there is also a mechanism to cross-check case study and interview data.

6. SITE SELECTION

During the initial discussions for the Study, research site locations were proposed for five provinces. These included:

1. West Sumatra
2. West Java
3. East Java
4. South Sulawesi
5. West Nusa Tenggara

However, after further exploration and discussions with a number of agencies and consultants in irrigation, a decision was made to explore locations that had a large number of pump projects with five or more years of production experience. Thus, during the first phase of the project the following sites were explored in depth, including multiple visits and collection of secondary data and project documents for each location.

1. Subang and Purwakarta areas of West Java
2. Sragen and Pati areas of Central Java
3. Gunung Kidul area of Yogyakarta
4. Madiun, Kediri and Nganjuk areas of East Java
5. Area around Pamekasaan in Madura.

These visits have identified six major types of pump irrigation with respect to technology:

1. Large River Pump
2. Portable Pump
3. Deep Well
4. Intermediate Well
5. Shallow Well
6. Well Points (no pumps).

In addition, there are three possible institutional approaches: private investment, public investment with continuing public backstopping and assistance, and public investment with little or no continuing assistance. In general, the first two approaches are the major ones in Indonesia and the primary ones that can be studied in any detail. With six technologies and two possible institutional approaches, there are 12 possible individual case studies that could be carried out. However, as 12 exceeds the budget, staff capability and time available (the project was originally designed for four or five research sites), a sub-set of these or a combination of different types and approaches at a single location are required in order to have a reasonable number of research sites.

The sites visited also do not provide locations outside Java and Madura, which is clearly one important element of the Study. However, fortunately, staff from UGM carried out a detailed study in Lombok of 7 public deep wells and 3 bank loan funded deep wells. The results of this study are well documented[1] and provided an excellent base line set of data for a follow-up study of the same wells. This can be done by a graduate student from UGM and will provide a valuable cross check against data obtained from the other sites.

---

1 Laboran Akhir, Survai Agro Ekonomi di Daerah Rencanna Ekploitasi 7 Sumur Pumpa di Gerung, Tahap I and Tahap II, Maret 1981. Oleh Fakultas Teknologi Pertanian, Universitas Gadjah Mada.

ASSESSMENT OF CONJUNCTIVE USE IN MAHARASHTRA MINOR IRRIGATION SYSTEMS

M M Sawant, R E Barrett, D J Molden, and T S Sheng

1. INTRODUCTION

The State of Maharashtra in India, like much of South Asia, has witnessed a striking growth in the number of wells used for irrigation. The use of groundwater for irrigation greatly benefits agricultural production and farmer welfare. Farmers in Maharashtra typically construct, operate and maintain wells on their own initiative. The state-run irrigation agencies indirectly support the use of groundwater for irrigation, but there is a marked absence of a single agency that specifically manages the conjunctive use of both groundwater and surface water. Donor agencies would like to assist in improving the status of conjunctive use, but it is sometimes difficult to identify the areas in which to help and the agencies through which to work.

The objective of this paper is to provide a brief assessment of the status of well irrigation and conjunctive use in Maharashtra. In light of the assessment, we will note areas where assistance could be used to improve the status of conjunctive use. The focus of the paper is on minor irrigation systems. Minor irrigation systems serve less than 2,000 ha and usually consist of a small tank for storing water and a canal distribution system. The development of surface irrigation has led to a rise in wells due to canal seepage in the command areas.

First presented in the assessment is a physical and socio-political overview of conjunctive use in minor irrigation systems, where we will briefly describe the physical, agricultural, and institutional settings for use of groundwater. Based on this presentation, we will then assess the strategies for managing conjunctive use of ground and surface water. We will then assess the strategies and give recommendations on what can be done to improve conjunctive use.

Conjunctive use is a common irrigation term usually referring to a means of coordinating the use of surface and groundwater supplies. Todd (1980) defines conjunctive use as the 'coordinated and planned operation of both surface and groundwater resources to meet water requirements in a manner whereby water is conserved.' Chavan (1984) defines it as 'the coordinated and harmonious development of the two sources in a basin or group of basins to maximise agricultural production.' Often times 'optimal use' of water resources is used with the term conjunctive use.

For conjunctive use to be successful, it is often felt that there must be active management, including central agencies for planning, monitoring, setting, and enforcing conjunctive use policies. In Maharashtra, there is no such agency, and the style of management allows farmers to make most of their own decisions regarding groundwater use. This style of management may seem to go against the grain of the definitions of conjunctive use, yet we will argue that there is conjunctive use of ground and surface water in minor irrigation systems in Maharashtra, and that conjunctive use is quite successful.

2. PHYSICAL AND SOCIO-POLITICAL OVERVIEW

This section provides a background description of the physiography and irrigation practices in the region (both for the state of Maharashtra and for minor irrigation commands), as well as the policy and organisational framework that prevails in the state.

2.1 Statewide

The Sahyadri Mountain ranges running parallel to the Arabian Sea, divide the State of Maharashtra into the coastal region (Konkan) and the Deccan Plateau. The physiography of Maharashtra is quite variable, ranging from barren hills and wastelands to highly productive valley regions.

The Government of Maharashtra (GOM) Groundwater Survey and Development Agency (GSDA, 1983) has divided the state into five geological regions (listed in order of occurrence):

1.	Deccan trap volcanic multi-layered rock	81.2%
2.	Archaean and Dharwar metamorphic complex igneous rock	10.5%
3.	Alluvial unconsolidated sedimentary rock	4.7%
4.	Pre-cambrian consolidated and compact sedimentary rock	2.0%
5.	Gondawana consolidated sedimentary rock	1.6%

Clearly, igneous and metamorphic ('hard rock') predominate. The condition of these rocks varies with depth, beginning at the surface with a thin (0.5 to 2 metres) soil layer. Below the soil layer is a zone of weathered rock, known locally as 'murum', which varies in thickness from 2 to 10 metres. Below the murum lies a 3 to 20 metre thick zone of semi-weathered rocks characterised by multiple fractures. Below this zone exists a non-weathered and non-fractured massive basement.

When saturated, the weathered and fractured zones constitute a hard-rock aquifer. Groundwater storage and yield, however, are impaired by poor permeability and shallow depths. Exploitation of these aquifers by tube wells is therefore limited, but large diameter dug wells are widely-used to tap groundwater in these formations. The Deccan trap, formed primarily from lava flows, is the major groundwater province in the state.

Well yields in these rocks commonly vary from 45 to 90 m^3/day, but wells located in suitable sites have been reported (Agashe, 1989) to yield 100 to 240 m^3/day. The Archaean and Dharwar metamorphic complex igneous rocks are found in the Konkan and Vidarbha regions. The yield of dug wells in these rocks varies from 45 to 50 m^3/day. By comparison, tube wells in alluvial aquifers are generally more than 2000 m^3/day. For the entire state of Maharashtra, the average area irrigated per well is 1.23 hectares (Government of Maharashtra, 1977). The number of wells in the state is dramatically increasing as shown in figure 1 (data from Dhavan [1987], and Dhokarikar [1989]). GSDA (1983) estimates the number of wells to reach ultimate potential exploitation would be 2,740,000.

The hard-rock aquifers are primarily recharged by the monsoon rains that fall from June through September. A very close relationship between this rainfall and groundwater levels is reported by Sawant (1989) and Agashe (1989). Groundwater levels show large fluctuations, attaining their highest position at the end of the monsoon season (October) and their lowest in summer (May). A very wet monsoon season may raise the groundwater level by 8 to 10 metres from its summer low; consecutive lean monsoon seasons may drop the groundwater level low enough to leave wells dry. These monthly groundwater level fluctuations can greatly affect water availability from dug wells.

In irrigation project command areas, additional groundwater recharge occurs due to seepage from the tank, canals, and field channels, and due to deep percolation of irrigation water. In a theme paper presented by Kulkarni

(1989), recharge from canal water was estimated to vary from 15 to 34% of the water released at the canal heads of the major irrigation projects studied. The paper also reported an increase in the number of wells in command areas after commencement of irrigation projects by a factor as high as 10 in some commands.

2.2 Minor Irrigation Command Areas

Minor Irrigation Command Areas are those less than 2000 hectares in area. They are typically found in the higher watersheds of the state. Due to the steep slopes in these areas, drainage is good and waterlogging from high water tables is generally not a problem. Farms in these commands are small, usually less than 2 hectares. During kharif season, common crops include sorghum, millet, groundnut, chilies, and mung beans. Irrigation for these crops may be given during any extended dry period in the monsoon. Common rabi season crops include wheat, sorghum, and gram and receive most of their water from irrigation.

Wells provide the farmer with groundwater for additional irrigation. As described above, these wells are usually of the dug well variety more suited to the hydraulics of hard-rock aquifers.

Groundwater is popular with the farmers since they have more choice over when it is used, how much is used, and what types of crops they may irrigate with it, as compared to canal water. Daines and Pawar (1987) found that the economic rate of return for hardrock dug wells in irrigated areas is between 50 and 87% compared to a rate of 10 to 16% for canal irrigation.

2.3 Current Irrigation Policy

The current irrigation policy for Maharashtra is the result of numerous legislative acts dating back to 1887. Among these acts are the 1934 Bombay Canal Rules, in 1976 Maharashtra Irrigation Act, and the 1987 Bombay Irrigation Act. Groundwater in India is considered to be private property and not subject to control by the government. Therefore, these acts mainly govern the use of surface water.

Nevertheless, the interrelationship of ground and surface water has been recognised by the law-makers and current policy does, in fact, indirectly regulate conjunctive use. Some of these policies are:

1. In command areas, irrigated land is designated as either groundwater-irrigated or canal-irrigated. Areas irrigated with canal water may also receive groundwater if canal supplies become short. The farmer must report this use to the appropriate executive engineer within 8 days. The water charge in this case is 50% of the regular canal charge (Rule 18, Bombay Canal Rules, 1934). In contrast, groundwater-irrigated areas may at no time be irrigated using canal water;

2. Well water transported via surface channels constructed for canal water is charged at the full canal rate (Rule 19, Bombay Canal Rules, 1934);

3. With the permission of canal authorities, a farmer may divert or pump water from natural surface drainage that originates from percolation or leakage of canal water (return flow). The water charges for such use are at par with the direct canal water supply (Rule 55a, Maharashtra Irrigation Act, 1976);

4. Irrigation water from wells located within the irrigable command of a canal or within 35 metres on either side of a canal is charged at 50% of the normal canal water charge (Rule 55b, Maharashtra Irrigation Act, 1976);

5. Any person planning to construct a well in an irrigation command is required to inform the canal authorities of his intentions, or he may be penalised (Rule 105, Maharashtra Irrigation Act, 1976);

6. The irrigation of perennial crops with canal water is restricted as follows:

   (a) In major irrigation systems, the area planted in sugarcane, a heavy water-consuming crop, is limited to 1/4 to 1/3 of the total command area. This restriction, popularly known as the 'X Limit', does not apply to sugarcane grown exclusively with well irrigation (Form III, Condition 1, Bombay Canal Rules, 1934);

   (b) In minor irrigation projects it is not feasible to irrigate perennial crops with canal water since water cannot be assured on a year-round basis.

In actuality, adherence to the rule requiring a farmer to inform the irrigation authorities of his plans to construct a well in the command area depends on other financial factors. If a farmer is using his own money to construct a well, he often does so without seeking anyone's permission. However, if the farmer approaches the Maharashtra Cooperative Land Development Bank (LDB) for a loan to construct the well, the bank, with the help of GSDA, must first do a hydrologic feasibility study of the well site. Depending on the results of this study, the well may or may not be financed (see section 2.4.7). LDB loans are special long-term, low-interest loans. A farmer has the choice of obtaining a higher cost loan from another bank in which case the well may not need to meet any hydrologic guidelines.

Furthermore, while the irrigation of perennial crops with canal water is restricted, a farmer is free to grow any crop he chooses if he irrigates that crop with his groundwater. Use of return flow canal water in natural drainage is also available for any crop albeit at the full canal charge.

2.4 Organisations Involved in Conjunctive Use

Due to the existing policy constraints outlined above, there is presently no organisation in Maharashtra directly responsible for conjunctive use management in irrigation projects. However, discussions with officials from various organisations revealed that many of these organisations carry out activities related to conjunctive use, or at least to the use of groundwater. Furthermore, some officials had studied conjunctive use problems in the past and expressed an interest in being further involved in the activity, including possible computer model development. Highlights of groundwater related activities of various organisations follow.

2.4.1 Directorate of Irrigation Research and Development (DIRD)

The DIRD, a wing of the GOM Irrigation Development (ID), records groundwater levels in some 84,000 wells in 24 major irrigation projects around the state. Levels are monitored twice a year, before and after the monsoon. The purpose of this activity is to watch for drainage problems in the commands caused by waterlogging. Additionally, the organisation has carried out some water balance studies in a few of the major irrigation projects (Kulkarni, 1989).

2.4.2 Management Wing of ID

The Management Wing of the Irrigation Department manages day-to-day operations and maintenance of irrigation systems. It collects seasonal data regarding the crops grown and the area irrigated in the commands for the purpose of levying appropriate water charges. Discussions with project managers revealed that they too realise the importance of conjunctive use and have studied the problem (see Ralegaonkar, 1983, and Chavan, 1984). They would welcome any further research in this area.

2.4.3 Groundwater Survey and Development Agency (GSDA)

The GSDA was set up by GOM to explore for and develop groundwater in the State and provide technical assistance to various other agencies. It is actively engaged in hydrogeological reconnaissance and mapping (at a scale of 1:800) and monitors groundwater levels in a large number of observation wells.

In 1973 GSDA began periodic evaluations of the groundwater potential of the state's watersheds. One use of this information is to make decisions concerning financing the wells. The watersheds are classified as 'white', 'grey', or 'dark' according to their degree of groundwater exploitation. A white watershed is one in which the total groundwater potential is less than 65% exploited. Grey watersheds fall between 65 and 85% total exploitation and watersheds over 85% exploited area classified as dark. Of a total 1481 watersheds in the state, 1367 are classified as white, 80 as grey, and 34 as dark (Dhokarikar, 1989). GSDA provides this information as a general guide for groundwater development in Maharashtra.

2.4.4 Central Groundwater Board of the Government of India (GOI/CGWB)

The Central Ground Water Board, under the Ministry of Water Resources, Government of India, is the national apex body for groundwater activities. Its responsibilities include the preparation of regional hydrological survey maps (at a scale of 1:50,000), and the exploration, development, and management of country's groundwater resources. GOI/CGWB is preparing a computerised data bank of hydrogeologic data. There is some overlap in the activities of GOI/CGWB and GSDA in the state of Maharashtra.

2.4.5 Financial Institutions

Bankers come into the picture as providers of loans to farmers for well construction. NABARD is the controlling agency in this respect, setting technical guidelines and monitoring rural financing at the national level. NABARD finances the Maharashtra State Cooperative Land Development Bank (LDB) and other national banks at an 80:20 ratio respectively. These banks, in turn, do the actual financing of the farmers.

In approving the financing of well construction, LDB uses guidelines and other information from GSDA. If the proposed well site is in a watershed classified as white, financing for the well is approved if it is not within 150 metres of another well to prevent interference in hard-rock aquifers. If the well site is in a grey watershed, the well must meet the GSDA hydrologic feasibility requirements regardless of its proximity to other wells. If the well site is in a dark watershed, financing is not approved.

3. CONJUNCTIVE USE STRATEGIES

Surface and groundwater could be managed conjunctively for minor irrigation command areas using a variety of approaches as examined below. Through our discussions the following strategies were identified:

1. Periodically skip certain canal rotations to induce farmers to use well water during these periods;

2. Pump groundwater from wells in the command area into the canal system to increase its water supply;

3. Exclude areas irrigated with groundwater from the command area and expand the surface irrigated command area accordingly;

4. Allow the farmer to manage the available groundwater resource.

Strategy 1 was attempted experimentally in the Nira command but was found to be a failure. The approach is infeasible because not all farmers necessarily have a well and dug wells in hard-rock aquifers often cannot yield sufficient quantities of water to make up for the skipped rotation.

Strategy 2 is practised in the alluvial aquifers of the Western Jumana Canal System in Haryana (Michael, 1978) where a battery of tube wells along the canal is pumped to supplement the canal's supplies. The advantage here is two fold: to augment the canal water and to lower the water table to prevent waterlogging problems. This option has yet to be tried in Maharashtra but its success in the state is doubtful. The alluvial aquifers in the Haryana area are quite high-yielding compared to the shallow, hard-rock aquifers in Maharashtra. A variation of this approach is to pump groundwater into the canal system from a network of private wells. This probably has even less chance of success since additional distribution structures would have to be built and because individual farmers would be reluctant to share their private well water.

Strategy 3 has not yet been attempted in Maharashtra minor irrigation commands. It presents difficulties because it is hard to determine exactly how much the command area could be safely expanded. It cannot simply be expanded by one hectare for every hectare under well irrigation. This is due to two reasons. First, the efficiency of well irrigation is higher than that of surface irrigation. Second, distributing more of a given amount of canal water to new command areas means that less water will be applied to the old command area. This will consequently reduce the seepage that recharges the groundwater in the old command area, undermining the original reason for expanding the command area. In addition to these reasons, extending the command area eliminates any safety buffer provided by groundwater during periods of canal water shortage. For Strategy 3 to be successful, some rigorous methodology for estimating the water balance of a command area would need to be developed and applied.

Strategy 4 is, in fact, the present practice in Maharashtra. If canal water is in short supply during the kharif and rabi irrigation season, farmers will not hesitate to make up the difference with well water, if permitted. Moreover, during the summer when the canal system is not operated, it is common for farmers to grow cash crops using groundwater. The strategy is quite flexible. At one extreme (e.g. the Satana Minor Irrigation Project in the Godawari System), a farmer may opt for a more dependable 'on demand' groundwater resource over the less dependable (in both quantity and timeliness), government-controlled canal water. This allows him to cultivate more profitable crops, tilting farm economics against the use of canal irrigation. At the other extreme, where the groundwater potential is low, cash crops are unattractive, or the canal system is dependable, the farmer may choose to rely completely on canal water.

4. ASSESSMENT

The present government policy and institutional framework allows farmers a high degree of management control over their groundwater resources. The Irrigation Department plays an active role in managing surface water and, by allowing farmers to manage groundwater use, the Department has also been effective in conjunctive use administration in command areas. A more direct role by the government may adversely affect irrigation performance. Strategies for improvement of conjunctive use should encourage and facilitate the private control of groundwater use.

Of the four strategies for conjunctive use management on minor irrigation systems, the present policy (Strategy 4), has the most potential for success because it allows farmers to manage their own resource. It should be recognised that the present government policies and management practices contribute to the success in the utilisation of the groundwater resource. However, the irrigation department does not give itself due credit, because measurements of irrigation performance are restricted to surface water alone.

While the present policies allow for a high degree of farmer control of on-farm irrigation water from wells, the farmer has no control over the supply of groundwater. Provision of surface water infrastructure leads to an increase in groundwater potential due to leakage from dams and canals. The means of operating and maintaining surface water affects the supply and timing of groundwater supplies. By indirectly controlling a source of groundwater, the government may have a means of assisting farmers and improving conjunctive use performance.

To measure the benefits of conjunctive use, irrigation performance standards are required that consider both groundwater and surface water. Measures of performance relative to the standards and system objectives need to be identified and defined. Performance should be measured relative to economic, water use efficiency, and equity objectives. With conjunctive use performance measures it is possible to assess the baseline status of conjunctive use and to assess strategies for improving conjunctive use.

Given the current water policy and institutional constraints, there remains the question of what can be done to improve irrigation performance by considering conjunctive use. Possible options are:

1. Obtain a better understanding of the water balance in minor irrigation command areas. A water balance study would assist in understanding this complex system and may give indications on how to improve the system;

2. Develop a means of assessing irrigation performance that considers both surface and groundwater. Performance measures can be used to assess the present status of irrigation performance and compare alternative conjunctive use strategies;

3. Take physical, operational, and maintenance steps on the surface water system which would enhance the conjunctive use of groundwater and surface water strategy for enhancing conjunctive use should evaluated and compared to other strategies using performance measures;

4. Give farmers advice on technical, agronomic, and economic inputs to assist in their management of groundwater.

5. SUMMARY AND CONCLUSIONS

The outstanding physical feature in Maharashtra is the domination of low-yielding hard-rock aquifers. Recharged by monsoon rains and surface irrigation losses, these aquifers provide a reliable source of water for many small farmers. The fact that the aquifers are low-yielding limits possibilities for large scale pumping projects like those found in alluvial aquifers.

The Government of Maharashtra has set up laws and policies that separate surface and groundwater uses. The Irrigation Department constructs and manages surface irrigation systems while farmers control their own use of groundwater. Given this policy setting, the Irrigation Department does not have an agency for managing conjunctive use. The Government of Maharashtra does have several institutions indirectly involved in groundwater use whose functions are to observe groundwater levels, monitor the number of wells, and provide financial assistance to farmers.

An advantage of the policy allowing farmers to manage their own groundwater is that farmers have control over the timing and amount of groundwater used for irrigation. In spite of the capital and operation expenses, many farmers have constructed their own wells to use independently or to augment surface water sources. The government, through its financing system, regulates the spacing of wells to prevent groundwater mining and removal of water from canals. While there may be some options where the irrigation department can take a more active role in conjunctive use, we currently feel that the policies and management style of the Government of Maharashtra with respect to groundwater use is appropriate for the setting.

There does remain room for improvement within the present policy and system of management. A means of measuring performance considering ground and surface water should be developed to give the government due credit for its policies, and to evaluate the effect of various surface water strategies on conjunctive use. Focus could also be placed on the farmers, assisting them in improving their use of groundwater.

ACKNOWLEDGEMENTS

This paper draws on consultancy work carried out by Computer Assisted Development Inc, under the contract of Sheladia Associates Inc, in connection with the USAID-sponsored Maharashtra Minor Irrigation Project.

REFERENCES

Agashe, R M., (1989) 'A Review of Activities and Achievements of Central Ground Water Board in Maharashtra', a theme paper presented at the Seminar on Role of Groundwater in Use of Water Resource of Maharashtra State, Pune.

Chavan, R V., (1984) 'Conjunctive Use in the Command of Nira Left Bank Canal (Maharashtra)', Government of Maharashtra, Irrigation Department, Pune Irrigation Circle, Pune.

Daines, S R., and Pawar, J R., (1987) 'Economic Returns to Irrigation in India', report submitted to USAID Mission to India, New Delhi.

Dhavan, B D., (1987) *Economics of Groundwater Irrigation in Hard-Rock Regions - with Special Reference to Maharashtra State*, Agricole Publishing Academy, New Delhi.

Dhokarikar, B G., (1989) 'Groundwater Activities in Maharashtra', theme paper presented at the Seminar on the Role of Groundwater in Use of Water Resources of Maharashtra, held at Pune on September 29-30 1989.

GOM, (1977) *Maharashtra State Agricultural Census*, Department of Agriculture, Government of Maharashtra, Pune.

GOM GSDA, (1983) 'A Glimpse into Groundwater Resources of Maharashtra and its Development Programmes', Pune, 41 pp.

Kulkarni, S Y., (1989) 'Activity of Directorate of Irrigation Research and Development', theme paper presented at the Seminar on the Role of Groundwater in Use of Water Resources of Maharashtra State held in Pune.

Michael, A M., (1978) *Irrigation Theory and Practice*, Vikas Publishing House Pvt Ltd, New Delhi.

Ralegaonkar, G P., (1983) 'Conjunctive Use of Groundwater for Canal Development: a Case Study of Pravara Canal System', Symposium on Water Management Experience of the Past and Directions for the Future, Central Board of Irrigation and Power, New Delhi, 1983.

Sawant, M M., (1989) 'Extending Utilisation of Hard-Rock Dug Wells in India Using Advanced Irrigation Technologies by Expert System Models', PhD dissertation presented to Utah State University at Logan, Utah, USA.

Todd, D K., (1980) *Groundwater Hydrology*, 2nd edition, John Wiley and Sons, New York.

Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England.
Telephone: +44 71 487 7413
Telex: 94082191 ODIUK
Fax: +44 71 487 7590

odi

IRRIGATION MANAGEMENT NETWORK

THE LIBRARY
OVERSEAS DEVELOPMENT INSTITUTE
REGENT'S COLLEGE
INNER CIRCLE REGENT'S PARK
LONDON NW1 4NS

CONJUNCTIVE WATER USE FOR IRRIGATION: GOOD THEORY, POOR PRACTICE

Linden Vincent and Peter Dempsey

Network Paper 4

October 1991

Papers in this set:

1 *Groundwater Development on Madura, Indonesia: Gender Issues in an Irrigation Project* by Margaret Casey.

2 *Development of Water User Associations on the Madura Groundwater Irrigation Project, Indonesia* by Robert Jackson.

3 *National Pump Irrigation Study: Material Developed During Inception Activities, January 14 - 8 February* by Effendi Pasandaran; *Assessment of Conjunctive Use in Maharashtra Minor Irrigation Systems* by T S Sheng, et al.

4 *Conjunctive Water Use for Irrigation: Good Theory, Poor Practice* by Linden Vincent and Peter Dempsey.

5 *News from the Field - Groundwater Development and Lift Irrigation* from Tunisia, Mali, Sub-Saharan Africa, Bangladesh and South India.

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

Linden Vincent
Editor, Irrigation Management Network
Overseas Development Institute
Regent's College
Inner Circle
Regent's Park
London NW1 4NS

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

The opinions represented are those of the author and do not necessarily reflect the policies of the Overseas Development Institute, or any other organisation with which the author is connected.

ERRATA

Conjunctive Water Use for Irrigation: Good Theory, Poor Practice
by Linden Vincent and Peter Dempsey

Table 1 on page 16 should read Table 2

CONJUNCTIVE WATER USE FOR IRRIGATION: GOOD THEORY, POOR PRACTICE

Linden Vincent and Peter Dempsey

Contents **Page**

CONJUNCTIVE WATER USE FOR IRRIGATION: GOOD THEORY, POOR PRACTICE

Linden Vincent and Peter Dempsey

1. INTRODUCTION

As frontiers for new irrigation development become fewer, and the demand to produce more food increases, so does the need to use resources more efficiently, and operate existing irrigation schemes more productively.

Conjunctive use is the combined and integrated management of surface and groundwater for optimal productive and allocative efficiency. At farm- or scheme-level conjunctive use is the concern of farmers and scheme managers attempting to optimise the quantity, timing and reliability of supply and maintain soil fertility over the year. At regional level the combined management of the resource is of interest to planners and water resource engineers seeking to maximise water availability, and increase the quantity and sustainability of supply in the longer term. Ideally conjunctive use of resources extends the utility of available resources, and should not be used to describe the development of one resource simply to hide shortcomings in the provision of the other resource. However, conjunctive use on irrigation schemes is often a system of 'joint use' where groundwater has developed for a variety of objectives, particulary to deal with waterlogging problems, or to compensate for failure in the surface water distribution system. Joint use has also emerged as a result of the spread of well technology outside of any specific operational programme organised by water management institutions.

This article reports the result of a literature survey of conjunctive water use. We looked at the breadth of existing literature, the contexts in which research was performed, the models built to analyse options, and the use of research to inform policy options (or the failure to use research constructively). By looking more at the various objectives behind the current interest in conjunctive use, we hoped that we could make some recommendations on research approaches. In this paper we look first at the diversity of objectives behind current interests to promote conjunctive use, and how this has affected the development of coherent research to inform policy. We then look briefly at the hydrology of conjunctive use, and some of the hydrological and rural planning models constructed to inform policy and implementation initiatives, with a longer overview of models provided in Appendix 2. Finally we look for at the use of institutional analysis as a means of organising research on conjunctive water use, and as a means for looking at the solution of multiple objectives in conjunctive use.

Conjunctive water use has been a water resource development tool since to 1960s. Concerns over the technical mobilisation of more water have shifted into serious considerations on water allocation as water resources are seen to be reaching finite limits. It has also been of specific interest in many regional rural development plans over the same period (see Biggs, 1974; Rogers and Smith, 1970). It has also become of increasing interest in irrigation scheme management. Conjunctive use became a component of World Bank irrigation development policy in the early 1980s, in response to increases in agricultural production of up to 20% witnessed in Pakistan (O'Mara 1984). It is claimed conjunctive use can contribute to improved agricultural performance, sustainability and equity (Prasad and Verdhen, 1990; Dhawan, 1988). An improved water supply can increase output by facilitating the irrigation of additional land and permitting increased irrigation intensities. It can also support changes in cropping patterns, especially crops with heavy water demands like rice and sugar cane, or cropping patterns which allow farmers to optimise their combinations of rainfed and irrigated crops. The reduced uncertainty of poor or irregular supply from surface water and allows farmers to risks investments in water-intensive and higher value crops, HYV seeds, and associated inputs like fertiliser and pesticides.

We found an historical analysis of research was important. Much of the analysis from the 1960s and 1970s proved to be highly relevant to some current dilemmas on research and policy formulation. Much of this literature pre-dates computerised abstracts, and is also linked to earlier research paradigms which predate the current focus on local water management institutions. As a result much work had almost disappeared from 'corporate memory'. We may talk much about the essential importance of farmer knowledge, but this literature review showed up the importance of using the knowledge of engineers and social scientists prepared to spend time not only recalling past work, but also evaluating it.

According to the World Bank (O'Mara, 1984), conjunctive use should be equitable or at least 'Pareto safe', i.e. no irrigator should be worse off, and the gap between richer and poorer farmers should not be widened. Irrigators should have access to one or other resource and there should be compensation where there are proportionately greater gains from one or other resource. Further, O'Mara suggests that variability in supply should not effect users inequitably, and rights should apply to all sources equally, i.e. they should not differ between surface water and groundwater. This is difficult to achieve in practice. While similar types of rights may make for easier control, there is no reason to expect changes would be culturally acceptable in all societies. Surface water and groundwater development have profoundly different needs in communal and 'supra-community' action, and we should not be surprised that it is very difficult to develop similar rights of access, ownership and control.

We found a great deal of confusion in the literature, with the reports on the diversity of circumstances of conjunctive water use threatening to overwhelm any systematic analysis of research needs, or systematic debate of institutional needs. We now know quite a lot, and certainly are speculating a lot, about the effects of joint use on farmers and tertiary level water management. However, we know very little about how farmers and bureaucrats are actually acting to ensure that risks in decision-making over the use of resources are reduced. At the regional level, we see few directives to ensure the production of useable technical documents, or to encourage a cadre of staff capable of debating technical and political recommendations, and transferring these into practical procedures to encourage conjunctive use.

One key source of confusion is the call for conjunctive use developments to serve more than one set of objectives. Research, however, has not always been designed to provide information for diverse objectives, and thus the resulting recommendations are abstract or politically infeasible. We also found it useful to distinguish studies which really were actually looking at the institutional prospects for joint use of water, and those studies looking at problems in technical innovation and the adoption of well technology. As we discuss later, these are actually very different initiatives, and great confusion has developed in the literature in the expectation that water management agencies should somehow encompass or organise all initiatives relating to changing the production of irrigated crops. Few authors have looked systematically at the scope for different institutions to evolve, and/or collaborate to meet different needs. Thus recommendations from research were not linked to a forum where recommendations could be debated.

We found many environmental models, a number of economic models, and several articles involved in descriptions of the utility of different models for different kinds of problems. Some modelling work has been well developed. However, many of the models are very abstract, and often have a very weak summary of the actual schemes they are supposed to serve and rarely consider the decision-makers supposed to use the recommendations. In fact, we have found no examples in irrigation where the utility of mathematical modelling has been subsequently assessed as a policy tool, although this issue has been debated in water resources planning (see IASH, 1989). In the literature there are no critiques of policy on conjunctive use to show how institutional development has interlinked with research and technology dissemination to achieve the existing levels of conjunctive use, or how better levels of conjunctive water use might be achieved (although summaries of administration exist [O'Mara, 1988], and such studies do exist in other areas of water management [Clay, 1974; Sexton, 1991]).

Our review of models suggested that many were constructed for fairly clear objectives, although some criticism is possible for the limitations of equations constructed and quality of data used. However, there is some tendency for models built for one purpose to be used subsequently to answer other purposes, as well as to be transferred regionally without very close attention to hydrological and economic differences. For example, field experience suggests that theoretical models and software of hydrological interactions are used rather uncritically. Palanasami (1991) has recommended a specific well assistance programme to promote conjunctive use. However, the model he uses to justify this recommendation was designed to show costs and benefits of rehabilitation options at the scheme level, and has very little detailed groundwater information in it.

Both hydrological and economic models were unable to operate at the 'local' scale (usually the most disaggregated level is the region or scheme). Hydrological models had particular problems in modelling the behaviour of dug wells (rather than tubewells), seepage and drainage (and how this manifested itself in space and time), and metamorphic or 'hardrock' geologies (rather than alluvial and sedimentary formations). Most 'economic' models were actually involved in looking at returns to technical investments either to maximise food production or to look at rehabilitation, and rarely interpreted these options in institutional terms. No models currently exist that study issues of equity and rural transformation below the scheme level. Thus modelling, although useful for some studies in conjunctive water use studies, either cannot help us with situations with complex objectives, or must be clearly subsidiary to other forms of research as a basis for reform of agricultural policy and water management.

This review has been undertaken by two authors who are essentially hydrologists with interdisciplinary training and full experience in development studies. Our review suggested a need for major improvements in research methods if they are to inform policy development. We found that improved institutional analysis and understanding was vital if more conjunctive water use is to be achieved. Please bear with us if we do not use the terminology developed by those more deeply involved in studies of organisations and public policy.

2. OBJECTIVES IN CONJUNCTIVE WATER USE

If we look at the objectives behind the promotion of conjunctive water use, the term first developed as a resource management objective to maximise water availability. However, 'joint use' of resources has also emerged as a technical option for a number of other objectives in irrigation management. These other objectives include:

- objectives on improved availability of water;
- environmental objectives to reduce waterlogging and salinity;
- production, equity and poverty alleviation objectives;
- fiscal objectives to optimise expenditure on rehabilitation;
- state disengagement from canal irrigation management.

With these other objectives, the system of joint use rarely maximises the physical availability of water - indeed, it may be tending to bring technical changes that fracture existing management institutions. However, the resulting pattern of water use may be optimal in economic, social or political terms.

Understanding these different objectives in conjunctive use, and how they have changed as a focus of irrigation research over time, is important since each tends to use rather different research methodologies and draw on different bodies of available information (and, in turn, ignore bodies of research).

A study of the literature on conjunctive use in irrigation showed a number of confusions in setting objectives, designing related research, and directing recommendations. Firstly, many authors expected more than one objective to be achieved by reforms. For example, some authors expected institutions to promote well irrigation in surface water schemes for equity reasons, but they also wanted to see maximisation of available water resources as well. Recommendations could be directed at institutions with very limited interests or influence in promoting well irrigation, or related support services. Secondly, researchers failed to consider how their research was informing the policy debate. Some researchers were indeed undertaking research linked to clear objectives, with prospects for their research to be linked to policy formulation. Many researchers, however, were undertaking research of topics that interested them, without seeing how findings could be linked to practical recommendations, and thus were making recommendations into a void. Thirdly (and following from this earlier point), authors thought they were doing research relevant to conjunctive use, where actually their results related to different issues (especially technical innovation in the use of wells, and the operation of water markets). One problem which is emerging is the expectation that all kinds of issues can be resolved within the 'water management' paradigm, whereas we may need to be looking at a variety of research themes, determined by a combination of institutions involved with rural development and water management.

In fact, we do not feel that research has yet been critiqued in terms of objectives and institutions. Instead, we find research directed in three areas:

- defining options for technical developments (here technology itself emerges as the objective);
- production and equity issues;
- concerns at technical innovation in groundwater use.

We now provide an overview of ideas in each of these three areas. In each section we review the weaknesses of approach, and try to show additional institutional studies which would be useful.

3. STUDIES ON TECHNICAL OPTIONS FOR IMPROVED WATER AVAILABILITY AND ENVIRONMENTAL MANAGEMENT

Although in theory conjunctive use may be planned from the outset, most planned irrigation initiatives have evolved over time for other objectives. One rare example of planned conjunctive use is the Yucheng Experimental

District in China (Ren Hongzun, 1990). Development of surface and groundwater resources have been combined with land levelling, soil improvement, forestry, and farmer management for an integrated irrigation and drainage system. The conjunctive water use component comprises a six level canal drainage and irrigation system which keeps water tables low in the flood season and stores water at other times, and a network of 1050 wells, 50 - 100 m deep, to increase the depth to watertables and supplement supply. The results have been massive reductions in areas suffering salinity between 1949 and 1984. There have also been large increases in grain yields.

Quite a lot of literature exists purely to summarise technological options. Wells (usually tubewells, but sometimes dug wells) may be introduced to: (1) supplement inadequate canal supply, or provide an alternative source of irrigation water should canal supply fail; (2) provide vertical drainage to mitigate salinisation and waterlogging; or (3) mix groundwater and canal waters of different qualities to provide water of acceptable overall quality. A typical list of technology options is shown in Table 1 (from Khepar, 1990).

Supplementary groundwater irrigation may be introduced where canal supplies are inadequate, either for design or operation reasons, or where crops production practices have changes. Groundwater development in some areas may enable the areal extent of an irrigation scheme to be increased. Groundwater development may also proceed spontaneously, where farmers are outside the canal command, where users are dissatisfied with surface water provision, where groundwater irrigation is more economic, or where development of groundwater markets provide a good return to investment.

In some of the larger schemes in Pakistan and China, inadequate horizontal drainage and profligate water use have caused waterlogging and salinity problems. Over-watering increases salts deposited at the surface, and the increase in water infiltrating to groundwater causes the watertable to rise, increasing the concentration of salts in the rooting zone due to capillary rise. Tubewells were introduced in the 1960s and 1970s to provide vertical drainage and increase the depth to water table, and some of the less brackish water is diverted for irrigation. In Pakistan, tubewells were introduced under public programmes like SCARP I & II (Salinity Control and Reclamation Project) to provide vertical drainage to offset waterlogging and salinity problems caused by rising watertables from canal irrigation.

Table 1: Conjunctive use is planned and practised with the following objectives:

(i)	Mitigating the effect of the shortage in canal water supplies often subject to steep variation in river flow during different periods in the year.
(ii)	Increasing the dependability of existing water supplies.
(iii)	Alleviating the problems of high water table and salinity resulting from introduction of canal irrigation.
(iv)	Facilitating the use of high salinity ground waters which cannot otherwise be used without appropriate dilution.
(v)	Storing water in ground water basins closer to the users, to ensure water supply to the users in case of interruption of surface water supply.

The various systems of conjunctive use may include the following:

(i)	Augmentation of canal water supplies by pumping ground water through deep tubewells along the canal system as has been done in Punjab and Haryana.
(ii)	Direct application of ground water in rotation with canal water through deep or shallow tubewells.
(iii)	Mixing of saline water pumping through tubewells along the water course/distributories.
(iv)	Reuse of drainage waters which may be good or of poor quality in rotation with surface water.
(v)	Storage of rain-water in farm ponds, big depressions and lakes and its use in conjunction with canal or ground water.
(vi)	Artificial recharge of ground water from supplies, run-off and subsequent use with surface water.

(from Khepar, 1990)

By example, private tubewells for irrigation have since proliferated rapidly, from 6,000 in 1961 to 190,000 in 1985 (Johnson 1989). Similarly, in China, conjunctive use was introduced as one of several rehabilitation measures to address waterlogging and salinity, high siltation rates in irrigation and drainage systems, and to provide a supplementary supply in drought years.

Chadha (in AIT, 1990) describes a typical transition from surface water to conjunctive use in Punjab, India. High irrigation demand has caused problems of inadequate surface water supply, waterlogging due to poor drainage (impeding clay layers), and widespread tubewell proliferation has led to the depletion of near surface aquifers. Augmentation tubewells are recommended which draw water from deeper aquifers (>60 m) to relieve stress on shallow aquifers, and provide higher quality drinking water near cities.

Poor quality surface water (high silt load) may be mixed with higher quality groundwater to provide a satisfactory overall quality, for example in China (Lou Puli, 1988). Alternatively in Egypt, mineral rich groundwater may be blended with better quality surface water (Scott, 1984). This may involve tubewells discharging directly into the surface water canal network, they may be placed adjacent to canals to recycle silty canal water, or tubewells may have their own distribution canal network consisting of temporary bunds managed and maintained by individual farmers.

Khepar goes on to note that choice of management is 'location specific', and then to look at research options in terms of better information on resource behave, and options in the use of models both for portraying the behaviour of resource and for the subsequent allocation of resources. Such an approach, where both institutions and water users are invisible, is a not uncommon approach to studies of the technical options to improve conjunctive water use. However, this framework is not that helpful for examining a policy framework for promoting improved conjunctive use, for a variety of reasons.

There are in fact, some important management distinctions which do enable comparison across very different kinds of technical options and which need to be understood for effective decision-making. The operational structure of the management institutions may indeed be very different in particular locations, but their form may not be. We can use an institutional analysis across the different technologies to see the functions of various institutions involved:

- Their existing and potential form (e.g. whether they are local, public, based in operations, based in collaboration with economic incentives etc). A fuller overview of institutional needs is given at the start of Section 6;

- How they should link together, to obtain both the 'joint use' needed for the particular exercise, and also to promote more optimal water allocation;

- Necessary development in procedures (changes, new developments);

Institutional analysis also tells us something about decision-making processes, especially whether groups of the *same level* of power are involved in the decision process, or whether organisations are in a *hierarchical* set of relationships (Schultz, 1989).

Secondly, such an approach fails to look at the different operational causes to existing problems in resource availability, both in terms of their nature and the institution with responsibility. This avoids analysis of some of the key current institutional issues creating uncertainty in the resource management environment. For example, simply providing new groundwater technology does make the technology adoptable, since the ongoing uncertainty of provision of surface water continues to influence both the hydrological environment and the risks to investment.

We can also see how limitations have emerged in both technical studies and organisation studies as a result of weak institutional analysis in many existing studies.

Where problems have emerged with waterlogging and salinity, there is often reasonable technical collaboration between research on groundwater and surface water management, for practical political reasons. On schemes where interest has developed in the shortfall of surface water supplies, information on groundwater is sadly lacking. Sometimes this may be a result of the bias of surface water irrigation bureaucracies, but it can also stem from other institutional problems. For example, much groundwater information in the state sector tends to come from wells dug for rural development reasons, which are often outside 'privileged' irrigation commands. Information in the private sector is difficult to coordinate. Many small tank schemes have never really been integrated into data collection systems of surface or groundwater bureaucracies. Hence available data is not coordinated, and it is difficult to organise new data sources.

As a result of institutional uncertainties (especially on the remit of state groundwater institutions), much research on operational constraints on water availability has been led largely by social scientists. They can tend to make assumptions on the 'automatic' availability of groundwater in irrigation schemes, whereas actually groundwater may be in limited supply, of poor quality, and expensive to develop because of depth to water table. This tends to happen particularly in smaller schemes in broken topography where aquifers are poor. Social scientists frequently (and rightly) call for better groundwater information, but we do not get any systematic review of the complexities faced in making this happen. This not just bureaucratic competition - surface and groundwater bureaucracies often understand the problems - but they are not trained or equipped to take on additional work. Difficulties may include the limited manpower and equipment of many groundwater institutions: headquarters of different bureaucracies may be far apart; also there may be no formal structure to bring surface water, groundwater and rural development staff together for discussion.

4. EQUITY ISSUES AND SUPPORT NEEDS IN JOINT USE

A lot of research work looks at the prospects of groundwater to reduce inequities of water distribution, and increase cropping intensities and crop yields to increase incomes in irrigation commands. The introduction of groundwater irrigation promises to smooth out peaks in demand and troughs in supply associated with canal irrigation (Chancellor-Weale, 1989). Dhawan (1988) makes a very strong case for the joint development of groundwater in surface commands.

Within the debate on conjunctive use within irrigation schemes, most attention has focused on the development of groundwater in areas irrigated by surface canals. Research covers both schemes where surface water is managed by state agencies, as well as smaller schemes organised through indigenous institutions.

However, conjunctive use does not always bring benefits and can be problematic. It is likely to disrupt surface water management practices or at least require its reorganisation. This might include changes in the timing and duration of canal releases and changes in crops and cropping patterns.

In the process, the role of canal management may diminish relative to well irrigation.

Venkata Reddy (1988) describes the Gokak canal irrigation system, which irrigates 6,450 ha in northern Karnataka, where shallow wells have been introduced in response to an inadequate canal supply. Opportunities for 'joint use' of resources has encouraged farmers to develop into production of water crops like sugar cane and rice. The main constraints to adoption included brackish groundwater aquifers, hardrock strata, lack of technical advice on tapping aquifers, poor electricity supplies, and irrigation department restrictions. Smaller farmers were especially constrained by lack of capital, and land holdings too small to make economic use of a single well. However, informal agreements between those with and those without wells and special credit arrangements ensures some access to groundwater for most farmers, and some have more than one well to expand irrigated area. Community tubewells are expected to address financial constraints faced by smallholders, and the overflow of wells during canal operation periods. However, Venkata Reddy warns that gains are likely to be undermined if soil fertility is allowed to decline due to more intensive cultivation and lack of integration between canal and dug-well irrigation.

Inequalities in supply between topenders and tailenders are familiar, but they can continue to exist even with conjunctive use developments. This applies to both canal and groundwater irrigation. Conjunctive use promises farmers equity benefits by providing an individual and more flexible supply. But both canal and well irrigation may benefit larger farmers more than smaller farmers who cannot afford to participate. This has been shown for large and small schemes. Wealthier farmers and landowners, who have access to capital and other resources, benefit more from new technology than less advantaged farmers. Smallholders, who may be shareholders or tenants, often lack the capital or credit required to buy a tubewell and are forced to borrow from informal moneylenders at higher rates of interest. Larger farmers can control the supply and inflate prices ('rentseeking'), or manipulate deliveries by persuading gatemen to extend the duration of canal supplies (Vaidyanathan and Janakarajan, 1989). Alternatively, water markets can be a very effective means of water supply (Shah, 1991).

Shah (1991) hypothesises about the role of water markets in overcoming local problems in joint use, and shows a variety of areas of uncertainty destabilising the organisation of water markets, and thus any kind of communal interactions which might begin to crystallise new local management structures for joint water use. These include charges for electricity, uncertainty about the release of surface water on a general basis, rehabilitiation initiatives which suddenly change water availability, and lack of access to drainage water at effective prices to encourage the environmentally desirable use of these waters.

There is little doubt that field research has demonstrated many equity and production issues in irrigation schemes. Many good recommendations have been made relative to particular schemes, although they often cannot be generalised. These include recommendations on the surface conveyance and drainage system, as well as groundwater. Important concerns have been a decrease in charges made if farmers wish to pump drainage water, or wish to use canals for water pumped from other sources. However, these recommendations often do not get used.

One important reason for this is a failure to recognise who the decision-makers are on particular topics, and the kind of information they can interpret and respond to. Because most researchers are currently working in a 'local water management' paradigm, they usually direct both recommendations and criticisms at water management agencies. Apart from the low likelihood of organisation accepting both criticisms and recommendations, the irrigation department at which comments are directed may not have responsibilities in the areas for which they are criticised, or there may be very, very cumbersome procedures for change which currently remain unseen by researchers anxious for change. Table 2 shows a diagram by Schultz (1989), to demonstrate this issue of different capacities of action by different organisations.

The introduction of well irrigation and drainage requires farmers and managers to adapt management procedures and technical skills to accommodate the new technology. The success of conjunctive use is likely to depend on there being production and income gains for most farmers, guaranteed access to either, or both, resources at the right time, and positive equity benefits. However, should we be looking at water management bodies to coordinate these initiatives? The answer is no. Poor water management is not what is causing the problems reported by research on equity production problems (indeed, local water groups may be functioning fairly well). It is technical innovation that is challenging water management, so we have to look at dimensions of technology policy before we can understand new water management options.

TABLE 1: HIERARCHICAL DECISION STRUCTURE IN WATER MANAGEMENT, NW GERMANY

	Decision Level		Level of water management expertise	Decision Power		Sample projects	Author's client
				engineering	political		
1	State Ministry		high	medium	high	Rise of Ennepe Dam	Ennepe Water Authority
2	District Administration		medium	low	low	Dhünn Drinking Water Reservoir	Wupper River Authority
3	Regional State Water Authority		high	low high	zero	Wupper Reservoir; Jubach Dam	Wupper River Authority
4	River Authority	strong	very high	high --	low	Wupper Reservoir; Emscher Flood Retention Reservoirs	Emscher Water Authority
	(public and private members)	weak	low	-- low	zero	Jubach Dam	Water Supply Agency Lüdenscheid

In studying groundwater options in extending water availability, researchers are tending to see well development as a local water management issue. In fact, well development cannot easily be incorporated into local management, because it is not a locally developed technology.

We know that access to many resources is determined by the role individuals have played in mobilising that technology. Since it is primarily through tax incentives, subsidies and price controls that many farmers have taken up well irrigation on an individual basis, we should not be surprised if we have to turn to these management nethods to look for help with resource management issues, and should not expect water management institutions automatically to play a primary lead in such areas. As Sexton (1991) points out, institutions associated with pump technology were organised to promote technology for agricultural water supply, rather than control it. Also, no collaboration is actually needed to *operate* the technology.

Where conjunctive use has been involved in the reduction of waterlogging, and in the mixing of water quality, and in the provision of public tubewells, we do find public institutions operating to coordinate at least joint use of water resources in the conveyance system. Where institutional studies are weak or non-existent is in the management of individual groundwater supplies. This, of course, is a more general problem in groundwater development.

We should not be surprised at this, since there has been little discussion of communal organisations for groundwater maangement, since, by and large, donors and state governments have become resistant to further extensive development of public tubewells, and tend to favour private developments. They have also been resistant to development of new bureaucracies for groundwater management. We should not be surprised if 'local water management' cannot coordinate all the new institutional needs associated with technical innovation. We certainly needs to draw heavily on other areas of research if we are to find effective institutions for joint management.

For example, let us take the case of individual well development in irrigation commands where canal water is inadequate to serve a local command. In India, many authors have promoted well development for production and equity reasons and looked at the potential of water markets to help local water management problems. Water bureaucracies have been criticised for not helping more to promote this evolution. However, in India, there are few forums to link the rural development agencies involved with credit, research linked to promoting innovation and adaptation of new technologies, or agricultural support services, with the larger water bureaucracies. These organisations have there own tensions and financial restrictions in helping ares seen to be more privileged. Despite many capable and concerned administrators, they have not been trained to understand each others work, and may not be able to assimilate the complex documentation provided for the discussion of certain problems.

If we keep trying to force rural development changes through public water management agencies, then we will remain with institutions where engineering 'decision power' is strong, social science understanding is weak (despite many motivated engineers), and political powers are low. Trying to make engineers more 'interdisciplinary' may increase understanding, but it will not necessarily make research better or improve decision-making.

Clearly there is a strong need for more studies of how institutions control research and decision-making to influence policy making. Past studies may tell us a lot, but we also have to recognise the challenges of the 1990s. The problem is not only the difficulties of getting political leaders convinced by certain ideas. The problem is also the current poverty and confusion of theory about inducing rural change, that results in national governments and donors with unclear and conflicting objectives. As funds decrease for bureaucracies, as centralised planning becomes weaker, and as state officials change posts rapidly, we need to study the new options for local and state structures that can encompass the findings of existing research paradigms in water management and technical innovation, and also answer the organisational challenges of the 1990s.

5. TECHNOLOGICAL INNOVATION IN THE USE OF WELLS

When we start to look at conjunctive use in terms of production and equity impacts, we are actually dealing with dimensions of rural development and technology policy. This requires a whole gamut of institutions quite different from water management institutions. Groundwater development was studied as an issue of technological innovation in the 1970s (Clay, 1974, 1980, 1982), independently of connections with large public surface irrigation schemes.

Such research showed a broader regional concern of 'conjunctive use', where the dissemination of groundwater technology has changed farming systems which were earlier based on heavy rainfall and flood recession. Here dissemination of groundwater technology has fitted well with technology preferences of donor and state organisations, especially where these can be encouraged as private sector developments. Groundwater development has expanded spectacularly in many wetland areas previously cultivated without extensive conveyance and drainage structures, or where wetlands were used for communal grazing activities.

The rapid development of tubewell technology across eastern India and Bangladesh, under waves of different types of pump technology, has been well-discussed. However, groundwater technology is making rapid headway in the river valleys (*fadamas*) and deltas (Woodhouse and Ndiaye, 1991) of West Africa, and for irrigation of the small gardens developed in the seasonally-wet depressions (*dambos*) of East Africa. In Africa, concern at the erosion of traditional uses of wetland is mixed with recognition of the benefit that do accrue to farmers who obtain the pump technology. These areas raise rather different policy challenges, since not only may institutions for surface and groundwater management be diffuse, but land rights may be rather different to water rights.

Tenure complications are, of course, an ongoing problem in irrigation schemes, especially as groundwater gets developed. As Geert Diemer points out (Diemer, 1991), many technical staff are unable to contemplate allocation principles for water as social contracts, and only a few realise that common engineering allocation principles are context-bound and specific. Their training generally anticipates situations where a single institution owns the infrastructure. Such expectations can be equated with current concern to make local water users associations 'stretch' to include all kinds of functions, which they can rarely do. There is a similar logic in O'Mara's arguments (1984) for 'source symmetry' in conjunctive use, with rights similar in surface water and groundwater (and by extension, probably individual and codified).

One important lesson of the early work on tubewell technology was the 'misfit' between the technology introduced and that actually required. It took a great deal of farmers innovation to improve the 'fit', and this involved cooperative ventures from various individuals and agencies in credit, production and equipment development, as well as water management. As we look over the history of technological innovations introduced in irrigation, from canal irrigation to artificial recharge to vertical drainage, we see an ongoing problem of technology that doesn't 'fit' first time, with action required by a variety of institutions to ensure that costs and availability of resources match farmers requirements. The current vogue for formation of water users associations has shown that many technical assistance teams recognise that institutions are required to make their technology useful. However, as the papers in this set by Casey and Jackson show, extensive dialogue with farmers to encourage innovation, and strengthening of a wide range of support services, has been essential. If we return to the documentation on tubewell expansion in Eastern India and Bangladesh, we find a variety of type of cooperatives (production, labour) involved in the adaptation and take-up of new technologies, not only water associations.

Technological change requires adaptation by farmers, operators and managers. Farmers and irrigation staff, familiar with operating canal sluices and gates, may have to adapt to use and maintain engines and pumps which require different skills to canal irrigation. Though an individual supply promises greater reliability, breakdowns and fuel and spare part shortages can interrupt production. Where farmers do not own the tubewell but depend on others for supply, this problem is exacerbated because operators have less incentive to make urgent repairs or carry the necessary stocks of fuel and spare parts. Farmers may face different suppliers for canal and groundwater supply which may cause confusion, with excessive supply in some areas, shortages in others. There may also be a differential reliability across the year causing acute problems in times of high demand. Joint management of two sources is more complex, and in the future the role of microcomputers will probably increase for scheduling and management, at least on larger schemes, and may demand managers be familiar with this technology.

In many places the high cost of groundwater supply, even at reduced heads, may discourage tubewell use. In the Philippines pumping costs may be five to ten times more costly than canal water and farmers will only use groundwater as an insurance against the surface water supply (Weller, 1990). Fluctuations in energy supply, and in electricity tariffs, may make investments in tubewells risky.

At farm level, tubewells have lower capital costs but higher running costs than canal water (Chancellor-Weale, 1989). However, canal schemes are usually publicly owned, capital costs of canal construction (and sometimes running costs) are met by government or donors, and canal water is therefore subsidised. Tubewells are usually privately owned and farmers face full capital and recurring costs as well as depreciation and replacement. This disparity can make supplementary tubewell irrigation an expensive option compared with other rehabilitation measures. Palanisami and Flinn's (1988) benefit-cost analysis of various options of tank improvement, demonstrated that management improvements were much more cost effective than additional wells (or canal lining). Additional wells yielded a B/C ratio of 1.3 and an IRR of 35 at a discount rate of 12.5%. The equivalent values from improved sluice management were 10 and 2204.

Farmers who own wells, therefore, need consistently higher incomes to justify their investment and stable prices for inputs and outputs (Chancellor-Weale, 1989). The major source of variation in annual costs is the fluctuating demand for groundwater which is largely dependent on the reliability of surface supply. Farmers who purchase groundwater face higher prices in drought years. Irrigators are also effected by the supply and price fluctuations for fuel and spare parts.

Changes in national prices caused by an increase in supply or increase in demand for inputs and outputs may have serious consequences for producers. Chancellor-Weale (1989) cites the case of Bangladesh where changes in both input and product prices have reduced returns to a level where recurrent costs can no longer be met. In the longer term these effects may change the investment decisions of farmers and agencies towards different cropping and irrigation systems.

More generally prices are effected by access and ownership. Wealthier farmers may own their own tubewells, others purchase water from an owner or operator. If water is purchased, farmers face prices set by operators and owners. Where competition between suppliers is limited, farmers may face monopoly prices. In addition the cost of a tubewell unit and its associated structures (pumphouse, canals, gates) is commonly beyond the means of individual farmers and requires collective or cooperative ownership and management. This dualistic system means price incentives may induce farmers to use one or other resource which does not fit with rational regional planning priorities.

6. STUDIES OF INSTITUTIONS FOR PROMOTING CONJUNCTIVE WATER USE

The last three sections suggest a diverse range of circumstances and institutions on which to arrange an analytical framework. However, they all share particular institutional needs:

- identification of decision-makers and information needs;
- formulation of objectives;
- generation of social, economic and political information needs;
- generation and preservation of technical knowledge to inform decisions;
- daily operational management procedures;
- construction/manufacture/installation of new technology;
- definition of access rights;
- resource management procedures;
- means to enforce procedures;
- means for dispute resolution;
- support to adopt new technologies;
- support to adapt new management procedures, new enforcement procedures and new means for dispute resolution;
- forums of discussion and policy evolution.

This list could be developed further, but it stresses the need for a study of the institution problems we must tackle to achieve conjunctive use. One problem is that work in conjunctive use has stayed almost entirely in studies of topics 4-6 above, and as we show later, much of the 'knowledge' generated by research studies and modelling has been very partial. The bulk of existing research in conjunctive use has worked either with *developing technologies* or studying *commodity transactions* within existing institutional arrangements. We have not looked enough at *institutional transactions* to change the rules, whether directed by organisations or induced by economic forces (Ashford and Biggs, 1991; Bromley, 1989). The limited research available on institutional issues in joint water use nevertheless shows up the diversity of issues to be considered, and the breadth of institutions involved.

Vaidyanathan and Janakarajan (1989) compare the effects of conjunctive use developments on operation and maintenance in two tank systems in Tamil Nadu. The Palar Anicut System (PAS) in N Arcot district serves 33,000 ha through 317 tanks. It is government-managed down to tank level, and locally managed thereafter. The Parambikulam Aliyar Project (PAP), in Coimbatore and Periyar districts, serves 73,000 ha, over a generally drier area (therefore comparatively higher returns to irrigation), and is government managed at all levels. Conjunctive use has contributed to increases in irrigated area, cropping intensities and (hence) yields in both areas. Although levels of local and government involvement in management are different, they note that the physical characteristics of the system were found to be more significant than institutional forms on productivity. In PAP, the expansion in groundwater supply resulted in large increase in irrigated area, and canal water had to be spread more thinly. The frequency of water releases into the tank system has been decreased to once every 18 months, and continuous supply has been replaced with an alternating week-on, week-off supply. Overall groundwater irrigation was encouraged by relaxing restrictions on well sinking. However, attention to distribution of surface water and maintenance of canals has declined with the development of groundwater.

Three examples of national conjunctive use policies are compared by O'Mara (1988). California has adopted a heterogeneous path which includes a system of riparian rights, water user associations (WUA), water agencies, water districts and consultants. The state offers a guaranteed supply and controls are through pumping taxes and adjudication. Water management includes artificial recharge and barriers to saline intrusion.

In Pakistan a system has evolved through SCARP I and II comprising quasi-legal allocation principles of historical water rights and distributive justice. These are considered to fare better than institutional solutions (fungible legal rights, efficiency taxes, subsidies, central and local control) which have had limited success in Pakistan, or efficiency guidelines. Success will depend on improvements in monitoring, administration, farmer participation, pricing and fee collection procedures.

In the North China Plain, surface water irrigation was relatively well developed until superseded in importance by groundwater in the 1960s and 1970s. Organisation is hierarchal under the commune-brigade-family system. Conjunctive use has improved efficiencies in the lower reaches, where surface water is used to irrigate land close to the canals and groundwater to irrigate land which is further away. However, there are problems of falling water tables and land subsidence, deterioration of well capacity, and inefficient use of water and energy. Water is spread too thinly and the supply is often inadequate. Institutional problems include divisiveness, poor legal provision to settle disputes, emphasis on construction over operation and maintenance, the lack of adequately trained and adequately motivated personnel, inadequate secondary and tertiary canal development and coordination, unauthorised offtakes, and topender/tailender inequity. The Chinese response relies more on quasi-legal allocations than institutional reforms although leadership is committed to these where they will bring significant gains.

O'Mara concludes that most legal-allocative and efficiency criteria are satisfied in all three cases except for source symmetry (the equal treatment of surface and groundwater) in Pakistan and California. However none are considered to have satisfactory institutions (defined as 'efficient and workable') to implement effective controls over resource use. California favours local controls and a pumping tax, China prefers local administration and the ease of administering taxes or quotas through the commune system, though pumping taxes (or quotas) would seem to be a likely ultimate choice. Pakistan has rejected centralised control and is facing a dilemma between a tax/subsidy policy or a legal rights scheme. O'Mara considers neither is feasible until some form of water user association (WUA) is in place.

O'Mara's choice of the term 'water user association' is unfortunate, because the kind of local institutions required in situations of joint use are very different from the 'water users associations' that are really local groups for the distributions of water. Under joint use, individuals have no real incentives to collaborate for operational reasons. They may, however, need to cooperate for resource management purposes (to stop others using their water), or as a more general body to make representations to government to protect resources, or to deal with taxation and marketing needs delegated to them by governments. In short, they may need to become a broad-based farmers' association, or that unfashionable thing - a cooperative. In their study of irrigation in the Senegal delta, Woodhouse and Ndiaye (1991) show surface and groundwater being coordinated within village institutions whose structure was determined by local needs over a wide range of agriculture-related activities in marketing, credit and supply of inputs. Village institutions survived also because of indigenous land tenure arrangements. Ironically the growing 'privatisation' of land being encouraged by state irrigation policies may actually be threatening the strength of many indigenous institutions.

Lemoine and Gosch (1985) speculated that in California, the magnitude of benefits of reorganisation and collective action would be insufficient to induce farmers to pay the necessary transaction costs. Clearly, if we want strong local groups that can make operational *and* resource management decisions, we are going to have to encourage their development. The research paradigm that supports the development of 'water users associations' will not be adequate, and looking purely at options in terms of FMIS will not be helpful. We must consider a wider range of functions for a water group, and the nature of its relationships with many dimensions of the agricultural sector, and the state. We need to use the large body of research on the influence of technology policy and findings on links between the wider institutional framework and innovation, technology adoption, and technology adaptation. It is not only local traditions in water management that help in innovation and adoption of new technologies. It is also the existence of other productive reasons to collaborate, and economic factors like the operational costs of the technology, security in return to investment in that technology, and profitability of goods produced, many other reasons.

We have similar dilemmas when we look at options in regional level development of conjunctive water use. Surface water and groundwater are often governed by separate authorities. Rivalries and poor coordination may result. Carruthers and Stoner (1981) cite the extreme example of Bolivia where two authorities put up schemes, one surface water and one groundwater, to irrigate the same piece of land. Further, surface water may be government owned and managed while wells may be privately owned. Hence regional authorities may have better control over surface water management and pricing than over groundwater, and policy may be ineffective. There are special implications for conjunctive use which demands the integration of surface water and groundwater management systems under one planning authority or user group.

In Pakistan the integration of regional planning and irrigation activities has been relatively successful. This has been attributed to WAPDA's institutional strength, an established tradition of hierarchal management, and the good technical and organisational skills of managers and engineers. However, the model is elsewhere criticised for its high requirements in manpower, technology and institutional cohesion. The system relies heavily on good data collection, the use of computers for data handling, and planning models, and a complex management system comprising department officials at every level. The system would be of more limited use where capital and human resources are scarce and institutions less developed.

The introduction of groundwater irrigation may disrupt established access entitlements to land, water an other resources, causing conflict and threatening its sustainability. Joint use may require the redefinition of the responsibilities and jurisdiction of social institutions to ensure access to either or both surface water and groundwater for participating farmers. Legislation relies on a relatively strong centralised authority, usually the state, and institutional cohesion. Where these institutions are weaker and informal rural politics are more significant, government policy is less effective. Where the state is very large and government has limited resources (e.g. China), there may be a tradition of village autonomy in resource management.

Riparian rights may entitle farmers to their full irrigation requirements from a river and restrictions on offtakes, or the introduction of charges, may meet with resistance. In canal schemes the frequency and duration of canal turns are usually determined according to the size of individual holdings or blicks, and much less commonly by volumetric consumption. A private tubewell owner, on the other hand, may be entitled to all he can pump in spite of the fact that this reduces the stock of the resource, and access to it for other users. Further, a well-owner who can pump unlimited groundwater is less likely to use canal supplies and the canal system may fall into disrepair. Complex legal questions also arise over river basins and aquifer units that are wider than regional and national boundaries (Barberis, 1986).

If we look at options for conjunctive use at the regional level, we will also need to look beyond simple components of institutional reform, and look for incentives and disincentives to impinge on production and resource use decisions by farmers. Systematising land and water rights to fit a centrally decided set of legal controls is not possible in many countries, nor can it be enforced (as previous examples show, these could actually be counterproductive to local cooperation). As the state bureaucracies become weaker as a result of financial constraints and changing government and donor policies, we face real challenges in understanding how both legal, economic and social incentive can emerge for conjunctive use of resources.

Centralised planning and the scope of public intervention are also changing. We must consider not only how this affects bureaucratic collaboration for policy formulation at the centre. We must also be concerned at how this may atomise the interaction of local agencies implementing these policies (in rural development, agricultural support, and water management), especially if we really want to achieve conjunctive (optimal) water use as well as joint use.

7. THE HYDROLOGY OF CONJUNCTIVE WATER USE

This section summarises some hydrological features and issues in the use of conjunctive water in its original concept - to maximise available water in technical water resources planning. Here conjunctive water use is a term used to describe the use of surface and groundwater in such a way as to increase the proportions used of both resources, to make maximum use of available water resources, and minimise any losses from either resource. The term has its roots in the concern over growing inadequacies of water supplies in Western countries in the 1960s, and it is important to note that initial ideas grew up in countries with temperate and fairly well-defined seasonal climates, and also relatively small catchments. In many of the Western countries at the time, the institutional configuration for water extraction also made this model administratively straightforward to consider. It liberated more water within a technical system under unified management. Today, with concern about finite reserves, we are looking at much more complex alterations between users and between managers.

Typically, groundwater is pumped to draw down water tables so that more surface water infiltrates. More water infiltrates from high flows and floods, which might otherwise have been lost to sea. This recharge can be natural or encouraged through artificial recharge. Groundwater extraction would predominate before, and across part of the season associated high river flows, but care is needed at other times, both in surface and groundwater abstraction, to ensure that minimum baseflow in rivers is preserved. Groundwater recharge consists of directly infiltrating rainwater and seepage from rivers, canals and reservoirs which are 'hydraulically connected' with underlying aquifers (i.e. there is little impermeable material between the riverbed and the aquifer). When groundwater is high, it may contribute to the baseflow of the same streams and rivers.

Conjunctive water use in irrigation often extends to mobilising good qualities of water as well as good quantities of water, as well as gaining benefits in drawing down water tables which otherwise acerbate waterlogging and salinisation. Table 1 showed the typical range of operational circumstances for conjunctive use in irrigation, and the types of technology which will have to be adopted and adapted in each area. On an irrigation schemes the natural elements of recharge and drainage combine with seepage from irrigation practices. This includes seepage from the irrigated area, and from the base of associated distribution and drainage canals, and reservoirs. This provides 'artificial recharge' to groundwater in the dry season and produces a localised rise in the groundwater table. Under conjunctive use, water 'lost' from canals and irrigated fields can be re-used by pumping it from the aquifer and combining it with surface water for high overall efficiencies (Rushton in Gorelick, 1986). Again, pumping can draw down water levels artificially, so that surplus surface and rainfall are encouraged to replenish the aquifer. Alternatively, low quality canal water can be 'recycled' by pumping purer water from aquifers adjacent to canals (Huang quoted in O'Mara, 1988).

The re-use of canal seepage by pumping a near surface aquifer offers the twin advantage of lowering the water table and reducing groundwater pumping costs. This reduces the need for improved hydraulic efficiencies by canal lining, or piped irrigation. Tubewells provide a supplementary source of irrigation water and the means for irrigation authorities to control waterlogging and salinity.

Conjunctive water use is not always seen as an automatic priority when we look at other objectives. For example, it might be argued that a near surface water table is not good practice for irrigation if environmental problems are to be avoided (Rydzewski, pers comm). Energy might be better spent in improving horizontal drainage systems and reducing the seepage from canals by lining. Further, controlling withdrawals requires good monitoring and institutional cohesion which is often lacking in less developed countries.

Despite a simple theory, the practical difficulties of developing optimal conjunctive use are significant. We have already discussed some of the institutional complexities. Hydrological complexities include difficulties in quantifying the volume and timing of available flows of surface and groundwater. In many areas of the world, even under irrigation schemes, prevailing rock types hold limited water, and the degree of 'hydraulic connection' between surface supplies and recharge from surface water is weak and unpredictable. In Appendix 1, we summarise some of the typical elements studies in hydrological models for conjunctive water use, and the difficulties admitted by experts in the field. Estimation of seepage, and derivation and use of key parameters of groundwater movement have been particular problems. Sadly too, much groundwater theory has developed to answer questions on regional water availability, and on responses to heavy-duty or large capacity tubewells of the kind found in large-scale public water supply systems in industrialised countries. We still have very limited theory to show how large-diameter dug wells behave, or predict how water levels in wells change over time.

Clearly, the hydrological concept of conjunctive use is applicable at both a small and large-scale, including developments at local and regional level. As water resource become more heavily utilised, administrators are increasingly looking at ways to maximise resources. However, when we move to more complex river basins in more extreme climatic circumstances, especially if they are intensively farmed, practical hydrology becomes more difficult (apart from the questions of institutional collaboration). In areas where the time of rise and duration of high river flows is unpredictable, it is not easy to draw down water tables in advance. What happens if water levels fall and the surface flow does not arrive? Who will pay the increased pumping costs of such a policy or, compensate farmers without water? Perhaps flood flows should be stored and recharge encouraged, so flows are not lost to the sea. However, where can the ponds for artificial recharge on a large scale be sited? Who will fund the high costs of artificial recharge, especially in areas where the links to actual recharge are weak or poorly understood? In areas with hard metamorphic rock, the depth of weathered rock, and thus of water storage potential is limited. Storage in such geology may be replenished by one rainstorm. How can it be systematically draw down so that more surface flow infiltrates rather than runs off?

These are some of the technical issues which have created complex problems for the promotion of conjunctive use at regional level, especially where the objective of optimal use of available water is not the key priority. A fuller technical discussion is given in Appendix 1.

8. MATHEMATICAL MODELLING IN CONJUNCTIVE USE

Models have a chequered reputation in the field of conjunctive use, with both supporters and detractors. As noted, we find very few published studies evaluating the utility of models constructed to study conjunctive water use. However, we have a very interesting set of views from some people involved in the construction of models. Some model builder do criticise the art, noting its tendency to be divorced from reality, and to prefer complex techniques to simple one (Biggs, 1984; Schultz, 1989). Schultz (1989) discusses the 'ivory tower' people who assume that planners preferences can, and should, be directly dictated in terms of parameter values for a model, or who expect decision-makers to be able to work with mathematical information cited directly from the model. He also points out that modellers often naively assume that the decision-maker is a person, able to accept a single optimal solution. However, decision-makers are often complex systems of people, and can rarely accept a single optimum solution. Thus a dialogue is never created, and decision-makers remain as 'ghosts'. In reverse, model-builders are disappointed to find that no-one uses the model.

Wunderlich (1989) reminds us that there is no unbiased approach to an uncertain future, and thus assumptions much be made clear to decision-makers, or every attempt must be made to study their biases. This of course, also requires discussion. Stephenson (1989) also reminds us of the actual bias within modelling. Established donors, planners and engineers all have preferences in techniques. It is very important in model building to have *end-result* contracts rather than *method-related* contracts.

We find many environmental models aimed at portraying the hydrologic interactions between surface and groundwater. These combine a water management model and an optimising decision making model. The former simulates surface and groundwater flows and offers the user a range of water management options. The optimisation model compares various combinations of surface and groundwater, and selects an optimum combination based on hydrologic, economic or allocation criteria, for example minimum conveyancing, least cost, water quality or resource conservation. A more rigorous definition and a review of groundwater models is given by Gorelick in O'Mara (1988). Some are summarised Appendix 2.

Models simplify reality dramatically. Simpler groundwater models commonly assume aquifer conditions to be isotropic, homogeneous, and prescribe single values for transmissivity, storage and specific yield. While an alluvial aquifer, or a simple sedimentary aquifer can be modelled relatively easily, it is very difficult to study flows in hardrock aquifers. Field conditions are of course highly variable in space and time. As discussed in Appendix 1 the unpredictability of seepage and drainage causes special problems in conjunctive water use studies in irrigation. In sensitivity analysis, Rogers and Smith (1970) found return flows from drainage an important source of variation in potential outcome in their regional planning model, and one of the most difficult elements to predict.

In addition there are agricultural planning models which simulate the response to changes in policy variables. Many of these models have a specific focus on rural development and poverty alleviation. In their broadest form, such models portray the role (and the impact) of changing irrigation technology in the agricultural sector. They attempt to predict changes in the economic behaviour of farmers to changes in the availability, and relative supply of surface and groundwater and the impact on farm outputs and incomes. This might include changes from one source to another, changes in management of supply, or changes in cropping patterns and intensities.

Although there are a range of agricultural and rural development models that could be used to look at the rural development effects of conjunctive water use (see Biggs 1982), few have actually been used. Stephenson (1989) also provides a study of the inappropriateness of many general economic assumptions in cost-benefit analysis when modelling economic benefits in developing countries.

Most existing models looking at rural development aspects of conjunctive use are large-scale, aggregated over regions. We have many fewer models looking at the schemes level, and we could not find any models looking at the village level. Although such models could have been developed to optimise equity issues, most were actually concerned either with maximising food production, or with looking at efficient cost aspects of water development. Both the levels of aggregation and types of variable uses all tend to make such models rather useless for predicting actual equity effects, except in crude terms of topenders and tailenders. Most of these models combine a fairly crude hydrological model to portray water availability, with a stylised crop production package for a 'representative' farmer. Sometimes they may also include production functions for linking improved yield with better water control. As Biggs (1982) points out, although such models could include many more variables that typify *actual* rural conditions, they rarely do. Elements that could be included were availability of assets, transaction costs, actual labour availability, the variability of crop and employment options for small farmers, sharecroppers and labourers. We did not find any models constructed to examine the differentiation effects of conjunctive water use practices, or the local constraints to adaptation of new technological practices.

Put simply, regional planning models that have been constructed to date have been set up purely to answer macro-questions about the scale and costs of hydrological developments to achieve yield gains. Despite their apparent algebraic complexity, both the hydrological and economic relationships inferred are often very crude, and the data input for parameters very weak. They may have their uses for certain kinds of investment decisions, but great care needs to be taken in good sensitivity analyses to ensure that results portrayed are useful.

Where models are set up with clear and relevant objectives, and use sensible data, they may be valuable to planners, managers and scheme designers. However, modelling is very expensive, and takes up skilled manpower. Coordinators of research should look carefully to see if models can give a good picture of objectives before a great deal of money may be wasted in modelling.

Users should be aware of the nature and significance of simplifying hydrologic and economic assumptions which limit their descriptive capacity. Hydro-geological conditions are very rarely homogeneous but vary widely in space and time. In difficult hardrock environments aquifer hydraulic behaviour may be unpredictable. Single values of parameters like transmissivity, permeability, are unlikely to be very representative and extrapolating from field to regional scale compounds the error.

Simplifying economic assumptions that farmers are independent, price responsive, income maximising and risk averse, and have access to both surface and groundwater supplies, and to each if the other fails, are often false. The assumption of physical interdependence between water resources makes the assumption of independence between farms invalid - there are no free optimising economic agents (O'Mara 1988). In less developed countries where farming is difficult and risky, farmers may forfeit maximum income for reliable income over a stretch of drought years. They are subject to constraints such as whether the supply is operational, and whether they can access that supply. As for hydrological variables, extrapolating the behaviour response of one farm to regional level obscures the differences in endowments and incentives between farmers at field level.

Who will use the model? A policy evaluation model may be used by an agency, a government planning authority, and water and river basin authorities. Conjunctive use scheduling models will be aimed at scheme managers. There is a danger that they will be taken at face value when simplifying assumptions are not explained or understood. Is the model is to be used with caution by well-trained staff able to judge when the model's recommendations should be overridden? Or is the model to be used by semi-skilled staff who use the model uncritically when training and staff development will be required? We know of examples where conjunctive use models were used to identify 'surplus' groundwater and surface water across a river basin. Although the technical studies ran over many months, it was set up purely on hydrological theory and data, with no concern for the users of the information, or practical local development procedures. The results were disseminated to administrators and politicians in a one-day seminar, and from that they were supposed to adapt complex decisions on whether, and how, to change existing procedures for deciding groundwater and surface water developments. Where farmers are more directly involved in management, models may be of even less usefulness. They rather need to understand the nature of the resource and simple budgeting for it's management.

Will the results of a model be available on time? Many models take months to come to fruition, by which time data may no longer be correct, and the entire institutional context for decision-making may have changed. Good modelling depends on good monitoring and information. This depends on a developed system of data collection and analysis which is lacking in many less developed countries. Moreover, models must be calibrated by groundtruthing in the field, and improved over time as new information becomes available.

Some argue that modelling is too rarely applied in the field, especially in less developed countries, and should contribute directly to improved irrigation management (Khepar, 1990). However, of over 700 models described in the UN's Water Resources Journal, only 5% have been used in the field (Biswas, 1990). There is certainly a danger that models will divert resources away from other priorities and preoccupy the research staff of water departments. Nevertheless, simple 'user friendly' models may be useful for conceptualising and studying simple objective in conjunctive use.

However, if we return to our current planning dilemma of conflicting objectives in joint use of water resources, it seems that models constructed to date cannot help us very much. If we return to our list, we have seen models linked to questions of the costs and returns to technical investments, and those looking at rehabilitation. However, we have not seen any that link up questions of rural development and equity with changing water technologies and optimal use of water resources. It is very rare indeed for modellers to interpret their results in terms of management needs, although Lemoine and Gotsch (1985) did try to try some general conclusions (see Appendix 2).

9. CONCLUSIONS: DEVELOPING THE INSTITUTIONAL FRAMEWORK

One way forward to examine the critical issues of forums for better debate, and to cut across conflicting objectives, is to look for complementarity and not to get overwhelmed by complexity and fragmentation. In fact, all these different objectives bring us back to essential questions about *institutions*. Failure to look at existing and potential institutions, and above all how they can link and inform each other, has been an essential limitation in the work on conjunctive water use to date. By clarifying objectives, even where multiple, we can then develop the theoretical model to identify the areas of research needed, the tools to use and the relevance of existing research. With understanding of the outcomes to be achieved, we can then make careful analysis of institutional needs and decision-making processes.

We feel that some of the limitations in research and implementation for conjunctive use have been:

- unclear or partial definition of objectives (e.g. to consider rehabilitation without looking for more optimal use of water);

- failure to examine the full range of institutional issues;

- failure to clarify decision-making processes and needs;

- lack of definition of research methods and information sources to examine objectives;

- poor use of available bodies of research;

- poor evaluation of research methods, so that approaches continue (especially in modelling) which have limited contribution to evolution in water management;

- recommendations from research are being directed to wrong institutions;

- a tendency to expect water management institutions to encompass all technology innovation issues, whereas what is often needed is more liaison between water management institutions, rural development institutions and other support services to promote technology adoption and adaptation.

Without a clear statement of objectives in promoting changes in water management, there can be little real evaluation of outcomes, and the decision-making needs to ensure relevant institutions evolve.

One of the interesting features about the papers by Sawant et al in this set, is a sense of looking to see how the debate can go forward in ways that are politically realistic. The paper demonstrates the point of working with the institutional transactions preferred by those involved, which in their case is the avoidance of *directed* organisational change. From the literature it is clear that donor activity has been important in requesting and supporting forums for discussion, and Sawant et al's paper shows that this has not changed.

When we are looking at the dissemination of new technological initiatives and management needs it is important, too, that we go back to understanding institutions in their fullest sense. One of the difficulties resulting from the focus on local water management over the last 15 years is that we increasingly expect water organisations to handle all aspects on innovation, and undertake research with this focus. We have also become restricted in the type of organisational structures we seek to impose. In fact, in innovation we need to call on a wide range of research and support services that go well beyond water institutions, be they state, communal or individual. Often in looking for changes in the structures of water institutions for better performance, we have lost sight of the issues in *linking* institutions and encouraging dialogue.

In the 1960s the concept of conjunctive use was based in ideas of mobilising more water within the supply sector (although as Schultz [1989] shows, even here there are complex questions of institutional interaction). However, in the 1990s we are looking at needs to link up complex social and economic interests, both among *suppliers* and *users*.

If we are to disseminate new technology, and encourage innovation in water use and water management, we must be informed about the restrictions and potentials of existing management institutions and support services to encourage new developments. If we wish to promote equity and ensure profitable and sustainable production, again we become involved with institutions. If we put institutional reform back at the centre of debate on conjunctive use, then we can use all available bodies of research information, and ensure that we get more integrated reform not only of local water management institutions, but of scheme-level management and institutional developments in agricultural support services and research. In the accompanying paper by Sawant et al, it is interesting that we do not even know the context of the interest in 'conjunctive use', but we do see some interesting development of certain key institutions beginning to acknowledge the issues that are restricting the development of more optimal water use.

This is not just a problem of 'blinkered' research - we must also recognise the refusal of many water institutions to play a role in discussions. Indeed 'institutional reform' has become so linked with the politics of many irrigation bureaucracies, or disagreements between donor recommendations and national needs on water institutions, that we have not only lost sight of the original broad meaning of 'institutions', but many have also lost the will to look at options to reform these institutions. Results of this confusion have included a focus on technological intervention to avoid difficulties in bureaucratic reform and improved information exchange, and the limitation of much social research to tertiary level issues in water management and water markets.

Until existing institutions become prepared to discuss the changes they will countenance in water management and various legal and fiscal arrangements, or to admit the uncertainties they face, social scientists are unable to study the potential impacts of new water provision. Social science investigations will remain confined to tertiary level studies relating to equity issues. For social scientists, improved debate of their work will not be encouraged by simple criticism of bureaucratic behaviour. It will come from looking to strengthen linkages between institutions, and greater debate on the 'art of the possible'.

These are fine words, but of course we need to acknowledge how difficult this is. Furthermore, the extent of state withdrawal from water management which is taking place in many countries makes the ideas of forums of debate and institutional strengthening even more difficult. The growing strength of an environmental focus, in which irrigation has a chequered (and often negative) image, also creates new pressures. The loss of status of many technical agencies now they have fulfilled their supply duties (as shown in Sexton, 1991), adds to uncertainties of effective debate. One important step will be to detach ourselves from dominant research themes, and move on to new activities where we can draw on useful findings from these themes but not be restricted by them.

In Section 6 we tried to show the matrix of the institutional issues that need to be addressed both to achieve 'joint use' as well as the optimal conjunctive water use. Participation of existing institutions in this framework would enable a far more effective socio-economic critique both of necessary institutional changes as well as likely development and equity impacts at the local level. It is likely to be particularly useful if we are looking to make joint water use more optimal in resource availability terms.

It is not for us to say for which objectives should be given priority in programmes affecting water management. These programmes will nearly always be pragmatic, however much we wish otherwise. However, while seeking to promote optimal water use as the key priority, we can nevertheless also improve debate on optimal water use in the context of other objectives. A central requirement in the achievement of objectives is always identification of institutions that will be involved in decision-making, and be involved in their implementation. A technological approach that tries to avoid management reform will simple end up repeating many mistakes, and curtailing resource management options in the future.

BIBLIOGRAPHY

Ashford, T. and Biggs, S D. (1991) Dynamics of Rural and Agricultural Mechanisation: The Role of Different Actors in Technical and Institutional Change, draft paper for the *Development Studies Association Annual Conference*, Swansea 11-13 September 1991.

Asian Institute of Technology (AIT), Proceedings, *International Conference on Groundwater Resources Management*, Bangkok, Thailand, November 1990.

Attia, F A R. (1990) Integrated Management of Groundwater and Surface Water for Land Reclamation in the Nile Valley, in AIT 1990.

Barberis, J A. (1986) International Groundwater Resources Law, FAO Legislative Study No 40.

Bhatti, M A. and Kijne, J W. (1991) Irrigation Allocation Problems at Tertiary Level in Pakistan, *ODI-IIMI Irrigation Management Network Paper* 90/1c, Overseas Development Institute, London.

Biggs, S D. (1982) Agricultural Models and Rural Poverty, in *Agricultural Sector Analysis in Asia*, (eds) Langham, M R. and Retzlaff, R H, Singapore University Press for the Agricultural Development Council, pp 356-383.

Biggs, S D. (1976) A Linear Programming Model of the Kosi Rural Economy for the Planning and Policy Making, The Kosi Symposium, *The Rural Problem in North-East Bihar: Analysis Policy and Planning in the Kosi Area*, (eds) Joy, J L. and Everitt, E, Institute of Development Studies, University of East Sussex, UK.

Biggs, S D. and Burns, C. (1976) Transactions Modes and the Distribution of Farm Output, (eds) Joy, J L. and Everitt, E. *Kosi Symposium*, Institute of Development Studies, University of Sussex, UK.

Biggs, S D. (1974) Lament for Policy-Oriented Research: Observations on a Research Project to Formulate a Computer's Model for Regional Rural Planning in the Kosi Region, Bihar, India, *IDS Bulletin* 5(4): 29-35.

Biswas, A K. (1990) Environmental Modelling for Developing Countries. Tycooly Publishing, London, UK.

Bromley, D W. (1989) Economic Interests and Institutions, Oxford, Blackwell.

Casey, Margaret. (1991) Groundwater Development on Madura, Indonesia: Gender Issues in an Irrigation Project, *ODI Irrigation Management Network Paper 1*, Overseas Development Institute, London.

Chadha, D K. (1990) Planning and Management of Surface and Groundwater Resources in Parts of Upper Bari Doab Area: Punjab-India, in AIT 1990. (op cit).

Chancellor-Weale, F M. (1989) Conjunctive Use as a Component of Rehabilitation, in Wooldridge, R (ed), *Asian Regional Symposium on the Modernisation and Rehabilitation of Irrigation and Drainage Schemes*, ODU, Hydraulics Research.

Chaolunbagen, and Xue Fenghai. (1988) The Model for Conjunctive Use of surface and Groundwater in Yaoba Irrigation District, in Wuhan (1988), op. cit.

Clay, E J. (March 1982) Technical Innovation and Public Policy: Agricultural Development in the Kosi Region, Bihar, India, *Agricultural Administration* 9(3): 189-210.

Clay, E J. (May-June 1980) Dispelling Some Myths About Appropriate Technology, *The Economics of the Bamboo Tubewell*, pp 43-47.

Clay, E J. (January 1974) Planners Preferences and Local Innovation in Tubewell Irrigation Technology in North East India (1), *IDS Discussion Paper* 40, Institute of Development Studies, University of Sussex.

Diemer, G. (1991) Engineers Not Exposed to Training in FMIS. *IIMI FMIS Newsletter* 9, p.13.

Dhawan, B D. (1988) Economic Linkages Among Irrigation Sources: A Study of the Beneficial Role of Canal Seepage, in *Indian Journal of Agricultural Economics*, 43(4).

Gorelick, S M (ed). (1986) Conjunctive Water Use, Proceedings of the *Budapest Symposium,* July 1986, IAHS Publication No 156.

Hossain, A F M. Afzal. et al. (1990), Integrated Use of Surface and Groundwater in Kemubu Project, Kelantan, Malaysia, in Asian Institute of Technology, 1990 (op. cit).

International Association of Scientific Hydrology (IASH) Systems Analysis for Water Resources Management (1989) Systems Analysis for Water Resources Management: Clsong the Gap Between Theory and Practice. Proceedings of the Baltimore Symposium. IASH Publication 180.

Jackson, R. (1991) Development of Water User Associations on the Madura Groundwater Irrigation Project, Indonesia. *ODI Irrigation Management Network Paper 2,* Overseas Development Institute, London.

Javaid, A. and Weatherhead, E K. (1991) Optimising the Alternative Use of Different Quality Waters for Irrigation, Paper accepted for *ECOWARM European Conference on Advances in Water Resources Technology*, March 1991, Athens.

Khepar, S D. (1990) Conjunctive Use of Surface and Groundwater Resources, paper from the *National Symposium on Management of Irrigation Systems*, Karnal, India, 24-27 February 1991, Central Soil Salinity Research Institute, Karnal, pp 195-204.

La Loggia, G. and Mazzola, M R. (1989) Synthetic Performance Indices in a Real Decision Process, p 175-185 in International Association of Scientific Hydrology 1989 (op. cit.).

Lemoine, P H. and Gotsch. (1985) Water Resource Development in the Salinas Valley: Economics and Hydrology in a Closed Control Model, in *Food Research Institute Studies* Vol XIX, No 3.

Liu Zhaoyi, and Ma Wenzheng. (1988) Joint Utilisation of Surface and Groundwater in Irrigation Area, in Wuhan, 1988 (op.cit.).

Lou Puli, and Hou Linxiang. (1987) The Rehabilitation of Irrigation System along the Yellow River, in *Hydraulics Research, Design for Management-Asian Regional Symposium*, Sri Lanka, 1987.

Morel-Seytoux, H J. and Restrepo, J I. (1986) SAMSON: A Model for Conjunctive Operation of Surface and Groundwaters, in Gorelick, 1986 (op.cit).

O'Mara, G T. (ed) (1988) Efficiency in Irrigation, The Conjunctive Use of Surface and Groundwater Resources.

Palanasami, K. (1991) Conjunctive Use of Tank and Well Water in Tank Irrigation Systems, *Future Directions for Indian Irrigation: Research and Policy Issues*, (eds) Meinzen-Dick, R. and Svendsen, M, International Food Policy Research Institute, Washington DC, January 1991, pp 134-145.

Palanasami, K. and Flinn, J C. (1988) Evaluating the Performance of Tank Irrigation Systems, in *Agricultural Systems*, 28.

Paudyal, G N. and Das Gupta, A. (1987) Operation of a Groundwater Reservoir in Conjunction with Surface Water, in *Water Resources Development*, 3(1).

Prasad, T. and Verdhen, A. (1990) Management of Conjunctive Irrigation in Alluvial Regions-Issues and Approaches, in AIT 1990. (op cit).

Pei Yuan Sheng, Management Programme for Conjunctive Use of Surface and Groundwater, in Wuhan 1988 (op. cit).

Rao, N H. (1990) Influence of Surface and Sub-Surface Conditions and Implications for Conjunctive Use, in *Water Resources Development*, 6(1).

Ren Hongzun (1990) Design Issues in Controlling Drought and Waterlogging/Salinity in Farmer-Managed Irrigation Systems on the North China Plain, p 247-254 in Yoder, R. and Thurston, J. (eds) (1990) Design Issues in Farmer Managed Irrigation Systems, IIMI conference, Thailand.

Rogers, P. and Smith, Douglas V. (February 1970) The Integrated Use of Ground and Surface Water in Irrigation Project Planning, *American Journal of Agricultural Economics* 52(1): 13-24.

Sawant, M.M et al (1991) Assessment of Conjunctive Use in Maharashtra Minor Irrigation Systems. *ODI Irrigation Management Network Paper 3*, Overseas Development Institute, London, UK.

Schultz, G A. (1989) Ivory Tower Versus Ghosts? - or - The Interdependency Between Systems Analysts and Real-World Decision Makers in Water Management, p 23-32 in International Association of Scientific Hydrology 1989 (op. cit.).

Scott, V H. and El-Falaky, A A. (1984) Conjunctive Water Use - The State of the Art and Potential for Egypt, *EWUP Project Technical Report* 44.

Shah, T. (1991) Managing Conjunctive Water Use in Canal Commands: Analysis for Mahi Rich Bank Canal, Gujarat, *Future Directions for Indian Irrigation: Research and Policy Issues*, (eds) Meinzen-Dick, R. and Svendsen, M, International Food Policy Research Institute, Washington DC, January 1991, pp 287-304.

Shah, T. (1990) Sustainable Development of Groundwater Resources: Lessons from Two Indian Villages, *ODI-IIMI Irrigation Management Network Paper 90/1b*, Overseas Development Institute, London.

Shah, T. (1988) Managing Conjunctive Water Use in Canal Commands: Lessons from the Analyses of the Mahi Right Bank Canal, Gujarat. *IRMA Research Paper No 3*.

Shyam. R, Chauhan, H S. and Ram. S, (1985) Conjunctive Use of Irrigation Water in Naintal Bhabar (India), in *Journal of Indian Water Resources Society*, Vol 5, July 1985.

Stephenson, D. (1989) Planning Model for Water Resource Development in Developing Countries, p 63- 72 in International Association of Scientific Hydrology 1989 (op. cit.)

Vaidyanathan, A. and Janakarajan, S. (1989) Management of Irrigation and it's Effect on Productivity Under Different Environmental and Technical Conditions, Madras Institute of Development Studies.

Venkata Reddy, M. (1988) Development of Well Irrigation in Canal Commands; The Prospects and Some Emerging Issues, ODI-IIMI Irrigation Management Network Paper 88/2b, Overseas Development Institute, London.

Weller, J A. (1990) Performance of Porac Gumain Rivers Irrigation System (Philippines), *Hydraulics Research Report ODU No 119*.

Woodhouse, P. and Ndiaye, I. (1991) Structural Adjustment and Irrigated Agriculture in Senegal, *ODI Irrigation Management Network Paper (African)* 6, Overseas Development Institute, London.

'Wuhan 1988', Proceedings of International Conference on Irrigation System Evaluation and Water Management, September 1988, Wuhan, China.

Wunderlich, Walter O. (1989) Experiences with Water Management Model Development and Use, p 34-40 International Association of Scientific Hydrology 1989 (op. cit.).

APPENDIX 1:
THE HYDROLOGY OF CONJUNCTIVE WATER USE

The principles of hydrological interaction between surface and groundwater is widely understood. However, it is often difficult to describe the availability of water locally, both in strict environmental terms and in terms of the probabilities of availability of surface and groundwater. Water availability models usually try to deal with both the hydrological parameters that control the movement and quantum of water available, and the actual likely arrival of resources. Hydrologists tend to be interested in the former, whereas farmers are probably more interested in the latter.

Sources of sub-surface flow include drainage through the soil and influent flow from rivers, canals and reservoirs. The rate of recharge depends on the degree of saturation, the permeability (or hydraulic conductivity) of the subsoil between the ground surface and the water table (or phreatic surface), and on the 'leakiness' of the aquifer, i.e. the rate at which percolating water transmits vertically and laterally within the aquifer.

For saturated conditions the rate of percolation through the subsoil is assumed to be the product of its permeability (or hydraulic conductivity) and hydraulic head. For unsaturated conditions permeability also varies with water content. Most irrigation seepage calculations assume fully saturated conditions. Rushton suggests a value for saturated hydraulic conductivity of 5 m/d for sands and 0.001 m/d for clays.

For relatively uniform hydrogeological conditions, for example the alluvial river basins of S.Asia and China, seepage is predominantly vertical (with perhaps 10% moving laterally) and shallow aquifer groundwater is recharged directly each season. Rushton computes a seepage rate of 1.95 mm/d for SCARP. However, for heavy black cotton soils, clay pans and other less permeable strata, seepage rates may be reduced to 0.5 mm/d (ibid). Recharge to deeper aquifers and in hardrock areas may be indirect, infiltrating in one area and transferring underground.

Seepage from fields is generally more significant than that from the canal network because of their greater relative area and because canals may be lined. Seepage losses can be maintained around 2 mm/d by puddling but actual seepage rates may be nearer 20 mm due to evapotranspiration and percolation into unsaturated bunds and adjacent fields (ibid).

Seepage from canals is usually assumed proportional to wetted perimeter and expressed as a seepage per unit length of canal. However, water generally flows vertically to an underlying or permeable layer and horizontally to a distant fixed head boundary, ie another canal or a drain. Hence the rate of seepage depends on the distance to the boundary, the change in head and the permeability of the subsoil and the canal lining. Rao (1990) recorded canal seepage of 0.2-2.1 m^3 per day per meter of canal (m^3/d/m) for cement lined canals spaced 400 m apart in Mahi Right Bank Canal command (MRBC), Gujarat. This compared with 1.1 m^3/d/m using the wetted perimeter relationship.

Aquifer 'leakiness' is estimated as the product of the hydraulic head and the transmissivity (T), so for a uniform alluvial aquifer, a head of 2 m and a transmissivity of 2000 m^2/d, the lateral flow is 4 m^3/d. For a hardrock aquifer where the head remains constant (say 10 m) and T varies from 50 to 70 m^2/d over 1 km, the change in lateral flow is 0.2 m^3/d over an area or 1000 m^2, equivalent to a vertical flow of 0.2 mm/d (Rushton).

Canal lining can reduce canal seepage by up to 25% (Rushton, Palanasami & Flinn, 1988) and is an important component of rehabilitation schemes. The lining material is usually cement (in slabs or interlocking sections), a bituminous membrane or occasionally buried plastic sheeting. In practice linings deteriorate and develop cracks and holes which may have a disproportionate effect on permeability. Rushton estimates that cracks and holes equivalent to 0.4% of wetted perimeter in a 10 cm thick lining may cause losses equal to 75% of those for unlined canals. This suggests canal lining is only successful when the lining is in virtually perfect condition. Further, canal lining may be inappropriate in low and medium rainfall regions where seepage losses from fields and canals may be considered a gain to groundwater, reducing pumping costs and encouraging conjunctive use (Dhawan, 1988).

Seepage rates vary with the change in position of the water table through the irrigation period. Hence Rao (1990) advocates an alternating management system under which aquifers are first pumped to lower the water table to its design value, then the canals are operated to raise it again before the next cycle of pumping, thereby maintaining an acceptable equilibrium recharge rate.

A sustainable conjunctive use system relies on maintaining the groundwater balance over time. In Pakistan and China, widespread tubewell use has been used to lower the water table to reduce salinisation and maximise leaching. It is estimated that 2 m is the minimum depth to water table in uniform deltaic soils to provide adequate leaching and prevent salts entering the rooting zone (Ren Hongzun, 1990).

However, uncontrolled tubewell use may cause problems. High well densities and discharges may cause mining, an increase over time in the mean depth to the water table greater than that which can be sustained by conjunctive management. Consequently shallow tubewells (which lack the capacity to pump from greater depth), wells in higher areas, and those not supplied with canal water, may dry up. Well densities of one well or more per ha are not uncommon in areas of India and Bangladesh (for example, Vaidyanathan and Janakarajan, 1990). In addition, the depth to water table will vary across a well field. The phreatic surface is not flat but is conditioned by the radius of influence (RI) and cone of depression of pumping wells. This depth variation and interference between the RIs of adjacent wells may cause drawdown in excess of the design depth to water table in localised areas. Groundwater pumping near coastal areas may encourage saline intrusion as saline groundwater transfers to occupy that part of the aquifer vacated by pumping. Excessive abstractions may cause deeper aquifers to settle, causing a permanent reduction in the groundwater resource and land subsidence at the surface.

Well spacing may be governed by regulations which specify the minimum distance from canals and maximum permissible discharges. For example, in Tamil Nadu the minimum distance was 400 m from a main canal and 200 m from a distributary before being reduced to 200 m and 100 m respectively to encourage conjunctive use (Vaidyanathan and Janakarajan, 1990). Wells spaced too close to canals or of large capacity may induce seepage. A detailed hydrogeological study of the area is necessary to draw up guidelines for well siting and capacities.

Good management and control is specially important if these externalities are to be recognised and checked in good time. Hydrogeological surveys and long-term monitoring of groundwater levels is necessary to chart the behaviour of groundwater in space and over time, and spacing and discharge controls are necessary to keep well pumping within the designed capacity. However these resources are lacking in many less developed countries.

APPENDIX 2:
CONJUNCTIVE WATER USE MODELS - SOME EXAMPLES

(a) Water Management Models

Water management models allow the user to alter physical variables in one part of the system to simulate the response in another. For example, a reduction in the frequency or duration of canal turns will reduce recharge and be reflected in a change in the level of the water table. The rate of response will be determined by physical parameters for subsoil conditions (e.g. permeability) either contained in the model (endogenous), or variable by the user (exogenous).

Conjunctive use models may include surface and groundwater components. At the surface a water balance divides irrigation water into infiltration, evapotranspiration and evaporation. River and canal flows may be treated deterministically, i.e. reliable in time or, less commonly, probabilistically. Recharge to groundwater may be estimated from fluctuations in groundwater level or related to percolation rates in the unsaturated zone.

Groundwater flows are assumed to conform to equations for Darcian flow in a porous media (e.g. Laplace), and for diffusion and advection (e.g. Bear, Verrujt). The area of interest is divided into discrete subareas of regular (finite difference) or irregular (finite element) shape, and the values of decision variables specified at the boundary by the user. Parameters are estimated for aquifer characteristics (hydraulic conductivity, transmissivity, and co-efficient for storage, diffusion and advection co-efficient). Drawdown from pumping stresses are usually modeled on type curves (Theis/Theim). Physical decision variables include heads, and rates of pumping and recharge rates.

Models simplify reality dramatically. Simpler groundwater models commonly assume aquifer conditions to be isotropic, homogeneous, and prescribe single values for transmissivity, storage and specific yield. Field conditions are of course highly variable in space and time. They therefore must be used with caution and the results of the simulation used critically. We look here at some of the models used for decision-making in the irrigation sector (there is a much larger body of work on water resources management which we did not have time to critique).

Regional water management models may be used to simulate regional flows between surface and groundwater resources and estimate potential storages and releases. For example Hossein et al (in AIT, 1990) developed a model to simulate the integrated use of surface and groundwater in Kumubu Project, Kelantan, Malaysia. The existing water supply was found to meet only 61% of demand in a critical year or month. It was claimed that conjunctive use could solve the problem of water shortages for irrigation, domestic and industrial use in dry periods. A model is used to optimise the combined operation of available and proposed surface and groundwater sources at minimum cost in a partially gauged catchment over a 26 year planning horizon. The following parameters are required to input the conjunctive use model:

(1) Surface water balance; (2) Surface Water Resource (based on low flow analysis); (3) Water Rights (assumes users have equal rights within categories but gives priority to domestic and industrial over irrigation); (4) Surface Storage Facilities; (5) Existing Weir Supply; (6) Water Re-use (of irrigation water returning to channels); (7) Subsurface Hydrology (extent, capacity, safe yield and recharge); (8) Cropping pattern (hence crop water requirements over season); (9) Salinity (a minimum residual flow is required to avoid saline intrusion); and (10) Monthly Total Water Demand (for each category of use).

The optimum design recommends an increase in canal supply from 49 to 80 $M.m^3$/month (million cubic metres per month), an increase in groundwater pumping capacity from 1 to 14.5 $M.m^3$/month and a surface reservoir of capacity 30 $M.m^3$. These very considerable increases are possible because groundwater pumping was very low before the project and the provision of a surface reservoir is possible. More usually groundwater is not so under-utilised, and surface flows may be inadequate to sustain a new reservoir or raising the level of an existing dam crest.

Paudyal and Das Gupta (1987) developed a model to simulate the operation of a groundwater reservoir with surface water for Tinao river basin in Southern Nepal. The model outputs optimum combinations for surface and groundwater each month for changes in volumetric recharge. The groundwater reservoir is treated as a renewable resource with a limited reserve. Preference is given to surface water which is assumed to be cheaper than groundwater. A water balance assumes natural recharge to be equal to rainfall in excess of losses due to runoff, evaporation and evapotranspiration. To this is added artificial recharge from canals and irrigation channels, and seepage induced from canals by adjacent tubewells. Monthly parameters include crop water requirements, minimum downstream demand, a weight for relative shortages and factors for streamflow availability, deep percolation and return flow. The model confirms the expected result that in wet periods the proportion of surface water increases relative to groundwater, and decreases for dry periods. The model can be extended to include stochastic streamflows, surface reservoirs and water quality considerations.

Morel-Seytoux and Restrepo (in Gorelick, 1986) developed SAMSON (Stream-Aquifer Model for Management by Simulation and Optimisation) which consists of a physical model and an allocation or decision making model. The physical model simulates daily surface water flows and weekly groundwater flows for any time horizon. The river water distribution system is at four levels, river headgate, supply area headgate, farmgate, and plant level. Supply is determined by crop water requirements, physical constraints (e.g. canal carrying capacity), allocation constraints (quantity or priority of water rights), and losses due to seepage, runoff, evaporation and evapotranspiration. The allocation model is based on operational rules, which may be legal, agronomic, or governed by the magnitude of flows from a river or aquifer. Decision variables include diversions from streams or reservoirs and pumping from wells. It was verified at South Platte River Basin, Colorado.

Other conjunctive use optimisation models include Chaolunbagen and Xue Fenghai, Liu Zhaoyi and Ma Wenzheng, and Pei Yuan Sheng, all in *Wuhan 1988*.

Weller (1990) developed a farm model to simulate the viability of conjunctive use for the Porac irrigation scheme in the Philippines where groundwater is used as an insurance against the failure of surface water supply. The model computes the break-even crop yield per hectare for a range of farm sizes from 0 - 18 ha at levels of conjunctive use of 100%, 70% and 40%. Costs and aquifer characteristics are included in the model (transmissivity is taken to be 1,700 m^3/d, as measured at the project). At 100% conjunctive use, the optimum farm size was found to be 2 - 2.5 ha, requiring a yield of 3.6 tonnes per hectare to be viable. With lower levels of conjunctive use the range of optimum farm sizes increased and the necessary yield to achieve viability decreased. Overall the model was found to reflect the pattern of development of conjunctive use very well where very small and very large farms were found not to be viable for 100% use of groundwater. The larger range of viable farm sizes for lower levels of conjunctive use is attributed to farmers reluctance to adopt the more expensive supply.

Water quality models may be used to estimate the salt concentration associated with different combinations of groundwater and canal water, and the effect of different pumping rates on groundwater quality. For example, Attia (in AIT, 1990) considers the integrated management of surface and groundwater quality with respect to land reclamation in the Nile valley. Government policy restricts the use of Nile waters for new reclamation. Therefore reclamation of 40,000 ha is planned using tubewells conjunctively for irrigation and drainage in the flood plain, and for irrigation in the desert fringes. A model was used to estimate the likely build up of salts (Ca, Mg, Na, K, HCO_3, SO_4, and Cl) from groundwater pumping.

The model estimates changes in the salt concentration of groundwater over time for different pumping rates by simulating processes of convective transport, hydrodynamic dispersion, and mixing (dilution) from pollution sources. It is estimated chlorides vary from 9 mg/l for a 4 m drop in head to 21 mg/l for 19 m drop in groundwater head. The relationship between pumping, heads and changes in salt concentration indicates that groundwater cannot be used on its own to irrigate the desert fringes because of falling heads and salinisation. On the other hand groundwater pumping alone causes large increases in salt concentration. The optimum is a mix of 25% surface water and 75% groundwater. However, as surface water is in short supply it is proposed to use treated sewage water which is believed to be technically and economically feasible because the land is generally within 8 km of towns and cities and there are problems disposing of sewage effluent.

(b) Planning Models

O'Mara and Duloy (in O'Mara, 1988) describe a family of models developed by the World Bank and transferred to WAPDA in Pakistan for the rational planning of conjunctive use. A simulation model links the hydrology of a conjunctive use system, a network model of river and canal flows, and an economic model of agricultural production. 53 regions are represented by the model as irregular polygons with distinct boundaries. The polygons are linked by groundwater underflows over which the surface water network is superimposed.

Each polygonal model has embedded in it a single farm production system model which includes resource allocation choices facing an individual farmer for 11 crops and 4 livestock commodities. Decision variables are rainfall, evapotranspiration, and pumping from public tubewells. Private tubewell pumping and canal supplies are treated endogenously by the model for policy evaluation purposes. The optimising model maximises farm income less a risk premium term. The model allows for crop specialisation to meet farm family consumption needs and regional comparative advantage.

Explicit assumptions contained in the model are that aquifer withdrawals and returns are in balance - the only links between polygons are underflows (i.e. there are no economic links) and prices are constant for grain and cash crops. In addition the model incorporates implicit assumptions of projected world prices, the elimination of distortions in agricultural pricing and water allocation, and efficient investments. The use of border prices theoretically removes distortions and is expected to increase value added (at domestic prices) by up to 27% with virtually no effect on agricultural employment. It is also assumed that full utilisation of Pakistan's water resources will be achieved by 1995, and further development will have to come from technical development and higher value crops.

The model predicted that more efficient use of both resources would yield an increase of 17-20% in agricultural output, a 14-16% increase in employment, and an increase in basin-wide output of 200% between 1977 and 1995. That is equivalent to a 34% per capita gain over the period, a growth rate of 1-2% per year. Maximum gains are expected from a combination of more efficient water allocation, complementary investment in drainage in saline areas and the public control of private tubewell withdrawals. The model combines both investment-planning and basin-wide irrigation management using a hierarchal decision making multi-level programming model in which there are policy makers and policy receivers and policy receivers are optimising agents.

Lemoine and Gotsch (1985) developed a closed control model for Arroyo Seco water resources development project in Salinas Valley, California. As above, the model includes an aquifer model which simulates the response of groundwater to pumping or recharge and an optimisating algorithm which allocates water on the basis of its economic value. However unlike models which iterate between independent optimisations of the economic and hydrologic models, this model integrates the economics of water use derived from an optimisation model of the agricultural sector with the physical movement of groundwater simulated by the hydrological model. By solving in a single step optimal water use among regions over time, externalities related to the interdependency of pumpers in the various sub areas as they seek to exploit a common aquifer can be accounted for.

The model suggests overall benefits of collective management of resources to be in the order of 4.5% over a planning horizon of 20 years, a modest increase because although water is the binding constraint in agriculture, it is not sufficiently scarce to induce higher returns to management.

Implementation suffers from the following empirical limitations. The groundwater model assumes the whole aquifer to be confined, and stream-aquifer interactions were simplified in the discharge equations. The pumping cost equations assume that variations in drawdown in a given sub-area during the irrigation season are independent of the pumping and recharge in other sub-areas. Surface water allocation is treated as an exogenous variable and would be better included in the model.

The authors conclude that the model shows socially optimal water allocation is more efficient than private water allocations. However, it is thought that water institutions lack the political or legal mandate to redistribute costs and benefits reorganisation would require. Further, the magnitude of benefits of reorganisation may be insufficient to induce farmers to pay necessary transaction costs.

Under a tank modernisation strategy, Palanasami and Flinn (1988) compared the impact of additional wells with that of sluice modification (lowering the level to increase supply), canal lining, sluice management (closing the sluices for two days when the daily rainfall exceeds 60 mm), and rotational management (closing sluices on alternate weeks). A model was used to simulate water releases from the tank, water allocation to rice crops in different sectors of the command area, and crop yield reductions due to water stress at different stages of crop growth and at different positions in the irrigation system. It was run for different tank storages and levels of groundwater supplementation. It was found canal lining, additional wells, and rotation management reduced production losses by 56 to 66% and increased total rice production by 30-36%. In comparison, sluice management increased production by 14% and sluice modification had a negligible impact on yields. The greatest gains were from combined physical and management improvements.

Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England.
Telephone: +44 71 487 7413
Telex: 94082191 ODIUK
Fax: +44 71 487 7590

odi

IRRIGATION MANAGEMENT NETWORK

THE LIBRARY
OVERSEAS DEVELOPMENT INST
REGENT'S COLLEGE
INNER CIRCLE REGENT'S PARK
LONDON NW1 4NS

NEWS FROM THE FIELD

GROUNDWATER DEVELOPMENT AND LIFT IRRIGATION

News from Tunisia, Mali, Sub-Saharan Africa, Bangladesh and South India

Network Paper 5

October 1991

Papers in this set:

1. *Groundwater Development on Madura, Indonesia: Gender Issues in an Irrigation Project* by Margaret Casey.

2. *Development of Water User Associations on the Madura Groundwater Irrigation Project, Indonesia* by Robert Jackson.

3. *National Pump Irrigation Study: Material Developed During Inception Activities, January 14 - 8 February* by Effendi Pasandaran; *Assessment of Conjunctive Use in Maharashtra Minor Irrigation Systems* by T S Sheng, et al.

4. *Conjunctive Water Use for Irrigation: Good Theory, Poor Practice* by Linden Vincent and Peter Dempsey.

5. *News from the Field - Groundwater Development and Lift Irrigation* from Tunisia, Mali, Sub-Saharan Africa, Bangladesh and South India.

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

Linden Vincent
Editor, Irrigation Management Network
Overseas Development Institute
Regent's College
Inner Circle
Regent's Park
London NW1 4NS

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

The opinions represented are those of the author and do not necessarily reflect the policies of the Overseas Development Institute, or any other organisation with which the author is connected.

NEWS FROM THE FIELD

Contents **Page**

Introduction

This paper on *News from the Field* is a new venture for the Irrigation Management Network. We plan to use it for the longer letters we receive, and for summaries of work undertaken which are sent to us by Network members.

This first set carries some of the responses to a paper highlighting information needs in groundwater development and pump technology for irrigation. This was circulated to IMN members who had indicated an interest in these topics on their Network registration forms. We are still processing the information received, but hope to publish more material, and a discussion of the paper circulated, in a forthcoming Newsletter. If you have any comments on these papers, please write to us.

STUDY ON RATIONALISING GROUNDWATER USE BY ELECTRIFICATION OF SHALLOW WELLS[1] - May 1990

Al'atiri Boutiti Raqya
Rural Development and Irrigation Department
Ministry of Agriculture, Tunisia

1. INTRODUCTION

Groundwater is being over-exploited both by electrification and by illegal digging of shallow wells. In light of this, the Ministry of Agriculture set up a study to review options for rationalising groundwater use. Controlled electrification seems to be the best means available, allowing precise monitoring and evaluation of water consumption.

2. PRESENT SITUATION OF GROUNDWATER RESERVES

The electrification of water-pumping in shallow wells by STEG (Electricity and Gas Department - Société d'Electricité et du Gaz) has been placed under the authority of the Water Resources Administration (Direction Générale des Ressources en Eau) in an attempt to reduce over-exploitation. Zoning has been introduced; in the prohibited areas electrification for pumping has been forbidden and in the 'safeguard' zones electrification is only permitted under certain conditions. Only in areas where groundwater reserves do not seem to be in imminent danger of over-exploitation is electrification proceeding without restriction.

Despite these protective measures, proliferation of electrified pumping has not been slowed. This situation prevails even in the prohibited areas where groundwater continues to be more and more dangerously over-exploited.

The strategy adopted to safeguard groundwater evidently requires revision, especially since it has been rejected both by farmers and by development and finance organisations. Farmers, who know the difficulties and handicaps created by diesel pumps and who are aware of how the electricity

---

1 A 'shallow well' is no deeper than 25 m.

grid is developing in rural areas, constantly ask for their wells to be electrified.

It is already a fact that Tunisia's groundwater is over-exploited. This stems directly from increased withdrawals from electrified wells. The annual increase in the discharge of electrified wells is greater than that of wells equipped with diesel pumps. On average, electrified wells now discharge twice the average annual volume pumped by wells equipped with diesel pumps.

3. RESULTS AND INTERPRETATION OF STUDY

According to the results obtained from the study carried out in the provinces of Bizerte and Nabeul and after comparing real water consumption rates with theoretical plant needs, the following conclusions can be drawn:

- Water consumption rates tally with the theoretical level of crop needs for shallow wells which are equipped with diesel pumps;

- Whichever pumping equipment is used, electrical or diesel, water consumption rates on shallow wells are double those of deeper wells for the same irrigated area and cropping pattern;

- Holdings where shallow wells are electrified pump twice as much as those where the wells are equipped with diesel pumps (because electric pumps can be operated longer or more frequently);

- Large holdings (greater or equal to 4 hectares) use smaller amounts of water than in theory they need because farmers do not cultivate the full area under irrigation. Typically one family can irrigate 1 hectare depending on water availability, water wastage and intensity of land use. This can equally be the case of shallow wells with small pump yield. The following is an example: 972 metres^3/hectare (m^3/ha) in summer for a surface of 4 hectares;

- On the other hand consumption is clearly increased for a small area. This can be explained since pumped discharge is greater than the theoretical design flow which will provide the water requirements of a small plot.

Real examples:

12.150 m^3/ha during the summer for a parcel of 0.4 hectares
11.097 m^3/ha during the summer for a flow of 5 litres/second (l/s) and a surface of 1 hectare.

In general, water consumption in winter exceeds plant water needs. Water wastage occurs during this time of year. (*However, some of this water may be important for leaching purposes. Editor*)

- Water consumption is correct regardless of holding size and flow rates, where water-saving systems are in use (those encountered include sprinklers and mobile tubing).

A certain caution should be exercised over these findings since they are drawn from a study of only 36 surface wells. They also need to be checked against the results of studies which will be sent in by all the Regional Agricultural Development Offices (CRDA - Commissariat Régional au Développement Agricole). These results, though, do seem valid, and even predictable. The main point to note is the tendency to over-exploitation by a shallow well or farm with certain characteristics. A well or farm with these characteristics could be identified and studied over the longer term to see how extension advice can increase an owner's awareness of the various ways in which the resource may be exploited.

Certain practical proposals, based on these conclusions, are now presented, to reduce groundwater use while at the same time permitting electrification of shallow wells.

4. CRITERIA FOR EVALUATING GROUNDWATER OVER-EXPLOITATION

Agricultural production in the private sector is relatively well developed, primarily in those irrigation schemes where the rate of intensification is highest. From time to time, nevertheless, anomalies in water resources use are noted.

The illicit creation of shallow wells, electrification in prohibited areas or 'safeguard' areas or, quite simply, water consumption exceeding requirements (see study results), demonstrate how ignorant farmers are of basic technical ideas necessary for good management of water resources.

Once these basic ideas have been grasped at the popular level, they could help reduce groundwater depletion and saline water contamination. The aim is for farmers to pump only what they need for a given area of crops and reduce wastage. However, the danger is that these efficiency measures may encourage farmers to pump the same amount and irrigate a larger area proportional to waste water 'saved', which must be avoided.

The criteria which need to be defined to act on water consumption are:

- water needs in the private sector
- specifications of equipment to be installed
- corresponding energy needs.

It should be borne in mind that each shallow well represents a unique case and so generalising one piece of information or one result is problematic. The present study can only be a framework within which to place shallow wells which have similar characteristics. Therefore the characteristics of the irrigated parcel and of the shallow well must be known and indicated on the form requesting electrification. This must first be filled in by the person concerned, then by the Administration.

The parameters to be ascertained for a farm requesting electrification are:

- the number of the well
- the hydrogeological formation tapped
- the depth of the static and dynamic levels of the well
- the total surface area of the farm
- the crops to be irrigated

Then, with this information, the parameter limits to be calculated are:

- the theoretical water needs of the holding
- the maximum power of pump to be installed
- the maximum energy consumption for the year and for different periods of the year (winter, summer and peak times winter and summer).

5. PROPOSALS

Bearing in mind that energy conservation as well as water conservation is now of concern, an improved gravity irrigation system would be most appropriate for water distribution after pumping, especially since most of the underground reserves are relatively saline and require an extra quantity of water to flush out the salts.

By the same token, before any final decision is taken on electrification the possibility of equipping wells with renewable energy should be studied. Drip irrigation might be appropriate.

(a) The minimum tariff in Kwh as for improved gravity-fed systems should be applied up to maximum consumption levels. For any volume pumped which is greater than this, a penalty tariff will be applied. This will be the case if the infringement takes place for the whole winter, for the whole summer or for two consecutive months in the winter or the summer.

(b) Since total water use depends on the volume and duration of pumping,it is imperative to reduce pumping times, which should be carried out by STEG.

(c) Piezometers ought to be installed as an extra precaution in critical zones where saline water contamination threatens a groundwater reserve and also where there are concentrations of shallow wells. These would enable effective monitoring of changing water levels and water quality, of both shallow and deeper aquifers.

6. CONCLUSION

The findings of this study on electrification ought to be put into effect at the regional level by water resources technicians from the CRDA, and by regional district level technicians from STEG. On one hand this would fix the maximum energy requirement in relation to the depth of the dynamic level of the groundwater reserve and on the other would fix the length and timing of electrical supplies corresponding to the pump yield from that reserve.

A copy of the table (or the graphs) of the maximum energy requirement for a given region ought to be handed over to each District in the region so that tariff scheduling bands based on energy consumption can be worked out.

A standardised form ought to be drawn up for each hydrogeological formation in each province. Each time a request for electrification was made, such a form would have to be filled out by:

(a) the farmer, who would note down all the specifications of the holding and the well;

(b) CRDA personnel, who would add the characteristics of the groundwater reserve and the maximum water requirements in power and energy per hectare.

STEG, for its part, in collaboration with the Administration, would prepare a proposal for new tariffs based on the degree to which power and energy are overused, and also a proposal for power supply timings.

A 'STEG information sheet' ought to be produced for each province and given to any farmer who wants well electrification so that the farmer is aware of procedures.

A case study is now underway to gauge the economic and financial effects of this electrification project, with a view to its being implemented as soon as is best. New laws are now being drawn up in line with this study to determine how electricity is to be used. It is also intended to create farmers' associations for managing the system and implementing the guidelines.

DEVELOPING VILLAGE LIFT IRRIGATION IN MALI

Souleymane Dembeley
Chargé de projets, GUAMINA (ONG/NGO), Bamako, Mali

GUAMINA is an NGO undertaking development actions in response to the needs identified by local people and making use of their full participation. Our actions are strongly focused on food self-sufficiency through small-scale irrigation schemes for rice and market gardening. At the moment GUAMINA is involved in four main irrigation scheme projects. In this paper we discuss the project in Boya, 60 km from Gao in the seventh region of Mali.

From the outset, though, it must be stated that rice or market garden irrigation schemes cannot be undertaken in isolation or they are bound to fail. Other components are necessary, such as small farmer organisation around the scheme and training in rehabilitation and management techniques (which consist of small farmer organisation, literacy training, natural resource management and environmental protection).

Earlier the Boya scheme was under flood recession agriculture. The rising of the River Niger, which flows near the village of Boya, inundated that part of the plain and the local people made use of this to grow rice. With the drought of recent years and the very low level of the rise in the river, the plains were no longer sufficiently inundated to guarantee a good rice harvest. This situation led the local people to develop the plain, seizing upon GUAMINA and another Canadian NGO for this work.

A preliminary study was conducted to discuss the development plan and how the work would be carried out. This was followed by the project document worked out on the basis of the preliminary study and with the full participation of the people concerned. The project outline is as follows:

1. GOAL AND OBJECTIVES

The project is aimed at increasing agricultural production by controlling and using efficiently the river waters in order to meet the needs of the people of Boya in relation to food self-sufficiency (development of a small-scale irrigation scheme, and traditional fields). For this the project must guarantee the development of infrastructure to increase the capacity of agricultural production:

- securing agricultural production by total water control;
- local consumption of foodstuffs;
- building up reserves;
- sale or exchange of supplies for other foodstuffs;
- training in management techniques of men and women involved in the irrigation scheme;
- training local people to be able successfully to take over the project when the NGOs withdraw.

2. PROJECT SUPPORT STRATEGY

GUAMINA's approach aims at involving as many people as possible in community development. The ground work with local people represents the first step in reaching this goal. Priorities are to be set out by the local people in relation to their needs. The project will proceed in this way in the village of Boya stressing, of course, the other necessary components.

3. PRESENT SITUATION ON THE BOYA PROJECT

(a) What has been learnt from the Project, at the level of small-scale irrigation?

Having been running for four years, the Boya Project is at the moment in its last year of funding. During these first four years much important work has been carried out, with development of a small-scale irrigation scheme covering 50 ha with individual parcels distributed according to criteria established by the local people themselves. This scheme extends over more than 50 ha with two motorpumps and a canal system which allows each user to irrigate their holding at their convenience.

The main thing learnt is that the scheme itself originates with the people, which means that the small farmers already had expertise in rice-growing techiques, in this case setting up the nursery beds, re-planting, respecting fertiliser quantitites, organisation of watering and of seedling densities. Also we can add awareness of the crop calendar, of the over-lapping of mineral fertilisation as a function of the plant growing cycle and crop diversification on the scheme: sorghum IRAT-204 (or sorghum - Djebock variety, which is very well adapted to the area) and of Gorom-Gorom variety. The development of the scheme has been carried out with a lot of consultation and technical support from the two NGOs.

During high river levels the scheme received river water and motorpumps were used less. During the winter (the recession period of the river), however, the motorpumps were the only means available for irrigating the fields. This is why instead of double-cropping rice, the project adopted growing Djebock sorghum as the winter season crop. Market gardening should be added as well.

Traditional Fields

Rice growing in the bas-fonds (floodplains) is an activity which goes back generations in this area. The small farmers not only are totally expert in the different growing techniques but also have extensive knowledge of all the varieties cultivated locally. The need to conserve local strains must also be stressed. The disappearance of traditional varieties is a danger and a menace for this activity and might in the longer-term give rise to the disappearance of certain varieties if an adequate solution is not found. For the present, however, essentially three main varieties of local rice are grown in the region (Mobéri, Tétéré, Kossa), each made up of various strains maintained traditionally until the present.

In the traditional fields, growing is done as best as possible since the amount of flooding cannot be determined in advance.

Recently the river rise no longer allowed the traditional fields to be irrigated. The project therefore recommended supplementary irrigation, which is looking after the young shoots through using the motorpump until the river water arrives. At the times when the rise is small there will be recourse to the system of backup irrigation using motorpumps.

Also the project has introduced the system of planting carried out from a rice seedbed collectively maintained, in place of hand sowing in the traditional fields. This planting system will avoid the uncertainties of the floods which are often too strong or too weak.

(b) **Problems met with:**

- Inability to deal with the essential technical issues, in particular sticking to the crop calendar and the overlapping of mineral fertilisation as a function of the plant growing cycle;

- Lack of rest for the small farmers in the annual double-cropping;

- Overlapping of work times (irrigation scheme and traditional fields);

- Management of infrastructure, mainly the motorpump and irrigation network.

These different points are at present being dealt with in detail and adequate solutions are at present being recommended. These are to make investments profitable and to encourage take-over by the small farmers.

With a view to this, the project is in the process of putting the emphasis on:

- Training the small farmers and follow-up of the scheme;
- Awareness and extension of modern techniques;
- Improving the system of supplementary pumping for the traditional fields;
- Conservation of, and experimentation with, traditional strains with the intention of determining their potential and of improving cultivation methods.

(c) **What has been learnt:** In all, the project has:

- Carried out studies of development sites (50 ha);
- Set up infrastructure intended to consolidate the scheme and put the tools for working on the scheme at the disposal of the small farmers;
- Trained and introduced the small farmers to canal and masonry techniques;
- Achieved improved crop practices as much on the scheme as on the traditional fields;
- Diversified crops;
- Practised new techniques to produce seedlings in seedbeds of local strains used in the traditional fields;
- Achieved control and good water management from infrastructure created at the scheme level.

GROUNDWATER DEVELOPMENT FOR SMALL SCALE IRRIGATION IN SUB-SAHARAN AFRICA: TECHNOLOGY FOR SMALL SCALE GROUNDWATER IRRIGATION IN NORTHERN NIGERIA[1]

Richard Carter
Senior Lecturer in Water Supply & Management
Silsoe College, Bedford MK45 4DT, UK

INTRODUCTION

In northern Nigeria dry season vegetable cultivation has been practised for generations in the *fadamas* or seasonally wet bottom lands (Carter et al, 1983). These fadamas range from localised depressions to major river flood plains. Water is lifted from perennial rivers, water holes and wells by the locally constructed counterpoised device known as the *shaduf*.

This is a labour intensive, low capital cost device which permits the irrigation of approximately 0.1 ha (Nwa, 1981). The main crops irrigated by the shaduf are tomatoes, onions and peppers. Even in the more extensive flood plain fadamas this sort of lift irrigation is largely restricted to the banks of perennial water courses and to the margins of natural water holes.

The technical intervention in recent years has been the introduction of simple technology for the construction of shallow boreholes, together with handpumps and motorpumps, as alternatives to the shaduf. This has increased the potential area of vegetable cultivation back across the flood plain, to cover virtually the whole of the fadama, or at least those areas where the water table is no deeper than about 3-4 m below ground surface.

The method of borehole construction used is described in detail by the present author in BSADP (1984). A 50 mm steel pipe is jetted into the fadama soil by pumping water or bentonite mud through it and using this fluid to return displaced soil to the surface. Usually a temporary casing of about 100 mm diameter is driven at the same time as jetting proceeds, so

---

[1] A longer paper on this topic was first presented to the Geological Society of the UK in 1988. Please contact the author if you could like a copy.

that permanent 75 mm diameter linings can be placed to the required depth. The lower part of the permanent lining is perforated (saw-cut) PVC. Finally the temporary casing is removed and if necessary gravel can be poured around the well screen. This procedure of well jetting can be used to construct irrigation tubewells up to 10-20 m deep in favourable ground conditions (Carter, 1985). Moreover, the technique is cheap (see below), rapid and able to be carried out by relatively unskilled personnel.

More often than not in Nigeria the preferred system of water abstraction from jetted boreholes is by petrol driven centrifugal pump operating by suction lift. Handpumps have been introduced, but the uptake has been less widespread than with motorpumps.

Cost of and returns to irrigation with this system are summarised below:

Table 1: Costs of and Returns to Lift Irrigation by Motorpump in Northern Nigeria (after Chapman in BSADP, 1984)

Costs (N/ha)	
Labour	215
Seeds	199
Equipment (pump and tubewell)	600
Fertiliser	42
Fuel	360
Marketing	192
Total	**1608**
Receipts (N/ha)	4883
Gross Margin (N/ha)	**3275**

Note: Average farm holding 0.66 ha (sample size 58).

The gross margin of more than N3000 (then approximately US$4800) which was possible under the new technology at that time, compares favourably with Chapman's figure of N2163 which was obtainable by non-pump users (shaduf irrigators or residual moisture farmers), (BSADP, 1984). However, it should be noted that the Naira has been devalued by a factor of more than twenty since the date for which these figures apply. Fuel is still cheap, but imported equipment is affected.

At a seminar in Bauchi State in 1984 various encouragements and warnings were made in relation to future groundwater development of this type. Despite the attractiveness of the concept - and uptake of technology by farmers has been very rapid - a number of areas of concern were identified. These included:

(i) The effects of upstream developments (dams) on both traditional and introduced fadama agriculture;

(ii) The lack of data concerning borehole yields, drawdowns and recovery rates in the fadamas;

(iii) A lack of hard information on groundwater recharge, especially in fadamas affected by upstream developments;

(iv) The lack of any legislative control on groundwater abstraction.

Many of these aspects have been studied in the period since 1984, although much work remains to be done. The following sections relate to these concerns and to developments which have occurred in recent years.

1. CONFLICT WITH THE FORMAL SECTOR

Not surprisingly much of the land which is suitable for large scale formal irrigation schemes is that which either is being used or could be developed for small scale irrigation (SSI). So far most of Nigeria's larger irrigation schemes are based on surface water developments (dams in the head reaches of major rivers), and much cultivated and cultivable fadama land has been submerged under reservoirs. Often as much land has been flooded as is commanded by surface water reservoirs in the relatively subdued relief of the north of the country. In addition the combination of dam construction and poor rainfall in recent years has meant that annual floods in the middle and lower reaches of the major rivers have not reached the same magnitudes as formerly. Recharge to the fadamas may have therefore been reduced, with obvious effects on resource availability for SSI.

The reduction in oil revenues in the present decade has reduced the availability of funds for investment in highly capital intensive surface water developments and this has been to the advantage of SSI.

The recent merger once again of the Federal Ministry of Agriculture (which previously looked after small scale development) and the Ministry of Water Resources (which promoted the large formal schemes) at least give the opportunity for a more rational optimisation of combined small and large scale developments.

2. GROUNDWATER EXPLORATION IN THE FADAMAS

The use of electrical, and more recently electromagnetic techniques for groundwater exploration, is well established in the crystalline rock areas of many parts of Africa. In the hard igneous and metamorphic rocks of the Basement Complex groundwater has been located in the weathered zone above fresh rock or in hard rock fractures. With the advent of electromagnetic (EM) profiling the older resistivity profiling (constant separatio traversing) is less used, and now surface geophysical exploration generally consists of a combination of EM profiling and vertical electrical soundings (VES), (see for example, Beeson and Jones, 1988).

It is only recently that the same techniques have been applied in alluvial environments, but a considerable degree of success has been claimed for them there too (Temple-Hazell et al, 1988). The following observations are summarised from recent work of Temple-Hazell's Water Surveys Group in the northern Nigerian fadamas.

Significant aquifers suitable for SSI are to be found in the layered or lenticular sands and gravels of alluvial deposits in the often very extensive (up to 10-15 km wide) major river floodplains. To be compatible with the presently used drilling technology and pumping systems, aquifers with rest water levels no deeper than 4-6 m and in which drilling to 10-15 m depth is adequate, must be located.

The procedures used have included routine EM profiling together with vertical electrical soundings at selected type locations. Computer simulation for VES interpretation has been essential because of the difficulty of manual curve fitting. The greatest difficulty in quantifying thickness of sand and gravel aquifers occurs when they are overlain by highly conductive clay deposits which may be up to 6 m thick. Even in sequences of sands, overlying clays or silts, in turn overlying highly resistive bedrock, there is significant ambiguity in interpretation of both EM and VES results. However, the major ambiguity is in the predicted thickness of the conductive layer, not the more interesting overlying sand layer.

In all cases geophysical exploration needs to be backed up by drilling, but the advantage of the shallow alluvial environments under consideration is that they can be readily penetrated by low cost techniques such as jetting, auguring or vibro-bailing.

3. GROUNDWATER RESOURCE EVALUATION

The only detailed evaluation of aquifer properties and well characteristics in the Nigerian fadamas appears to be that carried out by the Water Surveys Group (1986). This work included constant rate and step-drawdown texts on 30 shallow wells in the fadamas of the Gongola, Jama'are and Dingaiya Rivers of Bauchi State.

Sand and gravel aquifers varied in thickness from less than 2 m-16 m (mean 6.6 m, 30 sites). Transmissivity (T) ranged from 100 - 10200 m^2/d (mean 1600 m^2/d). Storage Coefficients (S) were consistently high, ranging between 0.005 and 0.29 (mean 0.11). In some of the constant rate tests evidence of barrier boundaries was found after only 12 h of continuous pumping. Well efficiencies varied from 13-86%.

On the basis of a number of assumptions (mean T and S values, 100% well efficiencies expected abstraction rates of 6.71/s and a typical pumping duration of 6 h) drawdowns were predicted ranging from 0.1-2.0 m. Beyond about 15 m from pumped wells drawdowns were observed to be negligible. In the major fadamas it was estimated that well spacings of 100 m would not cause undue interference, and such spacings would be appropriate in terms of crop water requirements and abstraction rates.

Recharge in the major fadamas studied was observed to be complete in periods varying from one or two days to a maximum of 25 days following the onset of river flow. Water tables rose by about 2 to over 4 m in this period. This observation confirms previous assumptions of complete and rapid recharge, but the effects of major dams (e.g. Tiga, Dadin Kowa and

Challawa) are already being felt in reduced or non-existent flooding and consequent reduced groundwater recharge in other river valleys.

4. DRILLING AND WELL CONSTRUCTION TECHNOLOGY

The main low-cost drilling method used in the northern Nigerian fadamas is still that described in the Introduction - well jetting or washboring. More recently introduced methods include the use of a vibro-bailer (a steel bailer hand-vibrated inside PVC casing, using steel auger extensions as drilling rod) and the placing of drive points. The latter are particularly suitable in thin, otherwise unproductive aquifers - at least when 'Johnson' type (high open area) points are used.

Well screens and casings are normally of 75 mm PVC, the former being hacksaw slotted (usually 1 mm slots, although this is often too large). Slots of 0.5 mm are usually more successful. Open areas can be as little as 4% with hacksaw slots, and still less than 10% with bench slotted PVC. Screen lengths of 5-10 m are needed to ensure entrance velocities are kept within the normally accepted limits.

Well development is generally carried out only by overpumping, whereas surging has been observed to give much improved performance.

Direct connection of pump suction to well casings is reported to give significantly better well performance than the usual practice of lowering the suction pipe well down inside the screen.

The most recent estimates of drilling costs (by jetting or vibro-bailer to complete 9 m deep, 75 mm diameter holes) are US$150-200 per well (Water Surveys Group, 1986). These are based on 320 wells per year for a drilling crew.

It is likely that the efficiency of the well jetting technique can be significantly improved through design modifications. Current research at Silsoe College is concerned with the detailed relationship between nozzle size and angle, water pressure, volume and upward velocity, and hole diameter. These relationships are being investigated under laboratory conditions, and the objective is to optimise drilling performance, especially when well linings are sunk at the same time as drilling. The use of bentonite and other drilling muds is also being investigated.

REFERENCES

Beeson, S. and Jones, C R C. (1988) The Combined EMT/VES Geophysical Method for Siting Boreholes. *Groundwater* 26(1), Jan/Feb 1988.

BSADP, (1984) Bauchi State Agricultural Development Programme, Northern Zone Fadama Seminar, 6-8 March 1984.

Carter, R C. Carr, M K V. and Kay, M G. (1983) Policies and Prospects in Nigerian Irrigation, *Outlook on Agriculture 12(3): 73-76.*

Carter, R C. (1985) Groundwater Development Using Jetted Boreholes, *Waterlines 3(3).*

Nwa, E U. (1981) An Evaluation of Small Pump and Shaduf Systems of Irrigation in Northern Nigeria, *Samaru Journal of Agricultural Research 1(2): 191-201.*

Temple-Hazell, J R. (1987) Reconnaissance Study for Small Scale Irrigation Schemes in Borno, Plateau and Benue States, Nigeria, consultancy report to World Bank, Washington.

GROUNDWATER MARKETS IN RAYALASEEMA: A NOTE

V Ratna Reddy and B C Barah

This paper is based on extensive fieldwork conducted in Rayalaseema[1] region of Andhra Pradesh during 1986-88, in connection with the project on 'Economics of Water-Sharing in Droughtprone Areas'[2], sponsored by ICAR.

The research was taken up in order to identify some of the villages where well irrigation is prominent and groundwater markets are prevalent, and the problems they face. Our visits to the villages involved meeting the village heads, farmers and visiting the wells to get first hand information on well irrigation and water sharing. A number of villages were identified in Chittoor and Cuddapah districts where groundwater markets are prevalent. However, in Anantpur it was difficult to find a village with these features as there was no water in the wells during 1986-87 consequent to severe drought conditions in the past three years. Apparently, groundwater markets are more conspicuous in non-drought years and regions. Finally, three villages were chosen for the study where fieldwork was conducted for two full years. The fieldwork was conducted by field investigators who stayed in the village throughout the survey period.

The present note draws on the experience and data obtained from these three villages during the two-year study period 1986-88.

PROFILE OF THE VILLAGES

The selected villages are Karakambadi and Kadirimangalam in Chittoor district and Kondapeta in Cuddapah district: their salient features are presented in Table 1. All the three villages are of moderate size, and are well connected by *Pucca* (surfaced) roads to the major towns/district head quarters, which are all located within 20 km. As far as the social composition of the villages are concerned, backward castes along with scheduled castes and tribes are dominant in Karakambadi village, whereas forward caste populations dominate the social structure in Kadirimangalam

---

1 The districts of Kurnool, Anantapur, Cuddapah and Chittoor.

2 Gokhale Institute of Politics and Economics, Pune, and Department of Economics, University of Hyderabad, Hyderabad.

(Kammas) and Kondapeta (Reddys). It has been noted here that the social structure of the villages seems to play a vital role in the development of groundwater resources. It was observed that institutional support for well irrigation is marginal in Karakambadi village when compared to other two villages. Farmers expressed their reluctance to utilise available loans in this village due to the problems faced. The specific problems are: (1) it takes much time and effort to go around the offices in order to get the sanctions, and (2) nearly 50% of the sanctioned money would go towards bribing the officials. However, there are 2-3 well-to-do farmers who acquired institutional loans. On the other hand, in the other two villages very few farmers have expressed these problems.

Table 1: Salient Features of the Three Villages

	Karakambadi*	**Kadiri**	**Kondapeta**
No of households	600	200	200
Total population (NOS)	4000	600	
Total area (acres)	1000	300	200
% of area irrigated	75	90	100
Major source of irrigation	well/ tank	well/ tank	well
No of wells	100	60	100
Major crops grown	paddy and groundnut	sugarcane paddy and groundnut	betlevine paddy and groundnut

* Karakambadi consists of 5 hamlets

Of the three villages, the two villages in Chittoor district belong to the same geo-climatic region with similar soil quality. The cultivated lands of these villages can be categorised into uplands and wetlands. Irrigated dry crops like groundnut are grown in uplands and irrigated crops like paddy and sugarcane are grown in wet lands with the help of tank as well as well irrigation. The cropping pattern of these villages is presented in Table 2. The cropping pattern in Karakambadi is dominated by groundnut, whereas it is dominated by sugarcane in Kadirimangalam, and groundnut and betlevine in Kondapeta. The difference in cropping pattern, despite similar agro-climate conditions in the first two villages may be attributed to the poor resource base, and economic conditions prevailing in the first village.

Table 2: Cropping Pattern in the Sample Villages (%)

Crop	**% of area under crops in:** Karakambadi	**Kadirimangalam**	**Kondapeta**
paddy	25	28	4
groundnut	66	26	53
sugarcane	5	46	-
betlevine	-	-	43
others	4	-	-
Total	**100**	**100**	**100**

As indicated earlier, the farmers in Karakambadi are not able to mobilise institutional finance to develop groundwater and cultivate more renumerative crops like sugarcane. On the other hand, the farmers in Kadirimangalam are well supported by the cooperative sugar-mill in its vicinity. It not only provides concessional finance for digging wells but also provides material inputs for sugarcane. Although the sugar cooperative is located within 20 km of Karakambadi, its operations have not extended to it so far. As a result only a few well-off farmers grown sugarcane in this village. The resource crunch in the first village is also reflected in the greater depth of the wells across the villages, which is a major constraint to growing water intensive crops like sugarcane. It can be observed from Table

3 that the depth of 66% of the wells is below 50 feet in Karakambadi, whereas in Kadirimangalam 42% of the wells fall into this category.

Table 3: Depth of Wells Across Village

Depth of Well (in feet)	% of wells in: Karakambadi	Kadirimangalam	Kondapeta
below 50	66	42	7
51 to 150	28	55	38
above 150	6	3	55

In contrast, the picture in Kondapeta is quite different from the other two villages. Kondapeta is situated on the branches of river Penna. Though it comes under K C Canal, command water never reaches as it is situated in the tailend of the canal. However, because of its location on the branches of river it has rich groundwater resources when compared to the other two villages in Chittoor district. Kondapeta is traditionally a betlevine growing village. This village is buzzing with betlevine operations throughout the year. The high profitability of the crop has resulted in cash flows throughout the year and the village is conspicuously affluent as a result. In this village, groundnut and other crops are grown in the lands which are not suitable for betlevine cultivation. The wells in this village are mostly greater than 150 feet deep (see Table 3). Although the high water requirement of betlevine, as reflected in the depth-to-watertable, the groundwater is still reliable.

GROUNDWATER MARKETING

From our discussions with old farmers, it appears that groundwater marketing is as old as well irrigation in these villages. Well irrigation is not a new phenomenon in this region. Most of the wells in the sample villages are inherited from generations and hence old. In most cases the present owners do not know the age of their well, though a number of farms are going for new wells, especially in Kadirimangalam in recent years. The only changes that have taken place in recent times are energisation and deepening of wells. The depth of the old wells has almost doubled during the last 10-20 years indicating the depletion of water table consequent to energisation of wells. Except in Karakambadi, many of the wells in the other two villages are either bore-wells or in-well bores. In Kondapeta, a number of farmers have borewells on the river bed to facilitate uninterrupted water supply during summer. On the other hand, the very low adoption rates of rig technology in Karakambadi village can be attributed to capital constraints which are the consequence of their social and economic backwardness. Further, in this village only about 50% of wells have power connections and the rest use diesel pump sets. Whereas in the other two villages almost all the wells are equipped with electric motors. In the two villages in Chittoor district the horse power (HP) of the motors range from 3-5 HP, and in a few cases it is 7 HP, whereas in Kondapeta of Cuddapah district the HP ranges from 7-15 HP.

Selling and buying of water is a common phenomenon in these villages - at least for one season in normal years in the two villages of Chittoor district, while it is a round the year activity in Kondapeta of Cuddapah district. The magnitude of groundwater marketing in these villages is demonstrated in Table 4. It can be seen that more than 70% of the sample irrigated households are involved in groundwater marketing in one form or another. In order to understand various activities of groundwater marketing, we have grouped irrigated households into four categories, i.e. pure owners, joint owners, sellers and buyers. Pure owners are not involved in any kind of groundwater marketing activity. Joint owners are those who own the well or motor in partnership with one or more persons and sharing the water from the well. Joint ownership is observed in different forms. For instance, farmers become joint owners of the well by inheritance (through division of joint families). In this case farmers may have a jointly-owned motor, or separate motors. In some cases a well owner may join with a non-well owner to establish a motor on the well. In this case the well owner would be given preference in lifting the water. The other forms of groundwater marketing activities include water sellers and buyers. Water sellers are usually big farmers, while the buyers belong to the small farm size group who cannot afford to invest on a well. It can be observed from the table that marketing of groundwater takes place on a large-scale in all the villages. Even after taking out pure and joint owners, between 40-50% of the sample households in the villages are directly involved in water marketing.

Table 4: Distribution of Farmers by Groundwater Marketing Activities

Village	Pure owners	Joint owners	Sellers	Buyers	Total
Karakambadi	24 (30)	21 (26)	18 (22)	18 (22)	81 (100)
Kadirimangalam	26 (28)	18 (19)	20 (21)	30 (32)	94 (100)
Kondapeta	16 (19)	27 (32)	15 (17)	27 (32)	85 (100)
Total	**66 (25)**	**66 (25)**	**53 (20)**	**76 (30)**	**261**

* figures in brackets are % to the respective totals.

Water rates are charged on the basis of number of hours and horse power of the motor in all the villages and for all the crops, except in betlevine. For betlevine in Kondapeta a flat rate of Rs 20[3] per irrigation per acre is charged. This may be due to the high water demand of the crops which needs 4-6 irrigations per month throughout the year. Usually water buyers enter into an oral agreement with the sellers before they plant betlevine. In the case of other crops the charges are Rs 1/hour per one HP motor. Kind payments, especially in the case of paddy, are also prevalent, usually 4 bags (76 kg each) of paddy are given as water charges for irrigating one acre of paddy. Though these rates are uniform for all the villages, the share of water charges in gross income of the crop vary from village to village depending on the yield rates as well as intensity of irrigation required.

[3] In 1991, 20 rupees = $US 1.

As the buying and selling activities take place at an informal level and by oral consent, we have not observed any problems between buyers and sellers. It is generally understood that sellers will provide water to a buyer only after fulfilling their own requirements. In the case of multiple buyers, the distribution of water, i.e. who gets the water first from the sellers well, is on the basis of 'first come, first served'. That is, the person who approaches the seller first will get priority in the regular distribution of the water and he will be the last person in the event of seller withdrawing water supply due to paucity of water. In fact, in some cases where the well yield is high the distribution system goes as far as 1 km and the distribution systems, either field channels or pipe line, are laid by the buyer at his own cost.

GROUNDWATER DEVELOPMENT: SOME ISSUES

The experience of these three villages provide us three different developmental scenarios and helps us to raise some issues in groundwater development. Of these three villages, Karakambadi, a traditionally poor and backward village and Kondapeta, a traditionally rich village, stand at extreme poles. In Kondapeta private capital, accumulated over generations, dominates groundwater development. As such it does not face any problems, either economic or ecological, of groundwater exploitation as it follows the pattern established over years, and it is very unlikely that they would deviate from this pattern. It appears that the groundwater potential and the cropping pattern, though highly water intensive, are perfectly matched for the time being in this village.

On the other hand, Karakambadi suffers from capital constraints and negligence at official level which may be attributed to their lower social as well as economic status. Though these farmers are aware of the benefits of sugarcane crop and the available rig technology, which would facilitate growing the crop, only a handful of them grow sugarcane. These are some of the big farmers of the village who can afford to go in for deeper wells with rig technology.

The experience of Kadirimangalam is more interesting and revealing. This village is in transitory stage of development. It is a typical model of many such villages in various fragile resource zones of the country which are suffering from the reckless policies of the government. The establishment of a cooperative sugar-mill in this region in the early 1980s helped farmers to enjoy the benefits of this highly renumerative crop. Prior to this sugar factory their cropping pattern was dominated by paddy and groundnut. It was hardly ten years after they started growing sugarcane and enjoying the profits before they felt the pinch of depleting groundwater resources. Most of the farmers have either drilled bore-wells or in-well bores which are financed by the cooperative sugar factory. In recent years most of the wells are unable to supply the water for sugarcane. As a consequence of deepening of wells, some of the existing dug wells have gone dry and water selling for sugarcane has almost stopped. In fact, in 1986-87 on some plots sugarcane crop had withered away due to lack of water. This, in turn, prompted the farmers to go in for more and more deepening of wells and powerful motors, the latest being the submersible motors which cost around Rs 25 - 30,000. But this does not seem to be helping much. On the contrary, farmers are losing heavily. In fact, it was reported that in the summer of 1987-88 about Rs 10 million was spent in this village alone on new borewells with only 50% success rate (the cost of one well with submersible motor will be between Rs 50,000[4] - 75,000). It was also reported that some farmers got salt water when they drilled even deeper. After this the frustrated farmers started blaming the government for poor advice regarding the location of the wells. If the situation continues, the farmers may have to shift their cropping pattern, though they are not thinking of that option now.

Thus, natural resource planning needs more judicious planning and understanding of basic problems. Hasty and politically motivated decisions, like establishing sugar factories in low rainfall and water scarcity regions, prove detrimental rather than beneficial to the farming community in the long run. An appreciation of farmers' awareness and understanding of their resource structure is vital, and their involvement in the planning level would help in arriving at more appropriate policies. In this context, community participation of village community in solving their problems through institution of self-correcting mechanisms may be a viable proposition (Shah, 1990). But here the problem is that village communities at present are ill-equipped to organise themselves in order to solve their problems and hence, there is need for an outside organisation which can motivate and help the farmers in this regard.

As far as the problem of depletion of groundwater table in Kadirimangalam village is concerned two plausible solutions, at this juncture, can ameliorate

---

[4] In 1986, US$ 1 = 1 Rs.

the conditions. One is that groundwater recharging mechanisms like percolation tanks would enhance the availability of water (supply side adjustment). Another is shifting the cropping pattern towards less water intensive crops (demand side adjustment). It may be noted here, that contrary to the popular belief, there are crops like mulberry, grapes, citrus, etc, which are as renumerative as sugarcane and have lower water requirements, but they have marketing and/or processing requirements (Vincent, 1989)[5]. Moreover, some of these crops are suitably adopted to the conditions of these regions. Therefore, more concerted efforts are required on the part extension service department in order to educate farmers on various alternatives available for them within the given resource constraints. And, the role of non-governmental organisations (NGOs) in this regard would be vital.

REFERENCES

Shah, T. (1990) Sustainable Development of Groundwater Resources: Lessons from Amrapur and Husseinabad Villages, India, *ODI-IIMI Irrigation Management Network Paper 90/3d*, Overseas Development Institute, London.

Vincent, L. (1989) Assessing and Developing Irrigation Potential from Groundwater in Low Rainfall and Hardrock Areas: Case Studies from Andhra Pradesh State, paper presented at the workshop on Groundwater use and Management in Low Rainfall Hard Rock Areas, 4-6 October 1989, Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, India.

---

5 *These crops also have high cultivation costs, and thus can only be grown by farmers with available capital, and the tenure security to produce tree crops. With good water supply, groundnuts, vegetables and fodder can be profitable (although at a lower level than fruit crops or sugarcane): they have lower cultivation costs and are less demanding on operational budgets. With unreliable irrigation, net returns are low on most crops, and farmers will not risk extensive use of inputs. Editor.*

GROUNDWATER DEVELOPMENT AND DEPLETION: PROSPECTS AND PROBLEMS IN A POCKET AREA OF BANGLADESH[1]

M S U Talukder, M Ahmed, and M A Mojid
The authors are Professor, Associate Professor and Lecturer, respectively, in Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Bangladesh is mostly underlain by unconsolidated to poorly consolidated thick sediments. In addition, the tropical monsoon climate characterised by high temperature, heavy rainfall and often excessive humidity is very favourable for extensive development of groundwater resources in the country. Groundwater, a renewable natural resource, is observed in Bangladesh to be in dynamic equilibrium consistent with the extraction by natural and artificial means and recharge from rainfall, flood waters and surface water bodies. Different techniques and concepts for the development of groundwater are being practised without detailed investigation of the resources and its overall management policy. For example, the groundwater development programme using deep tubewells (DTWs) started in the country in late sixties. But tubewells were installed initially almost without evaluating the hydrogeologic characteristics and development potentialities of the local aquifers. There are important factors in determining the amount and cost of groundwater that can be developed and in forecasting the consequences of development.

The groundwater development programme in Bangladesh has been suffering due to various reasons, of which insufficient hydrogeological data, poor and widely variable estimates of potential recharge and improper matching of well numbers and types to the identified groundwater resources are all very important. Although many authors have called for better planning (Rust, 1983; Haque, 1984; Radosevich 1983), little attention has been given to the after-effects of heavy groundwater withdrawal and consequently many alarming situations have been anticipated (Khan, 1988). Often individual events are extrapolated without scientific foundation. For example, reactions began when in Bogra, Jamalpur, Pabna and Chittagong (four

---

1 A full version of this paper, complete with hydrological data, is available from the authors.

districts of the country) groundwater level failed to return to the previous year's level at the end of recharge period (Bhuiyan, 1983). In Joydebpur (an *upazila*) region, the groundwater levels dropped 15 m below suction pump capacity during dry season and it was estimated that the groundwater table might go 50 m below the pump capacity at the end of this century (Anik, 1984). At the same time, due to depletion of groundwater level the moisture content in the top layer of the soil diminished causing the land to become dry and sandy. If this trend continued without control, then certain parts of the country, especially the northern part could become deserts in the long run (Anik, 1984). Heavy pumping of groundwater in the northern part of Bangladesh exhausted soil moisture within the upper shallow aquifer affecting agricultural crops, many fruit and deep rooted trees and thus upsetting the natural econological balance (Khan, 1988).

However, many researchers did not agree with these predictions. It was observed that the highest and lowest static groundwater level at some locations in the northwestern part of Bangladesh (Rajshahi Barind area) came nearer the ground surface during 1987 after installing many deep and shallow tubewells, than during 1965-66 when there were no tubewells (Asaduzzaman, 1987). Asaduzzaman also reported that all types of trees and vegetation that grew in the area before installation of tubewells are still growing and no ecological imbalance have been observed.

We have completed a study of the Muktagacha upazila in Mymensingh, using test drillings and pumping tests. We studied monthly data on static water levels in 18 representative deep tubewells over eight years (1983-1990). We also estimated present requirements of groundwater based on total agricultural and domestic activities, made a field survey of existing vegetation in the dry season and interviewed experienced local inhabitants.

The aquifer in question is a single unit, layered with a mixture of fine, medium and coarse sands and sometimes with layers of gravels at the base. The aquifer was of the semi-confined/leaky type and possessed a good potential for development by 56 l/s (litres per second) to 85 l/s capacities deep tubewells. The thick clay layer above the aquifer limited the volume of storage in the upper part that restricted operation of suction lift pumps. The quality of groundwater in the aquifer was within the safe limit for irrigation purposes.

GROUNDWATER POTENTIAL

The overall development of the resources must be based on safe-yield which is actually the useable portion of the total dynamic component of the groundwater available within the zone of water table fluctuation. This component in the study area was essentially the result of the annual rainfall, seepage from surface water bodies and return flow from irrigated fields. The hydrologic safe-yield of the aquifer under study was estimated to be 621 millimetres (194.62 million cubic meters, MCM) for the dry season irrigation period with an allowable fluctuation of static water level of 12.42 meters. In fact, this safe-yield could be significantly increased by creating more recharge facilities through extending irrigation command area by abstracting more groundwater during dry season. The calculated safe-yield would allow water level fluctuation above mean sea level and would not create any possibility of saline water intrusion from coastal areas.

CURRENT UTILISATION STATUS OF GROUNDWATER AND EXTRACTION RATES

The utilisation of groundwater in the study area were being done by deep tubewells, shallow tubewells and hand tubewells. At present, 370 deep tubewells of capacities carrying from 56 1/s to 85 1/s, 50 shallow tubewells of capacities ranging from 14 1/s to 28 1/s and a large number of hand tubewells are operating over the groundwater basin. The amount lost from storage increased from 104.58 MCM in 1983 to 142.88 MCM in 1989, due to increasing extraction by continuous installation of new deep tubewells.

The effect of current rate of extraction was mainly focused on the position of static water level. The static water level started rising during March/April in response to monsoon rainfall, and started falling during September/October of the same year with recession of rainfall. The water table dropped very rapidly when irrigation wells started extracting groundwater. During the year the maximum and minimum depth of static water level from the ground surface in 18 locations were recorded to be 14.29 meters and 1.00 meters, respectively. The dry season water level dropped below suction lift capacity of suction mode pumps eliminating the possibilities of operation of these pumps. The lowest water level progressively declined from year to year due to increased extraction from storage by installing additional deep tubewells every year. However, the lowest values of static water level at the aforesaid locations indicated a fully recharged aquifer *at the end* of the rainy season except in 1989 (because of the severe drought in the same year). The long-term static water level trend also showed that whatever depletion of groundwater level occurred in dry season due to abstraction was completely recharged during the wet season indicating no mining of underground water. The results of this study clearly indicated that the groundwater reserve of the study area was in a stable equilibrium condition for the last 8 years (1983-1990) although a continuous annual withdrawal at an accelerated rate was made. Furthermore, almost in every year, the depleted aquifer was completely recharged from rainfall before the end of rainy season and a part of recharge opportunity time remained unused causing rejection of recharge.

AGRO-ECOLOGICAL EFFECT OF GROUNDWATER EXTRACTION

Attempts were made to evaluate the impact of heavy pumping on the agro-ecology of the study area. The large scale irrigation applied in high yielding variety (HYV) rice and other crops increased atmospheric water vapour and may have reduced temperature and increased the possibility of rainfall. Though static water level dropped beyond the extraction capacity of the roots of many fruit and other trees during the dry months of February to April, there remained sufficient soil moisture within the rootzone of these trees during the rest of the months of the year. The only problem encountered was the non-functioning of hand tubewells during the dry months which made stopped availability of potable water for drinking as well as household purposes. The deep tubewells served the purpose of hand tubewells during this period. The rural-based well-experienced people did not see any harmful effect on the growth of any type of vegetation including large trees, because of groundwater extraction. In some cases they were encouraged to grow some necessary vegetation through having facilities for continuous supply of water during dry months.

We know that the techniques of groundwater evaluation are relatively subjective, and that questions may be asked about the accuracy and rehability of our initial results. We suggest the evaluation studies should be continued for reassessment and refinement until a database is available which is suitable for long-term planning.

The main impact of current levels of development (which are still below the full aquifer potential) has been on shallow watertable conditions in the dry season, and it appears that local people have been able to adapt to these.

However, on-going monitoring is required. We know we are actually still pumping within the safe regional limits of the aquifer, but we must ensure that development stays within this limit.

REFERENCES

Anik. (1984) Irregularities in Irrigation Management, *The Sangbad*, May 27, (a daily newspaper), Bangladesh.

Assaduzzaman, M. (1987) Development and Utilisation of Water Resources in Barind Area, *The Sangbad*, June 8, (a daily newspaper), Bangladesh.

Bhuiyan, S I. (1983) Groundwater Irrigation in Bangladesh: Development at the Cross-Roads, paper presented at the Institute of Engineers, Dhaka, Bangladesh.

Chowdhury, A K M J U. and Bhuiyan, S I. (1977) An Inflow-Outflow System Analyses for Evaluating the Groundwater Potential of Mymensingh and Tangail Area, paper presented at the Second Annual Conference of Bangladesh Association for the Advancement of Science (BAAS), BAU, 23-27 January.

Khan, L R. (1988) Environmental Aspects of Groundwater Development in Bangladesh: An Overview, *ODI-IIMI Irrigation Management Network Paper 88/2c*, Overseas Development Institute, London.

Pitman, G T K. and Haque, M. (1984) Groundwater Development and Planning: Problems and Prospects, paper presented at the Second National Water Plan Workshop, 7-10 October, Bangladesh.

Rahman, M A. Haque, M M. Haque, M R. and Talukder, M S U. (1979) Recharging and Depletion Characteristics of Mymensingh Aquifer, *Agricultural Science 6(2): 161-166* (Bangladesh journal).

Rust, H. (1983) A consultancy report to United States Agency for International Development (USAID), Dhaka.

Radosovich, G E. (1983) Groundwater Development and Management in Bangladesh: Institutionalizing a Strategy.

GROUNDWATER DEVELOPMENT AND MANAGEMENT IN THE CRITICAL AREAS OF ANDHRA PRADESH, KARNATAKA AND TAMIL NADU STATES OF SOUTH INDIA

D S K Rao
Technical Manager, National Bank for Agriculture and Rural Development, Bangalore, India

INTRODUCTION

Liberal energisation of wells, subsidised power tariff for agriculture pumpsets and easy availability of institutional credit have contributed to a surge in groundwater development in Andra Pradesh, Karnataka and Tamil Nadu states of south India during the last three decades. The number of wells increased from 1,510,000 in the year 1960, to 2,860,000 in 1985 (Karnataka state registered a more impressive growth rate of 9.8% per annum). In the above period, the area irrigated by wells increased by more than two times.

Though rapid increase in groundwater irrigation was recorded in most parts of the country, the adverse effects of over development are more conspicuous in the three southern states because of the predominance of low rainfall hard rock areas which cannot sustain large scale development.

High initial cost, execution delays, inter-state disputes and environmental problems are a few limiting factors in expanding irrigation through major and medium projects. Poor management is eroding fast the vast potential of more than 100,000 irrigation tanks created through the ages. Given the above limitations, further increase in irrigation potential can be achieved only by maintaining the pace of groundwater development. The recommendation of the Working Group on Minor Irrigation for Formulation of the VIII Five Year Plan, proposing an investment of Rs 12 billion[1] for constructing 525,000 wells in the three states during 1990-95, confirms this view. However, development has to be on scientific lines. Otherwise, such ambitious targets will have devastating effects on the groundwater regime,

---

[1] In 1991, 20 rupees = $US 1.

1. PROBLEM AREAS

The critical groundwater ares in the southern states suffer from a number of problems related to estimation of potential and development and management of groundwater. Among them are the following:

Estimation of Potential The State Ground Water Departments (SGWDs) are responsible for estimating groundwater balance and classifying the blocks (group of villages) as 'white' (under-exploited), 'grey' (close to fully exploited) and 'dark' (fully exploited) areas.

Estimation of groundwater potential reveals that more than 90% of the blocks are under-exploited (white), whereas the ground realities are different. Over exploited conditions, reflected by alarming decline of water levels, are existing in many areas, including in a few white blocks.

Development of Critical Areas It is a paradox that demand for wells is more in dark and grey areas as compared to white areas because, the aquifer capabilities in a developed area are proven and the farmers are tuned to the advantages of well irrigation. Though institutional credit is not available for wells in the dark blocks, construction of new wells is going on unabated, resulting in alarming decline of water levels. Investments in such areas merely inflate the number of wells, with hardly commensurate increases in irrigated area.

Well Design in Critical Areas Design of wells in the hard rock areas, particularly in the critical areas, has undergone a vast change during the last decade. The traditional large diameter, shallow open wells were initially converted to dug-cum-bore wells, and later to bore wells (and then to still-deeper bore wells). Consequently, thousands of dug wells have gone dry and had to be abandoned along with their centrifugal pumpsets. However, the chase of groundwater through deeper and deeper bores cannot go on forever, because the productive fracture zone in the hard rocks is limited, which is already exceeded in the critical areas by bore wells.

Tradition-bound farmers insist of constructing large dug wells, at times 3 to 4 times larger than the optimum size, not realising that the recuperation capacity of wells is independent of the size[2]. Unproductive expenditure due to fall in water levels, reduces the useful life of a bore well to a mere 3 to 4 years. With thousands of bore wells constructed each year in the critical areas, the wasteful expenditure due to faulty well siting, over designing and reduced life is astronomical.

It is essential to arrest the declining trend of water levels. Improving recharge by desilting irrigation tanks and constructing new percolation tanks besides other soil conservation methods are a few important steps in this direction. In addition, drastic reduction in groundwater draft by shifting the crop pattern in favour of widely spaced crops which could be irrigated through drip system is necessary.

Inequitable Distribution In critical areas, due to lack of institutional credit, only those who could mobilise private resources could construct wells. Denying institutional credit in a dark block, however, justified, has deprived the poor farmers of the vital input of credit and forced them to continue with subsistence rainfed farming or purchase of water at exorbitant prices. Cultivating large ares of horticultural crops and irrigating them through community drip irrigation appears to be the solution for improving equity under well irrigation, particularly in the critical groundwater areas.

Electrification of Agriculture Pumpsets Farmers in the critical areas of Tamil Nadu construct bore wells because of deep water level conditions which do not favour dug wells. These farmers are forced to operate the bore wells with inefficient compressor pumps and incur heavy operational costs because of the enormous delays (up to 8 years) in receiving electric connections.

With the introduction of a flat tariff for agriculture pumpsets (in Tamil Nadu state, power consumption of electric pumpsets up to 5 HP is free), farmers are resorting to indiscriminate and almost incessant pumping, which has played havoc with the slender groundwater resources of the critical areas. As a result, even villages depending solely on groundwater for drinking are seriously affected.

---

[2] Many farmers construct these large diameter wells to provide a 'reservoir' for pumping, since in hardrocks the low transmissivities means water will be drawn down while pumping. These wells may take a day or more to recharge.

Government Sponsored Schemes - Subsidy Government of India and the State Governments have sponsored several schemes for groundwater exploitation and its efficient use. Under these schemes, selection of areas for implementation and the subsidy rates have to be determined more scientifically. For example, under the schemes for installing drip system, the subsidy rate does not vary between Thanjavur district which has abundant groundwater and Kolar and Coimbatore districts, known for scarce groundwater.

After demarcating the critical groundwater areas, schemes for conservation of water could be implemented in such areas more aggressively, if necessary by providing much higher doses of subsidy. The present policy of spreading the subsidy uniformly for all areas will not achieve the desired results.

3. WATER USER ASSOCIATIONS

The drop in water levels in the critical areas is bound to be more rapid in future due to lower aquifer transmissibility as a result of reduced saturated thickness. Serious attempts, therefore, have to be made to arrest the declining trends. Groundwater legislation, though effective, could not be considered seriously in view of the difficulties involved in implementation. The ultimate solution probably lies in the collective management of water resources by farmers themselves. Water User Associations at village/micro watershed level have to be organised to decide the future development of groundwater and also improved management of the available meagre resources.

4. ISSUES FOR FUTURE STUDIES

Estimation of Potential Study a couple of blocks/watersheds in detail to compare the potential for wells as estimated form the groundwater assessment carried out by the State Ground Water Directorates and on the basis of field conditions. Such comparison will give a clue to a realistic estimate of the feasible number of wells which will form the basis for more purposeful planning.

Design of Wells Study the well design adopted by the farmers and examine their suitability to the hydrogeological conditions.

Decline of Groundwater Levels Is the declining trend of water levels in critical areas due to erratic and inadequate rainfall or over development? Study the effect of large scale groundwater extraction through bore wells on the existing open wells and shallow bore wells.

Bore Well Failures Study the high rate of failure (reported to be about 60% in critical areas) of the bore wells are the construction stage. What is the life of bore wells in critical areas due to declining water levels and how does it affect the viability of the investments on wells and pumpsets?

Technical Advice to Farmers Study the existing institutional arrangements for tendering advice to farmers on site selection and well (and pump) design - suggest improvements.

Energy Tariff Study the impact of subsidised, flat energy tariff on the extraction of groundwater, particularly in bore well areas. Also the advantages of metered tariff over flat tariff. Which class of farmers is actually benefitted by flat tariff and at whose cost?

Inequitable Distribution How do poor farmers cope with the need of drilling deeper and deeper bores due to declining water levels? Is groundwater in critical areas the monopoly of the more affluent who could drill deeper?

Development of Critical Areas What is the impact of denying institutional credit for wells in critical areas? Which section of farmers is affected most by this policy? How far this policy has helped to retard the growth of wells and arrest the decline of water levels? What is the relevance to groundwater legislation to Indian rural conditions.

Protection of Critical Areas - Water User Associations What is the awareness of farmers and administrators in critical areas to the impending danger of declining water levels? Are the farmers in a mood to organise themselves and face the challenge? What could be the role of NGOs in this direction? What is the scope in the critical areas for shift in the cropping pattern in favour of widely spaced horticulture crops which could be irrigated through drip system? How far can marginal farmers could be benefitted by community drip irrigtion system, installed on a common well?

A PROPOSED ACTION PROGRAMME TO MAINTAIN GROUNDWATER LEVELS AND ACHIEVE SUSTAINABLE AGRICULTURE IN TAMIL NADU

R K Sivanappan
Chairman, Centre for Agriculture, Rural Development and Environmental Studies, Coimbatore, India

Groundwater is extracted through 1.6 m wells to irrigate about 1.2 MHa in Tamil Nadu, which is almost 40% of the total irrigated area. The depth of open wells vary from 10-15 m in some pockets and near the river bank to 50-70 m in districts like Coimbatore. Bores inside the open well have gone to a depth of another 50-70 m in various places. Groundwater bores have gone up to 100-150 m. The groundwater table has depleted from 10 m to 50 m in the last 40-50 years. The area of irrigation by each well has reduced from 1.5 ha to less than 1 ha in the last 20-30 years.

The assessment of groundwater potential is estimated by many agencies/scientists and the figures given are anybody's guess. It varies from 1.4 MHm to 2.56 MHm.

The last data given by the Directorate of Ground Water has indicated that the total groundwater draft is about 50% and there is scope for constructing another 1.2 MHm wells in Tamil Nadu. However, if you visit the various districts and analyse the groundwater potential, it is observed that most of the wells in all the districts have reduced water supply and thousands of wells have been abandoned. This alarming situation is not only found in Coimbatore, which is traditionally known for its groundwater shortage, but also in Madurai and Chidambaranar and Ramanad Districts.

The Government records say that the extraction of groundwater in Pasumpon District is 1% to 24% in various blocks and about 80,000 more wells could be constructed in the District. But the picture in the field is completely different. Though the district obtained good rains during January 1990, the situation is alarming. In many *taluks*, the water table has dropped to 20-30 m from ground surface and large numbers of irrigation wells have deep bore wells inside to a depth of 60-70 m, and side bore for a distance of 50-70 m.

Further, hundreds of wells in Chidambaranar district (Sathankulam block), Madurai District (Chinnamanoor and Andipatty blocks), and thousands of wells in Coimbatore district (Karamadai, Sulur, Madukkarai, Avinashi blocks) have been abandoned. The depletion of groundwater totals is very alarming all over Tamil Nadu. Therefore, there is an urgent need to look into this aspect very seriously and take some urgent action. Otherwise, even drinking water may not be available in another 5-10 years if the trend continues.

There are many controls in regulating/construction of wells in the State. Banks give loans if the spacing of 200 m is maintained. The electricity is given only for about 8-16 hours daily in most of the areas. Energisation is not that easy and it takes at least 4-6 years. In spite of these restrictions and constraints, many new wells are constructed every year, not only by the individual farmers but also by the Government. The net result is not only lowering the water table and reduced water supply but abandoning of these wells. Though the public as well as Government are aware of the situation, no concrete action is taken for want of proper perspective and will.

As early as 1977, the Tamil Nadu Government brought the groundwater control and regulation bill in the assembly. However, subsequently, it was dropped as there was a strong lobby opposing it. Government of India is advising all the State Governments (including Tamil Nadu) to enact groundwater laws, but nothing could be done so far. Even today, the farmers are able to pump water from these deep wells, thanks to the free (nominal) electricity charge (Rs 50 HP/year) levied by the Government. This again has accelerated the process of depletion of water table and wasting of ground water by many farmers.

Under these circumstances what is to be done is the question. The following action plan is suggested:

- The situation is very serious and all (farmers, public and government) should know the consequences;
- Critical analysis of the rainfall of the area/water shed;
- Assessing the groundwater potential realistically;
- Need for groundwater regulation and control at least in some basins/watersheds to start with;

- Need to diversify crops and cropping patterns based on the available water (tapped);

- Maintaining groundwater level at a determined/particular depth for sustainable agriculture;

- Introduce crops which will use less water, but give more profit per unit quantity of water;

- Adopt drip and sprinkler systems;

- Water should not be conveyed through open/earthen channels on any account, but use pipes with control structures;

- Recharge the groundwater by providing suitable structures.

Government should not invest money for deepening wells or to go for deep bore wells for getting water during the summer. Instead that money may be used to conserve the water during the rainy seasons and encourage economical utilisation of water. The farmers in one village (Iyyampudur in Gobi taluk) have spent nearly 10,000,000 rupees for drilling borewells up to 500 ft depth (250 wells) and installing compressors, but without success. This trend is there in Mettupalayam, Avanashi, Pallam taluks of Coimbatore district, and many other districts including Ramanathapuram which is supposed to be a backward district. If this trend is allowed to continue, the fate of the Tamil Nadu is very gloomy. If the people and Government do not view this trend seriously, immediately, the future generation will blame all of us. Hence, an action plan should be worked out and implemented before 2000 AD, otherwise all are doomed.

Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England.
Telephone: +44 71 487 7413
Telex: 94082191 ODIUK
Fax: +44 71 487 7590

odi

IRRIGATION MANAGEMENT NETWORK
(African Edition)

Network Paper 6

PROMOTING A SMALLHOLDER-CENTRED APPROACH TO IRRIGATION: LESSONS FROM VILLAGE IRRIGATION SCHEMES IN THE SENEGAL RIVER VALLEY

Geert Diemer, Boubacar Fall and Frans P Huibers

THE LIBRARY
OVERSEAS DEVELOPMENT INSTITUTE
REGENT'S COLLEGE
INNER CIRCLE REGENT'S PARK
LONDON NW1 4NS

CTA

The African edition of the Irrigation Management Network is supported by the Technical Centre for Agricultural and Rural Co-operation (CTA)

October 1991

Papers in this set:

6 *Promoting a Smallholder-Centred Approach to Irrigation: Lessons from Village Irrigation Schemes in the Senegal River Valley* by Geert Diemer, Boubacar Fall and Frans P Huibers

7 *Structural Adjustment and Irrigated Agriculture in Senegal* by Philip Woodhouse and Ibrahima Ndiaye

8 *Large-Scale Irrigation Schemes in Northern Cameroon: Development and Disengagement* by Achille Bikoi

9 *Design and Operation of a Small Irrigation Project in Zimbabwe to Minimise Schistosomiasis Transmission* by M Chimbari, R J Chitsiko, P Bolton, and A J Thomson

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

Linden Vincent, Editor, Irrigation Management Network (African Edition), Overseas Development Institute, Regent's College, Inner Circle, Regent's Park, London NW1 4NS

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

The opinions represented are those of the author and do not necessarily reflect the policies of the Overseas Development Institute, or any organisation with which the Institute or author is connected.

PROMOTING A SMALLHOLDER-CENTRED APPROACH TO IRRIGATION: LESSONS FROM VILLAGE IRRIGATION SCHEMES IN THE SENEGAL RIVER VALLEY[1]

by Geert Diemer, Boubacar Fall and Frans P Huibers[2]

Contents **Page**

---

[1] This article is based on our submission to the International Conference on the Crisis in African Agriculture, organised by the Cheik Anta Diop University in Dakar from 17-23 December 1988.

[2] Geert Diemer and Frans P Huibers are attached to the Irrigation and Water and Soil Conservation Department of Wageningen Agricultural University, The Netherlands. Boubacar Fall worked for the West Africa Rice Development Association (WARDA) between 1986 and 1989.

PROMOTING A SMALLHOLDER-CENTRED APPROACH TO IRRIGATION: LESSONS FROM VILLAGE IRRIGATION SCHEMES IN THE SENEGAL RIVER VALLEY

by Geert Diemer, Boubacar Fall and Frans P Huibers

FOREWORD

Many planners and technicians feel that the development of irrigation systems could offer a solution to the crisis in food production in Africa.

Irrigation seems to be an appropriate response to the harmful effects of irregular rainfall and frequent droughts. Moreover, irrigation seems to provide planners with the institutional means to channel smallfarmer production in accordance with national planning objectives. This is because current norms regulating the economic planning and technical design of hydro-agricultural schemes[3] require centralised management of the hydraulic network.

In this paper, we examine the empirical validity of these norms. Having identified the trends common to colonial and post-colonial policy with regard to agricultural development, we briefly review the historical background to the emergence of the current design procedures for hydro-agricultural schemes. We analyse the sociological research dealing with the phenomenon of irrigation in Africa, from the point of view of its contribution to the analysis of the crisis in hydro-agricultural production. We then identify the factors which explain an isolated case of success, namely the village irrigation schemes in the middle regions of the Senegal river valley. We pinpoint two factors governing the viability of hydro-agricultural infrastructure, viz, the dynamics of the smallfarmer production system and the local political system. We conclude by presenting the changes needed in terms of planning and designing hydro-agricultural schemes.

---

3 The term 'hydro-agricultural schemes' is a direct translation of the French term 'aménagements hydro-agricole'. We use the term as it is appropriate for interventions in the wide range of indigenous water management practices in African hydrological environments. These include flooding, and flood recession agriculture, as well as conventional irrigation practices.

1. IRRIGATION IN AFRICA: TWO DIFFERENT CONTEXTS

People who speak of a crisis in the development of irrigation systems in Africa should confine their remarks to projects which are not generated from within local societies. These interventions may be contrasted with the perfectly viable schemes set up by the Taita, Chagga, Meru, Pokot and many other peoples in the Rift Valley, East Africa. Other examples are the polders established and managed by Baga, Balanta, Diola, Mandinka and other smallfarmer societies in the marshlands of the Atlantic Coast and the gardens set up in the dunes by Wolof smallholders, to mention but a few. In other words, the crisis shows itself in irrigation schemes designed and managed by technicians from the outside.

Like African hydro-agricultural techniques and any other techniques, these irrigation interventions were developed in specific contexts for specific purposes. The irrigation techniques in the 'land of water' - the Netherlands - were not a result of the fight against the encroaching sea, but a legacy from the colonial conquest of the island of Java in present-day Indonesia. To be more specific, they have their origins in the development of sugar-cane as a cash crop. Irrigation schemes covering hundreds of hectares were set up and managed by a single owner: the sugar company.

French irrigation techniques date back to the 1820s in Senegal, where irrigated plantations for the production of rice and dye-producing plants were established in the Senegal river delta. These techniques were then transplanted to Morocco, to develop commercial agriculture for the colonial settlers, and to the interior delta of the Niger river in present-day Mali. Schemes along the Niger were intended to produce cotton for metropolitan industry, like the schemes established by the English on the banks of the Nile in present-day Sudan. These irrigation techniques were thus developed in situations with two specific characteristics: domination of the local people and the intention to mobilise resources (water, soil and labour) in the pursuit of aims foreign to rural society.

2. SOME CHARACTERISTICS OF THE ORIGINAL SCHEMES

Let us look more closely at these two schemes on the banks of the Nile and Niger rivers. Their aims were identical: on the one hand, to reduce the burden on the colonial power by generating income for the administration and, on the other, to strengthen the market economy by supplying raw material (cotton) for the textile industries. In both schemes, food crops were envisaged only to provide subsistence for the farmers. In Mali, the farmers were supposed to grow rice, although their staple diet was millet and sorghum. Moreover, they could only cultivate within the scheme; rain-fed crops were prohibited. In Sudan, rain-fed agriculture was impossible because of insufficient rainfall. Moreover, the extent of the schemes and their contiguous nature, an almost unbroken stretch of some tens of thousands, and then hundreds of thousands of hectares, made it impossible to associate irrigated crops with rain-fed crops or animal husbandry.

The areas under irrigation were contiguous as far as possible because this reduced investment costs per hectare, the main item of expenditure being the construction of dykes and canals. The expansion of these areas was designed to increase production and thereby the revenues of the colonial administration and the delivery of raw materials to the metropolitan industries.

The two schemes were managed by parastatal agencies. Before 1932, the Niger River Scheme (known as the Office du Niger) was managed by a cotton-growing company and then by a public body belonging to the French state. Both had Boards of Directors; in the case of the Gezira scheme, the 'Sudan Gezira Board'. Both agencies were the owners of the schemes and were judged by the economic and financial results of their means of production, i.e. the irrigation network and the labour power of the farmers. The latter were not allowed to own the land they cultivated. They were called 'tenants' and bound to the managing agencies by renewable annual contracts, although they also had to work for themselves. Such contracts stipulated that the tenants must obey the instructions of the agency's representatives and were liable to non-renewal of their contracts if they disobeyed.

The conditions under which such schemes were established, as well as their aims, meant that the managing agencies had to deal not only with the irrigation network, but also the management of the farms within it. The colonial power structure gave the managing agencies sufficient leeway to impose centralised management of the network. They could therefore, with the support where necessary of the colonial forces of law and order, ensure that their production objectives prevailed against those of the tenants.

3. CURRENT PLANNING AND DESIGN OF HYDRO-AGRICULTURAL SCHEMES

These first government attempts at hydro-agricultural development may be likened to the establishment and management of factories. The managing agencies resemble the management and board of directors of a private enterprise. The status of the tenant was less that of an autonomous smallfarmer free to choose his land, crops and methods than that of a worker obliged to produce a product selected by management, using methods also selected by the latter. The processed raw material - water - was distributed to the machines - the plots of land - in accordance with the theory of marginal costs. Economic performance was barely, if at all, measured in terms of income generated by the tenants, but rather in terms of the profitability of the investment.

This 'industrial' approach characterising Western irrigation techniques is reflected in current design methods such as the principle of selecting the crop in advance, the principle of sharing water between plots rather than between farmers, the stress placed on economies of scale, etc. These principles illustrate the fact that decision-makers and investors are seeking to introduce irrigation in the hope of meeting objectives not shared by the local society. An example in Africa would be that of planners wishing to reduce rice imports by stimulating in-country production.

As in the colonial era, irrigation engineers find themselves asked to design a scheme which will mobilise the resources of a rural society to attain aims pursued by elements from outside that society. Pedologists are sent to choose the soil and agronomists to select the varieties to be grown. The irrigation engineer is sent to calculate the plants' water requirements in accordance with the climate and the permeability of the soil. He then establishes the interval between irrigations and peak water needs. He orders a topographical survey to determine the sites and dimensions of the canals. All these engineers have to act as if the scheme belonged to a single owner. They work without having to consult the smallfarmers, as their responsibility is really to design a scheme against the single criterion of meeting the water requirements of the plant to be cultivated.

In this approach, the size of the network, the area to be irrigated and the choice of the crop and variety are closely linked. This 'industrial' approach also implies that farmers must sow during the period set by the engineers who design and manage the scheme and they must till, weed and harvest at the times determined by the latter. The scale of the scheme and the impossibility of supplying more water than peak-period requirements make centralised management inevitable. This in its turn assumes the ability to direct and coordinate farming activities, i.e. the smallholders' agricultural work. The role of individual farmers is less important and they have no influence on the major decisions by which they will be bound. Moreover, the management of the scheme takes no account of their other economic and social activities. It is quite common for managers of large schemes to use coercion to direct smallfarmer behaviour.

The result is that the design of African schemes is dictated by the following norms, which are very rarely made explicit:

- the users must be 100% dependent on their irrigated plots for their food and cash income;

- the users must maximize the net production of their plots to offset the initial investment;

- the bulk of their production must be sold in order to comply with the policy of such schemes and meet the costs they involve;

- the management must sign the contract only with the person they see as head of household and not with other people involved in production, in particular a wife or wives;

- the earlier division of labour between men and women, young and old, is not relevant in the context of the scheme;

- the crop must be chosen by the investor;

- means of production must only be allocated to the head of the household;

- income from sales must be handed only to the head of the household;

- the plots to be irrigated must be contiguous so as to obtain the most favourable ratio between the area under irrigation and the length of the canals;

- the soil must be homogeneous;

- the irrigation turns must be designed to make the best possible use of the water.

One may conclude from this that the fact that hydro-agricultural planning and design techniques are expressed in physical terms does not make them neutral parameters. The principle of allocating water to plots is a good example of what we mean. This principle ignores the fact that the plots belong to smallfarmers, and consequently ignores their mutual political and organisational relationships. All these principles reflect the way planners and technicians think an agricultural scheme should be managed and an irrigated plot should be worked.

This suggests that irrigation is a social as well as physical matter. Let us now look at the insights obtained from sociological research into irrigation in Africa.

4. THE SOCIOLOGY OF IRRIGATION IN AFRICA

As far as irrigation is concerned, the social sciences have not hitherto been greatly interested in the problems and techniques of hydro-agricultural development. They have tended to ask questions which reflect their theoretical perspective. These fall into two categories:

- what effect do government irrigation projects have on rural societies?

- how do African farmers manage systems they have built and maintained for themselves and to what purposes do they put their plots?

The first type of research deals with the *transformations* effected within the society. In the 1970s, several sociological surveys considered the introduction of government schemes. Studies on Nigeria, Gambia and Ghana, were conducted by Wallace (1979), Dey (1982), Adams and Grove (1983), Jackson (1985), and Konings (1986). These writers studied developments in the agricultural landholding system; the influx of landowners from outside local society; the advent of new working relationships; smallholders' relationships with input suppliers and crop purchasers, public authorities, politicians, officials and irrigation service technicians; and their relationships with other immigrants. The authors approached these subjects from a theoretical perspective. For their purposes, irrigated agriculture was the context within which they tested an anthropological or sociological theory.

Documentation dealing with endogenous irrigated agriculture tends to be of an ethnographic nature. There are also communities in Africa which have been practising irrigation since well before colonial times. Some systems have been described by sociologists, amongst them those of the Sonjo people in Tanzania (Gray 1963; Potkanski 1988), the Taita in Kenya (Fleuret 1985), the Ewe in Ghana (Grove et al, 1982; Chisholm, 1984), the Baga in Guinea-Conakry (Paulme, 1957), the Diola in Senegal (Linares, 1981; van der Klei, 1989) and the Mandinka (Haswell, 1963; Weil, 1973).

These researchers particularly studied the irrigation infrastructure and the political relationships within which these rural peoples managed their schemes. An analysis of this literature shows that management of the infrastructure was part of the local political system. Fleuret considered that management of the irrigation network was part of the daily political process for the Taita. Gray and Potkanski demonstrated that the key to the distribution of irrigation water was the balance of power between the three classes of free men recognised by the Sonjo. In a study of the legal system of the Chagga, Moore observed that this society comprises four autonomous entities: the market, the district, the lineage and ... the irrigation committee. The work of van der Klei and Linares established that the Diola do not recognise any chiefs at village level or in terms of managing their polders. Grove et al were more interested in relationships with the market. Fleuret, Gray and Moore stressed the integration of plots under irrigation within the system of resource use including dry farming and animal husbandry. Fleuret showed that the Taita use their hydraulic infrastructure to produce not only for subsistence purposes, but also for the market, like the Chagga who have become famous for their coffee.

These academic studies were backed up by work on what we might call the sociology of organisation. In this approach, researchers define their objective as developing more effective ways of organising the design and management problem. They study the development and operation of an irrigation project as a management problem. This approach originated in the USA during the 1970s, as a result of research commissioned by donors such as the World Bank, USAID, and the Ford Foundation.

These donors had become alarmed by the combination of high installation and operating costs with disappointing yields in South Asia, something which is also found in sub-Saharan Africa. Their concern was heightened by the fact that the yield of the new varieties of rice, developed with their financial assistance, depended on carefully measured amounts of water being delivered at the right moment. The research to be conducted by the sociologists dealt with relationships between farmers using irrigation, between the latter and the technicians and between the technicians. They were intended to design organisational principles enabling the new varieties of rice to receive an adequate supply of water.

Sociological research conducted within this framework takes the scheme and the irrigation service as the macrocosm. The picture which emerges is that of physical infrastructure (canals, plots, etc) constituting the 'hardware', and social relationships the 'software'. The sociologists' job is to put together a programme which will enable the engineers' 'hardware' to function (better). This approach does not call into question the assumptions which underpin the criteria used by planners and designers. It forms the core of papers in the book edited by Coward (1980), although he has been a key proponent of better understanding of local institutions. Research based on this perspective has so far been conducted primarily in South-East Asia.

What insights can be gained from these three viewpoints to overcome the crisis in the development of irrigation systems? The 'transformation' approach shows that the crisis is political and social as well as economic. The old power relations between farmers have been replaced by new ones which are sometimes more unequal. The division of labour between men and women, old and young men, almost ceases to be relevant within the schemes. Smallfarmers are often no more than mere tenants of people who live in towns. Researchers have shown that engineers restructure not only the landscape but rural society as well. In doing this, they meet not only the resistance of the land and the force of the water, but also the resistance of the production system and the force of the local political system.

The 'ethnographic' approach shows that the crisis in irrigation is confined to exogenous development. It provides the information enabling a comparison to be made between 'industrial' and indigenous schemes, even though the researchers do not themselves make such a comparison. It shows that amongst the Taita and other African peoples, planning and management of hydro-agricultural infrastructure are linked to the political system and that the use of the plots fits within the existing production system. It implicitly reminds us that Western methods of design and management are also imbued with political and economic norms.

Finally, the 'organisational' approach originates from quite a different context than that of Africa. In South Asia, canals stretch over tens and sometimes hundreds of kilometres, irrigating hundreds of thousands of hectares. Managing such networks presents quite different problems to those encountered in sub-Saharan Africa, where few schemes cover more than ten thousand hectares. Still more importantly, in Asian systems, the farmers still control their own land. Farmers retain at least a degree of choice as to the crop they grow and their land is not confiscated, except for construction purposes. In Africa, on the contrary, farmers do not retain control of their land but are dispossessed. Along with their land, they lose all freedom to choose their crop. The management does its best to destroy their farming system and their internal organisation in respect of production and consumption, and does not consider existing gender relations. In stressing management of the network, the organisational approach fails to take account of the fact of there being little economic interest in irrigated agriculture for smallfarmers.

None of the three approaches identifies planning and design methods which would help to rescue official irrigation schemes from the present deadlock. So let us now, armed with our knowledge of the 'industrial' vision which inspires current methods of hydro-agricultural planning and design, and of the sociology of irrigated production in Africa, look at the factors responsible for the recent success of village irrigation schemes in the Senegal River Valley.

5. THE RELATIVE SUCCESS OF VILLAGE IRRIGATION SCHEMES ALONG THE SENEGAL RIVER

The number of village schemes had risen from zero in 1970 to over 700 in 1988, covering a total of 14,467 hectares (OMVS, 1988). What are these schemes like and what factors have led to their rapid spread?

A village scheme often covers about 20 hectares. It is managed by all the owners of the plots who were known as producers' groups until 1988, but which are now changing into 'economic interest groups' following a new law offering tax advantages. These groups generally have between 40 and 80 members, equivalent to the number of plots in the scheme. The members own their plots. Plots within a scheme are about the same size, although the average size may vary from 0.2 to 0.8 hectares. In most cases, the owners live in the same village. The schemes are located close to a river or floodplain channel, usually less than 100 metres away. A motor-pump lifts up the water and pumps it back through pipes into the dispersal basin located on the levees. A basic network of open channels, regulated by an average of ten sluice-gates, carries the water to the plots.

The smallfarmers and a national agency[4] share the construction of village schemes. When the village lands include areas close to the river or a stream, the group suggests the site to the agency which makes a technical assessment. Should the group's village not have any land close to a water source, it may negotiate with a neighbouring village to make land available in accordance with the laws governing national resources and rural communities. Should the technical assessment be favourable, the agency sends a topographical team and the villagers clear the land, which is often wooded.

On the basis of a plan worked out by the technicians from the agency, smallholders belonging to the new group dig the channels and shape the plots. They are helped in this to varying degrees by the earth-moving equipment of the agency. The sluice-gates/weirs are constructed by skilled masons paid by the agency. Once the scheme has been built, the peasants draw lots for the plots.

This extraordinary way of allocating land was introduced by the teams from the agency who set up the first schemes. These were initially designed to save the people from famine. In view of this, both the agency and the villagers were agreed that anyone who wanted one should be allocated an irrigated plot. This procedure corresponded to the desire of the teams to break the domination of the 'free', land-holding clans over the descendants of slaves. It was made easier by the fact that the newly-irrigated lands were not very significant within the farming systems at the time. It should be noted, furthermore, that this procedure of allocating by lot is still practised. However, it is now more common for the representative of the clan holding the land before the scheme was set up to receive additional plots.

---

[4] The agency involved depends on location. In many locations, this agency is helped.

The next phase is to manage the scheme and bring the plots into production. The smallholders see it as natural and obvious that management of the scheme should be modelled on the organisational relationships to which they are accustomed in other fields. Haalpulaar villages, for example, have many associations, amongst them the 'youth association' for young people from the village. These associations seek to maintain the village, arrange construction or repair of wells, renovate market places, pay for the training of a village midwife or construction of classrooms, etc. They may also organise wrestling contests or other activities to make village life more agreeable. The associations sometimes manage substantial amounts of money, especially if their funds are topped up with remittances from migrant workers in France or other African countries. Associations also have procedures for monitoring cashflow.

The organisational model which underpins associations is learned in the 'age-sets'. Formerly, an institution for the initiation of boys, the age-set system has retained its function of socialisation. When children are between 8 and 12 years of age, their parents organise one age-set for boys and another for girls. Membership is for life. The children must elect a president, treasurer and so on. They may decide to pay dues in order to purchase sweetmeats, drinks, etc. In these age-sets, children learn to act as members of a group, take collective decisions and stick to them (or make sure others stick to them). Some children, particularly those belonging to dominant lineages, learn to dominate their peers, while the others, for instance the children of slave descendants, learn to obey. In the words of a Haalpulaar: "the *fedde* (vernacular for age-set) are our schools".

It is just as natural to replicate political divisions within the scheme. In the case of the Haalpulaar, there are three social classes, neighbourhoods/villages and political factions. The Haalpulaar divide themselves into free men, artisans and slave descendants. Until about 1980, village policy-making was the exclusive preserve of certain lineages of free men, with both artisans and slave descendants excluded. When it comes to selecting presidents or secretaries for irrigation groups, one generally finds free men rather than artisans or slave-descendants.

As a result of legislation, universal suffrage and migration, the gap between slave descendants and free men has shrunk to such an extent that, when irrigation schemes were established, descendants of slaves could join groups and own plots. The village now represents the local political unit. Inhabitants tend to see themselves as part of a particular village. When villages have to manage a scheme together, they also tend to do this, i.e. to see the others as belonging to a different political system, with all its implications in terms of dependency and loyalty. When there is an equal number of members from two different villages, management is deadlocked, because there are no institutions at inter-village level to resolve disputes. When members live in a single village, i.e. belong to the same political system, disputes are generally settled in the context of shared dependency and loyalty.

This indicates that valley dwellers have copied the organisational model of their age-sets in managing their new infrastructure in the form of the hydro-agricultural scheme. Members' access to prestigious and leadership posts, the distribution of plots and the settlement of other issues do of course reflect the divisions found in the village political arena. The success of village irrigation schemes is partly due to the match between the local political system and the infrastructure, as well as the fact that valley dwellers were free to organise the management of their schemes along the lines of a model with which they were all familiar.

Getting back to the insights gained from an analysis of the ethnographic research, it is clear that management of village schemes resembles the way the Taita and others manage their hydro-agricultural infrastructure in that it is an integral part of the local political system.

The fact that the valley dwellers were willing to organise themselves to construct and manage the schemes indicates that the use of irrigation fitted within their production objectives. During the 1960s and 1970s, production and consumption amongst the Haalpulaar was organised at household or *foyré* level. The *foyré* comprised the husband and his wife or wives, their children and sometimes some married children, the father or mother of a spouse, and/or another relative. The average was around six people.

Within the *foyré*, the man was responsible for tilling the soil and weeding the millet and sorghum crops. (These were generally grown in association with cow-peas.) He was assisted by his wife only in bird-scaring, harvesting and transportation. The woman would grow cherry tomatoes, sweet potatoes and other vegetables in riverside fields, if she had inherited any. During the 1960s fewer and fewer men were available to grow cereals. Before that time, they used to migrate to the groundnut-growing region or major Senegalese towns, returning for the rainy season. As the French economy expanded during the 1960s, they began to migrate to Europe, whence they could not return for the rainy season. By the 1980s, practically every *foyré* had at least one man who had been away for at least three months in the last twelve. The women stayed in the village, covering the cereal deficit by buying millet and sorghum in the village with the remittances from their husbands (Diemer and van der Laan, 1987).

Drought added to the problems caused by migration. Average annual rainfall dropped by 25%, placing the valley within the 150-600 mm range where before it had fallen within the 250-800 mm range (Van Driel, 1988). Rainfed crops failed, while the traditional fall-back of flood-recession agriculture was available to only a few valley dwellers.

TABLE 1: Division of Tasks Related to Date of Establishment of Schemes

	Number of Seasons (since establishment)	
	1 - 2	**> 4**
Men	58%	49%
Women	21%	32%
Children	21%	19%
All	100%	100%

Source: OMVS (1980)

Village irrigation schemes were conceived in the light of these changes. The local people used them to bridge the cereal gap caused by the combination of drought and male out-migration. Households also adjusted their division of labour to the realities of migration. The socio-economic survey conducted by the OMVS (1980) indicated that women's participation in farming increased the longer schemes had been established.

During the 1980s, local people introduced several changes to this irrigated subsistence agriculture. Let us take the women first. Even in the 1950s, about two-thirds of valley dwellers had no access to the riverside gardens where the women grow sweet potatoes, okra, cherry tomatoes, etc, (Boutillier, 1982). These gardens provided a small cash income for the women, as well as ingredients for the sauces to go with meals. As irrigated rice-growing was added to flood-recession cropping, irrigated gardening was added to existing riverside gardening. Women's associations in nearly every village now have an irrigated orchard, usually located near the village and served by a well.

Another change was the decrease in the intensity of cropping in rice-growing schemes. In the hope of increasing the proportion of rice sent to market, the national development agencies increased the size of plots over the decade. The average of about 0.2 hectares around 1980, had risen to about 0.3 hectares by 1989. The agencies assumed that the farmers, many of whom practised double cropping, would continue to do so, but the farmers decided otherwise. They took advantage of the increased size of their plots to grown all the rice they needed in one season. This meant that they did not have to cultivate during the dry season when pumping costs are greater because of the higher rate of evapotranspiration and the need to pump from a greater depth (Jamin, 1987; Bastiaansen, 1988; Diemer, 1990).

Irrigated rice-growing has become an integral part of the production system. The good rains which fell in the Sahel in recent years did not lead farmers in the mid-Senegal valley to abandon their schemes. On the contrary, the commitment to irrigation increased, with people trying to reserve fields close to the river for their children.

Very few groups have had to stop irrigating because they could not replace their worn-out pumping equipment. One reason for this is that SAED (Land-Use and Development Company of the Senegal and Falémé Delta) and SONADER (National Rural Development Agency), after some hesitation, made provision for depreciation costs. In the case of SONADER, a strict depreciation rate is applied which enables the motor to be replaced in five years. In the case of SAED, a more flexible rate is combined with less strict application, which means that many groups needing to replace their motor have only 80% of the necessary funds available. They get round this by allowing a local businessman/politician to supply the missing amount or by getting a foreign NGO interested in their plight. Even more frequently, the group whose motor-pump has broken down puts pressure on SAED to lend them a pump until the end of the season. This leads to almost interminable negotiations as a result of which the group often succeeds in getting a considerable grant towards their new motor-pump.

To sum up, it is clear that the success of village schemes lies in their adaption to the local production system and, more specifically, to changes within it. In addition, the Haalpulaar were free to organise the management of their schemes according to their own organisational model and fit this into their political system. This is contrary to the industrial approach which is characterised by rejection of the production and political systems of the smallfarmers/tenants, together with the imposition of particular organisational relationships. The importance of the production system may also be deduced from the rapid spread of irrigated gardens and the decreased intensity of cropping practised by farmers over the decade.

6. POINTERS FOR MORE EFFECTIVE PLANNING AND DESIGN METHODS

How does identifying the reasons for the success of village irrigation schemes help us to develop more effective planning and design methods? We think this shows that planners and designers must devote more attention to the smallfarmers' production system and local political system. Study of the former should pinpoint the organisational criteria for designing the hydraulic network, while study of the latter should be undertaken with a view to identifying the criteria for allocating plots.

Let us first look at management of the infrastructure. As the impetus for the spread of village schemes came from the valley dwellers themselves, they organised in the same way to present their requests as they intended to do in managing their scheme. The point is that they found it natural and obvious to organise themselves on the basis of their belonging to a village. Although this was not made explicit, their planning and design practices were based on the relevant organisational unit and political affiliation. Their approach thus almost automatically matched the scheme with the local political system.

This is the opposite to current procedures. Comparison with developments in the Senegal river delta makes this quite clear. In the 1970s, schemes covering a thousand to two thousand hectares were designed. They were supposed to be managed by cooperatives including residents from different villages. The very fact that the president of the cooperative belonged to another village led a good number of members belonging to other villages to mistrust him with regard to vital activities like payment of dues and selling the harvest (Waldstein, 1986). This mistrust was not unfounded inasmuch as the mutual dependency and loyalty which linked these dignitaries to the inhabitants of their own villages were stronger than their links with members of that new, foreign and more or less politicised and state institution: the cooperative.

The chosen management unit in villages was viable because it resulted from proposals made by the farmers themselves. During the sixty or so years which elapsed before village schemes began to spread in the valley, both the colonial and post-independence governments always avoided the mid-Senegal valley. This was in spite of the fact that the technical services often pointed out its physical hydro-agricultural potential. However, the plans submitted by the engineers did not fit in with local political realities. The 'controlled flooding' system, for instance, was designed for seasonally inundated depressions.

The land tenure arrangements in these depressions generally involve lineages of farmers along with lineages of fishermen and herders (Schmitz, 1987). Yet, these fishermen and herders found themselves forced out of their lands by these purely agricultural schemes. Moreover, these areas are often farmed by several lineages from different villages. Successive administrations were therefore afraid of encountering political resistance they would be unable to overcome (OMVS, 1980; Boutillier et al, 1962). This lack of suitable approaches led them to concentrate their investments in the delta. However, the success of village irrigation schemes suggests that viable ways of irrigating land in the valley could be developed so long as the local political system is considered not just as a constraint, but also as a potential management tool.

The Haalpulaar smallfarmers were able to impose their own management model. This is not due to the planning and design methods adopted by the rural engineering service, but rather to the fact that the government did not dare to impose its own management model on the smallfarmers. This historical accident shows us that the design of the hydraulic network should be based on the definition of the management unit. Feasibility and detailed pre-project studies should identify the most appropriate unit on the basis of field surveys and discussions with the smallfarmers.

The example of village-schemes indicates that the local political system should be viewed not only from the angle of what it precludes, i.e. as a constraint, but also from the angle of what it allows, i.e. as an opportunity. This same reasoning may be applied to the production system. The proposals for developing the hydro-agricultural potential of the valley made by the engineers implied profound changes in the political system as well as in the local people's production system. They were designed to realise the potential of the annually flooded depressions where the people grew their staple food - sorghum. The engineers were keen on these areas not only because of their clayey soil, suited to irrigated rice, but also because they thought they could channel water by gravity without pumping (for instance, by installing coffer-dams to control flooding, as mentioned above).

The schemes introduced a new risk in the sense that a tried and tested technique was being replaced by one which had yet to be adapted to the social and physical environment. The irrigation system which invaded the valley and is now predominant does not use the depressions. It is practised instead on the uplands situated either on the levees or half-way between these levees and the depressions. These lands were of only marginal in the production system, since they were rarely flooded. Bringing these lands under cultivation did not add a risk but created an additional resource. It strengthened a production system based on minimising risks, unlike the 'industrial' approach which generally expects that the tenants should depend 100% on their irrigated plots for their livelihood (see Richards, 1986).

Furthermore, the system which has swept all before it obtains water by pumping rather than gravity. As migration expanded rapidly during the 1960s and 70s, the market economy penetrated ever deeper into the smallfarmer production system. Demographic growth, drought and the stagnation of farming techniques were all factors pushing towards the use of resources outside the valley. Migration offered a way of minimising risks in this context of unfavourable changes. Moreover, it generated income. This income made possible the intensification of agriculture demanded by the combination of drought and more mouths to feed. While maintaining their production objectives, i.e. subsistence, the Haalpulaar introduced pumping into their production system (with financial support from migrants), once again contrary to the 'industrial' approach in which the cost of pumping is to be covered by agricultural sales.

We should also point out that households took advantage of new subsistence cropping to replace a division of labour which had become obsolete with long-term migration. In the mid-Senegal valley, women began to undertake almost all farming operations. This again shows the gap between the industrial approach and smallholder practices. Many engineering reports mentioned migration, but it was seen as an obstacle to hydro-agricultural development because work on irrigated land was primarily seen as men's work. This (male) labour seemed to be lacking as a result of migration (FAO, 1983).

In parallel, it is noticeable that women are organising themselves to set up and manage market gardens which have their own pump or well and are not dependent on the irrigation scheme's motorpump. Women have organised themselves in virtually all villages to set up these gardens, as if replicating in the context of irrigated agriculture the kitchen gardens of yesteryear. As before, they sell about 25% of their produce and use the rest for preparing meals (Helsloot, 1988).

The particular features of this irrigated subsistence farming show that one cannot merely describe the production system. It is necessary also - perhaps especially - to analyse the system with the smallholders. By so doing, one may hope to identify inter-action between the components of the system which the scientific literature would not lead us to expect, and which opens up new avenues. Migration created new opportunities which the smallfarmers were the first to recognise. The later evolution of village schemes shows the need for such joint analysis.

The rapid spread of village schemes gives glimpses of several processes of change within the production system. As with the local political system, this must not be considered static. These changes did not stop when village schemes had become widespread throughout the valley. After the wave of irrigated cereal production, almost all villages established irrigated market gardens.

CONCLUSIONS

Analysis of the success of village schemes shows that the success of any physical infrastructure is dependent on its conformity with smallfarmer reality. To be precise, the characteristics of the plot (soil, surface area, distance from home, etc) must be matched with the smallholder production system and the water distribution network must be matched with the mode of political organisation. The fact that the motor-pump is imported is unimportant. The main thing is that the farmers should be able to use it for their own purposes[5].

This conclusion goes beyond the literature taking the 'transformation' approach. While this approach notes the gap between the schemes and smallfarmer society is noted, it is not identified as the cause of failure. The pretentions to universal validity of this agricultural science are accepted and, therefore, the 'transformation' approach seeks merely to make its impact on smallfarmer society less painful.

Our conclusion goes beyond the ethnographic approach in the sense that it transforms its main finding into a prescription for hydro-agricultural planning in Africa.

Planning and design of irrigation schemes in Africa are presently governed by norms which could hinder the development of irrigation. Norms relating to the place of irrigated plots within the smallfarmer production system and the appropriate form of organisation for managing the hydraulic network originate in an ethnocentric approach which we could describe as 'industrial'. They should be replaced with empirical norms. The study of hydro-agricultural schemes which are recognised as viable helps to build a picture of the gap between the 'industrial' and 'smallfarmer' perspectives. Current planning and design methods have hitherto started from the premise that the industrial approach was the only possible way. It was therefore deemed inevitable that the scheme should be imposed on smallholders (men and women) and that they should be obliged to adapt themselves to it.

Trained by educational institutes in the industrialised countries, or by their sister institutions established in African countries, these specialists in rural engineering design act according to a vision of irrigated production which may be classified as industrial. Like other agricultural sciences, methods of hydro-agricultural design are based on social and economic premises emanating from industrialised society which are not valid for the rural societies currently found in the African countryside.

If viable schemes are to be set up, methods of planning and design must be reversed. If the scheme is to be a tool in the hands of smallfarmers, it must

---

[5] Witness the 2 hp portable pumps which irrigate the market gardens around Sahelian towns, as well as individual farmers' fields on the plains of the Niger and Benoué rivers in Northern Nigeria and the Mwea plain in Kenya.

be designed in accordance with their production objectives and models of political organisation. That is to say that planning and design must be based on norms identified through study of the local production and political systems. This study must be coupled with discussion, as both systems are constantly changing. They continually present the smallfarmers with choices that someone from the outside is incapable of making.

This is a challenge for sociologists, who should be studying the effects of village society on the scheme, at the same time as they look at the latter from the traditional angle, i.e. the effect of irrigation in relationships between villagers.

RECOMMENDATIONS

Analysis of the success of village schemes and the ethnographic literature suggests that the first thing to do is to reverse current methods of design rather than vainly seek to adapt male and female smallholders to the designers' assumptions. Smallfarmer production objectives and organisational relationships should be incorporated in design. This will be a tricky matter, as investments are made by the state and its donors, who have their own objectives. There should be a forum on irrigation, where smallfarmers and officials can negotiate the scheme's production objectives and management model. This should enable design parameters to be determined which faithfully reflect the balance of power between smallfarmers and state. This will prevent the construction of schemes which assume a higher degree of state control over the smallfarmers than is actually the case.

We therefore think that the terms of reference of consulting organisations responsible for designing schemes or assessing their feasibility should include: a detailed description of the production systems of the different smallfarmer sectors, indicating to what extent male and female smallholders consider that a better water supply would lift constraints; a detailed description of their political culture and its implications for the layout of the infrastructure and organisation of management; detailed reports of negotiations between smallfarmers and officials as to production objectives, and lay-out of the network and management model.

We also think that trainee rural engineers should be obliged to prepare theses in which, on the basis of prolonged stays in the villages, they compare their training with smallfarmer practices. We do not of course think that the adoption of these recommendations will make the crisis in African irrigation a thing of the past. We also consider it vital that irrigation programmes should be integrated in overall national development policy, stressing research into appropriate technology while setting up a guaranteed price policy to stimulate production and use of inputs and realistic terms of trade.

REFERENCES

Adams, W. M. and A.T. Grove, eds. (1983). Irrigation in Tropical Africa, problems and problem-solving. Cambridge, Royaume-Uni, African Studies Centre: 121-131.

Bastiaansen, C. (1988). L'aménagement et l'exploitation des périmètres irrigués villageois. Wageningen: rapport du projet de périmètres villageois, 32 pp. et 2 annexes.

Boutillier, J.L., et al. (1962). La moyenne vallée du Sénégal. Paris: Presses Universitaires de France.

Chambers, R. and J. Moris, eds. (1973). Mwea, an Irrigated Rice Settlement in Kenya. Munich: Weltforum Verlag.

Chisholm, N.G. (1984). Indigenous Irrigated Production in S.E. Ghana: lessons for the design of small-holder irrigation schemes. Dans: M.J. Blackie, éd.: African regional symposium on small-holder irrigation. Harare, Université de Zimbabwe: 427-437.

Coward jr., W.E., ed. (1980). Irrigation and Agricultural Development in Asia. Perspectives from the social sciences. Ithaca, N.Y., Cornell University Press.

Dey, J. (1982). Development Planning in the Gambia: the gap between planners' and farmers' perceptions, expectations and objectives. *World Development* 10,5: 377-396.

Diemer, G. et E.Ch.W. van der Laan (1987) *L'irrigation au Sahel.* Paris: Karthala.

Diemer, G. (1990). *Irrigatie in Afrika.* (L 'irrigation en Afrique.) Amsterdam: Thesis Publishers.

Driel, W. van (1988). Etude de faisabilité de la cuvette de Cascas. Rapport principal, Université Agronomique Wageningen, Pays-Bas.

FAO (1983). Rapport de la mission de préparation du projet d'irrigation de Saldé-Wala. No. 44/83 AF-SEN 12. Phase II. Rome, Centre d'investissement. 57 pp. + annexes.

Fleuret, P. (1985). The Social Organisation of Water Control in the Taita Hills, Kenya. *American Ethnologist* 12,1: 103-119.

Gray, R.F. (1963). The Sonjo of Tanganyika, an Antropological Study of an Irrigation Based Society. London, Oxford, University Press.

Grove, J.M., A.T. Grove, M. James and N.G. Chisholm (1982). Irrigation in the Volta Delta, Ghana. In: H.G. Mensching, ed.: Problems of the Management of Irrigated Land in Areas of Traditional and Modern Cultivation. Report of an inter-congress meeting of the International Geographical Union. Hamburg: 24-37.

Haswell, M.R. (1963). The Changing Pattern of Economic Activity in a Gambian Village. London, Her Majesty's Stationery Office, Department of Technical Corporation, Overseas Research Publication No.2, 109 pp.
Helsloot, L. (1988). Vrouwen op het Ile à Morphil (Les femmes sur l'Ile à Morphil). Cascas, Sénégal: rapport du projet périmètres villageois. 109 pp.
Jackson, C. (1985). The Kano River Irrigation Project. Kumarian Press, West Hartford, États-Unis.
Jamin, J.-Y. (1987) La double culture du riz dans la vallée du Sénégal: mythe ou réalité? Montpellier: CIRAD, Actes du troisième séminaire du Département systèmes agraires: Aménagements hydro-agricoles et systèmes de production, pp. 581-595.
Klei, J.M. van der (1989). Trekarbeid bij de Diola in Senegal. (Migration cyclique chez les Diola). Thèse de doctorat. Université Libre d'Amsterdam.
Konings, P. (1986). The State and Rural Class Formation in Ghana: a comparative analysis. Londres, Routledge et Kegan.
Linares, O.F. (1981). From Tidal Swamp to Inland Valley: on the Social Organization of Wet Rice Cultivation among the Diola of Sénégal. Africa 51, 2: 557-595.
OMVS (1980). Etude socio-économique du bassin du fleuve Sénégal, Dakar/Saint-Louis, 5 tomes.

OMVS (1988). Bassin du fleuve Sénégal: périmètres irrigués aménagés en maîtrise totale de l'eau. Notice explicative de la carte 8: aménagements.
Paulme, D. (1957). Des riziculteurs africains: Les Baga. *Cahiers d'Outre-Mer*, 10: 257-279.
Potkanski, T. (1988). The Sonjo community in face of change. Dans: *Hemispheres* 4:191-222.
Richards P. (1986). Coping with hunger. Londres: Allen et Unwin.
Schmitz, J. (1987). Agriculture de décrue, unités territoriales et irrigation dans la vallée du Sénégal. Montpellier: actes du troisième séminaire du département systèmes agraires du CIRAD, pp.545-561.
Waldstein, A.S. (1986). Irrigated Agriculture as an Archetypal Development Project: Senegal. In: M.M. Horowitz et T.M. Painter, eds.: Anthropology and Rural Development in West Africa: 117-144. Boulder et Londres, Westview Press.
Wallace, T. (1979). Rural Development through Irrigation: Studies in a Town on the Kano River Project. Zaria, Nigeria. Centre for Social and Economic Research, Ahmadu Bello University, Paper no.3, 135 pp.
Weil, P.M. (1973). Wet Rice, Women and Adaptation in the Gambia. Rural Africana, 19: 20-28.

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 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.

Technical Centre for Agricultural and Rural Co-operation (CTA)
The Technical Centre for Agricultural and Rural Co-operation (CTA) was established in 1983 under the Lomé Convention and is based in Ede-Wageningen in the Netherlands. Its mandate is to help the African, Caribbean and Pacific countries which comprise the ACP group achieve greater food security by providing them with better access to scientific and technical information on all issues related to agricultural and rural development. Working in close cooperation with ACP and EEC countries and with international, regional and national institutions, CTA fulfils its mandate through a range of activities, including seminars, studies, publications and support to ACP documentation centres.

The ODI Irrigation Management Network is sponsored by **The Overseas Development Administration (ODA), 94 Victoria Street, London SW1E 5JL; and The Ford Foundation, 320 E 43rd Street, New York, NY 10017, USA.**

The African Edition of Irrigation Management Network is sponsored by the ACP-EEC Technical Centre for Agricultural and Rural Co-operation (CTA), Postbus 380, 6700 AJ Wageningen, The Netherlands

© Overseas Development Institute, London, 1991. Photocopies of any part of this publication may be made without permission. (Requests for commercial reproduction of Network material should be directed to the copyright holders.)

This African edition is sponsored by the Technical Centre for Agricultural and Rural Co-operation (CTA), Postbus 380, 6700 AJ Wageningen, The Netherlands

Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England.
Telephone: (071) 487 7413
Telex: 94082191 ODIUK
Fax: (071) 487 7590

IRRIGATION MANAGEMENT NETWORK (African Edition)

Network Paper 7

STRUCTURAL ADJUSTMENT AND IRRIGATED AGRICULTURE IN SENEGAL

Philip Woodhouse and Ibrahima Ndiaye

The African edition of the Irrigation Management Network is supported by the Technical Centre for Agricultural and Rural Co-operation (CTA)

October 1991

Papers in this set:

6 *Promoting a Smallholder-Centred Approach to Irrigation: Lessons from Village Irrigation Schemes in the Senegal River Valley* by Geert Diemer, Boubacar Fall and Frans P Huibers

7 *Structural Adjustment and Irrigated Agriculture in Senegal* by Philip Woodhouse and Ibrahima Ndiaye

8 *Large-Scale Irrigation Schemes in Northern Cameroon: Development and Disengagement* by Achille Bikoi

9 *Design and Operation of a Small Irrigation Project in Zimbabwe to Minimise Schistosomiasis Transmission* by M Chimbari, R J Chitsiko, P Bolton, and A J Thomson

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

Linden Vincent, Editor, Irrigation Management Network (African Edition), Overseas Development Institute, Regent's College, Inner Circle, Regent's Park, London NW1 4NS

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

The opinions represented are those of the author and do not necessarily reflect the policies of the Overseas Development Institute, or any organisation with which the Institute or author is connected.

STRUCTURAL ADJUSTMENT AND IRRIGATED AGRICULTURE IN SENEGAL

Philip Woodhouse and Ibrahima Ndiaye

Contents **Page**

Philip Woodhouse is a Lecturer at the Institute of Development Policy and Management, at Manchester University, UK. Ibrahima Ndiaye is Head of the Département d'Informatique et de Traitement de Données at the Réseau Africain pour le Développement Intégré, Dakar.

This paper is abstracted from a longer monograph published by the Open University (see Woodhouse and Ndiaye, 1990), and based on research funded by the Social Science Research Council (USA) and the Open University (UK).

STRUCTURAL ADJUSTMENT AND IRRIGATED AGRICULTURE IN SENEGAL

Philip Woodhouse and Ibrahima Ndiaye

1. INTRODUCTION

By the start of the 1990s, structural adjustment programmes linked to IMF and World Bank lending had been implemented by the government of Senegal for ten years. The IMF strategy has tried to reduce budget and trade deficits by reducing consumption, particularly public consumption, and by stimulating exports through shifts in domestic price policy. The series of three World Bank structural adjustment loans have also emphasised price policy and reduction in state expenditure, particularly through restructuring or abolition of parastatal organisations. These policy orientations were embodied in the Senegalese government's Nouvelle Politique Agricole (NPA) published in 1984, which established guidelines for four main areas:

1. Transfer of certain parastatal functions, such as crop storage, to producers - *responsabilisation paysanne* - linked to a reorganisation of cooperatives and farmers groups;

2. Transfer of the agricultural input supply system from parastatals to the private sector;

3. Overall reduction in the activities of parastatal development agencies;

4. Changes in price policy to remove all subsidies on agricultural inputs, and to establish domestic consumer prices at levels high enough to provide protection for domestic cereals production against imports.

The price policy for cereals was set out in the Plan Céréalier in 1986, whose objective was to increase domestic food production from around 50% of national requirements in the mid 1980s to 80% by the end of the century. To achieve this, the Plan proposed increased producer prices, an increase in consumer prices to allow a minimum 25% protection rate for domestic cereals against imported cereals, and an increase of 75% in cereal yields through higher input use (Commander et al, 1989).

The most important element of protection was for domestic rice production. Rice was the largest component of food imports: constituting 77% of the 453,000 tons average annual commercial cereals imports between 1981 and 1984. Rice is a significant and increasing part of food supply in both urban and rural areas.

The emphasis on increasing rice production is heavily reliant on developing irrigation for food production. To this end, 75% of the agricultural investment budget in 1986-89 was to be used for irrigation development. Of this, two thirds, constituting 46% of all agricultural investment, was to be spent in the Senegal river valley (Afrique Agriculture, 1986). The government's emphasis on the Senegal river valley rests on the belief that conditions for irrigated production would be dramatically improved by two factors:

- *l'Après-barrage*: the completion of two dams, one at the top of the river basin, at Manantali in Mali, and the other close to the estuary at Diama, which would allow year-round irrigation throughout the valley;

- *le Désengagement*: the withdrawal of the state from the supply of agricultural inputs and services to allow provision through commercial markets.

With the completion of the dams in 1987, *l'Après-barrage* became a reality. Thus the rapid growth anticipated in irrigated food production is now seen to depend on the pace of state withdrawal. This paper describes the extent of this withdrawal in early 1989. Based on field work carried out January - March 1989, it identifies emerging trends in irrigated farming and uses these trends to assess the effect of the "disengagement" process on agricultural output.

We continue to use the term 'disengagement' in this paper to describe the process of state withdrawal. In other Anglophone work, the terms 'turnover' and 'privatisation' are both in use to describe different components of this process. 'Turnover' is generally used to describe the delegation of water management duties to local institutions (and sometimes credit, marketing and fertiliser coordination). 'Privatisation' is the delegation of responsibilities to the private sector.

2. IRRIGATION IN THE SENEGAL RIVER VALLEY

The Senegal river flows along the southern limit of the Sahara Desert, forming the frontier between Senegal, on the south bank, and Mauretania on the north bank. In 1972 the governments of Mali, Senegal and Mauretania formed a river basin development organisation (OMVS - Organisation pour la Mise en Valeur de la Vallée du Sénégal) which, with foreign financial and technical assistance, has drawn up plans for a total of over 300,000 ha of irrigated agriculture in the valley, of which 224,000 ha are on the Senegalese bank.

Farming conditions vary considerably along the length of the river, due to climate and topography, but for the purposes of this paper we distinguish only three regions on the Senegalese side:

the *delta*, which extends from the coast to a point a few km upstream from Dagana. Before the construction of the Diama barrage seawater intruded as far upstream as Podor during the dry season, and the resulting salinity of much of the soil made crop cultivation impracticable. The Delta was therefore sparsely populated before the advent of irrigation.

the *middle valley* from Dagana to Dembakane, where traditional flood-recession agriculture has centred on the use of the *cuvettes* - low-lying parts of the floodplain which are covered for a month or more by the annual flood of the river. Customary land rights on the *cuvettes* are distributed between three main caste groups, involved, respectively, in fishing, pastoralism and crop cultivation. Access to the *cuvettes* is tightly controlled through village hierarchies, as described by Schmitz (1986) and Bleeker (1987).

the *upper valley*, from Dembakane to the Senegal-Mali frontier. The valley is narrower than in the middle valley and opportunities for flood-recession farming are more limited, but higher rainfall allows rainfed millet and groundnut cultivation on lighter soils at the valley margins. Detailed accounts of farming by Soninké communities in this part of the valley have been given by Adams (1977, 1985).

The history of irrigation development in the Senegal river valley has been set out elsewhere (OMVS, 1984; Engelhard et al, 1986; Adams, 1981; Diemer and van der Laan, 1987). This irrigation may be regarded as having one of two distinct origins.

Firstly, large-scale schemes of 1,000 ha or more were established to grow rice for the national market. These schemes were originally constructed in the delta in the 1960s to grow rice under partially-controlled flooding. The characteristics of the Senegal river flood proved too irregular, however, and in the 1970s large electric pumping stations were introduced for improved water control. Land distribution had been carried out according to the criteria of 0.5 ha per *actif.* As a result household units frequently had total holdings of 1.5 ha, rising to several hectares in some cases. The relatively large landholdings require mechanised tillage, a generalised use of herbicides for weed control, and seasonal hired labour during harvest.

Elsewhere, small-scale schemes (PIV - Périmètres Irrigués Villageois) were established from 1975 onwards, each covering an area of 20 - 50 ha. The PIVs were typically constructed on the levees of the main courses of the river (thus avoiding conflict with traditional land rights in the *cuvettes*), which had soils of a lighter texture than the *cuvettes*. Each perimeter was irrigated from the river by a float-mounted diesel pumpset, the running costs (fuel, spare parts, operator) of which were met by those cultivating the irrigated plots. The size of individual holdings on PIVs varies between 0.1 and 0.5 ha, but is most commonly 0.2 - 0.3 ha, and practically all operations are carried out manually, including tillage.

Except for one commercial sugar plantation, by the 1980s all the irrigated areas were divided into smallholdings, allocated to individual farmers by the irrigation management body. For the PIVs, 'management' was the village authorities; the state corporation SAED (Société d'Aménagement et d'Exploitation des terres du Delta du fleuve Sénégal) managed the large-scale schemes. SAED, formed in 1965, played a central role in both types of scheme, however, by undertaking design and construction of the irrigation work, provision of technical and input supply services including tractor hire, operation of the large pumping stations (large perimeters), and supply and maintenance of small pumpsets (PIVs). Thus, farmers' irrigation organisations have been shaped by conditions in which the state had responsibility for the supply of key factors of production, and the withdrawal of the SAED from this responsibility - *le désengagement* - implied a change in the functioning of the farmers' irrigation organisations.

On both types of perimeter the direct production costs were covered by credit from the supplier of inputs and services - also SAED. By 1984 the accumulated debt arrears were 255 million fr CFA[1] in the valley as a whole

[1] $US 1 = 449 fr CFA (1985); $US 1 = 310 fr CFA (1989).

(SAED, 1986), with the indebtedness running at a higher level on larger perimeters. This large unpaid debt was a factor in persuading the state to withdraw from input and credit provision as part of the structural adjustment programme.

However, two sets of improvement measures, aimed at circumventing the perceived weaknesses of both small- and large-scale irrigation, were introduced before the decision to withdraw. Firstly, "intermediate" schemes were created to provide larger irrigated areas for participants of the PIVs of the middle valley, where small irrigated plots were often barely sufficient to cover subsistence needs.[2] Secondly, the success of village irrigation organisations in managing PIVs was extended to larger schemes by breaking up cooperatives which had previously grouped about 400 participants into small *Sections Villageoises* (SV), with a greater degree of managerial autonomy. The SV was further subdivided into *groupements*, which were to be the unit of irrigation management. Despite modifications during the SAED withdrawal, these initiatives continue to exert influence over the evolution of irrigation in the Senegal river valley.

3. LAND RIGHTS IN IRRIGATION MANAGEMENT

With the promulgation of the land reform law in 1964, some 97% of the land in Senegal was nationalised, and traditional land rights were no longer recognised. Instead, the right to use land in rural areas was to be allocated by the newly-formed "rural communities" through their elected rural councils. The new law aimed to improve equity of access to land through allocation by an elected body. In practice, members of traditional landholding families were often elected to the rural councils, and "the modern law practically reinforced the local standing of the traditional chief by conferring upon him a new state function" (Engelhard et al, 1986).

However, two further provisions of the law have influenced the evolution of irrigated land rights. Firstly, the state can declare an area *'zone pionnière'*, in which the jurisdiction of the local rural councils is suspended, in order to implement projects deemed to be in the wider national interest. A second provision stated that, while a rural council could reallocate land that it

2 Although this would require extension of the PIVs from the levees to the more extensive, but flood-prone *cuvettes*, with attendant increases in cost (for flood-protection and mechanisation) and conflict with customary land tenure.

considered under-utilised, such reallocation required compensation to be paid by the new user(s) for any buildings or infrastructure on the land.

In 1965 the delta was declared *zone pionnière* under the jurisdiction of SAED, extended to the entire southern side of the valley in 1980. In practice SAED found it expedient to accommodate local rural councils when they defended traditional land rights. The strength of such rights varied across the valley. In the delta, where historically population was sparse and where subsequent immigration gave rise to heterogeneous communities, traditional land rights were weak. In contrast, the villages of Halpulaar (Toucouleur) people in the middle valley and of Soninké in the upper valley were long-established and local land rights were well defined. In these areas establishment of irrigation infrastructure was sometimes opposed by traditional landholders who saw it as an irreversible transfer of land tenure. With the arrival of *l'après-barrage* this identification of irrigation with land tenure has assumed increased importance throughout the Senegal river valley.

In the middle and upper valley the potential for conflict over land rights was reduced because the PIVs were generally situated on the levees of the river to facilitate pumping, on land that was of less importance in traditional farming than the low-lying *cuvettes*. Once irrigation was established, rural councils or village councils played a central role in deciding the allocation of irrigated plots. However, redistributive effects are biased.

Diemer and van der Laan (1987) argue that in the Halpulaar villages of the middle valley the access to irrigated plots is more egalitarian than traditional land tenure. In particular, their data shows that socially disadvantaged castes descended from slaves, who had no traditional land rights, have access to irrigation comparable to that of descendants of slave-owning castes. However, in the same villages women have not been so fortunate. Gaudet (1988) states that by the 1970s the scope for independent cultivation by Halpulaar women had diminished to such an extent that their traditional economic autonomy had been replaced by dependence upon their husbands, for whom they provided labour for sowing and harvesting the flood-recession sorghum crop. Diemer and van der Laan (1987) cite evidence that, despite massive migration of men from the middle valley, the proportion of work done by women in the sorghum crop (29 - 33%) was no greater in 1978 than in 1957. Their figures also indicate, however, that the proportion of work done by men in irrigated rice is lower (49%) than in sorghum (67 - 71%). Thus a switch from flood-recession sorghum to irrigated rice, such as took place in the 1970s and 80s, would indicate an increase in the proportion of agricultural work done by women.

In the PIVs of the middle valley, women have no rights to cultivate irrigated plots independently of their husbands. At Podor, also in the middle valley, a proposal in 1984 to allocate irrigated plots equally to the 57 male and 61 female participants of the Niandane III perimeter, by the Senegalese NGO, OFADEC, was opposed by the local rural council in favour of an allocation to heads of households (Engelhard et al, 1986). The matter appears to have been resolved by allocation of plots to male participants only. When visited in 1989, of the 56 participants cultivating the perimeter, none were female.

In Soninké communities of the upper valley women appear to have retained their independence as cultivators to a greater degree, largely through growing rainfed groundnut on the *dieri* soils at the outer margins of the valley (Adams, 1985), and this is reflected in their participation in PIVs as holders of irrigated plots in their own right. Thus, Blijdorp (1987) found that women accounted for some 60% of the participants in a sample of 13 PIVs in the Bakel area. However, women's plots tended to be smaller than those of men and accounted for only 40% of the irrigated area. More important, perhaps, all irrigation management was carried out by men, even on women's plots.

Restrictions placed on women's independent access to irrigated plots on the PIVs of the middle and upper valley appear to have promoted the formation of women's groups to develop women's irrigated agriculture. These initiatives have centred on the establishment of small areas of high-value vegetable crops. These "gardens" have often been established close to the river, from which water is carried in buckets to the crops. External support specifically for women's projects has raised the possibility of women acquiring pumpsets and operating PIVs of their own, and a perimeter of 12 ha has been established in this way by 232 women at Moudery, near Bakel (Blijdorp, 1987). Elsewhere, on the Ile à Morphil external funding has provided pumpsets to women's groups who have thus been able to greatly expand the size of their vegetable-growing areas. Ultimately, however, the development of irrigated farming by women's groups depends upon the willingness of the men on village and rural councils to allocate land for this purpose.

In the delta, there is little to indicate that women's access to irrigation is any greater than elsewhere, but this issue is somewhat masked by that of access according to age. In the middle and upper valley migration has been the established source of income for young men during the past 40 years. In the delta, however, long-distance migration is less common among young men. As a result, there is greater pressure among the youth of the delta to obtain access to irrigated land. Yet this pressure finds little relief in the tenure arrangements on the large-scale irrigation schemes. Land allocated to heads of family groups according to the number of *actifs* within the family has remained unchanged. Holdings are therefore concentrated in the hands of older men, who make up the membership of the *Sections Villageoises*, providing younger men little scope for cultivation other than on their older relatives' land. This situation has motivated the development of youth organisations, or *foyers*, aimed at providing independent access to irrigated farming for young people. The *foyers* have attracted support from foreign development agencies, particularly NGOs. These agencies have assisted expansion of small-scale irrigation in the delta using the same technology as the PIVs of the middle and upper valley. With the decline in wage opportunities elsewhere, the numbers of young men seeking irrigable land in the middle valley is also increasing. The case noted above, of the OFADEC project at Niandane, Podor, indicates that while allocation of irrigable land to younger men may conflict with the immediate need of heads of households to retain control of 'family' labour, rural councils seem more likely to make such allocations than to allocate land to women.

As the dams at Diama and Manantali neared completion, considerable publicity was given to the improved potential for year-round irrigation. In line with the market liberalisation measures of the Nouvelle Politique Agricole, the government has encouraged individuals and groups to invest in irrigated farming. Since 1984 such investment has been made possible through the allocation of land in the delta (by rural councils) to wealthy individuals, and to associations of farmers (*Groupements d'Intérêt Economique* - GIE). As in the case of the *foyers*, these investments have taken the form of "PIVs" irrigated by small diesel pumpsets. The resulting proliferation of small-scale irrigation in the delta has apparently accelerated during the period of SAED disengagement.

4. THE DISENGAGEMENT OF SAED

4.1 The Programme

The Nouvelle Politique Agricole stated that the SAED would begin a phased programme to terminate its activities over a period of five years in order that these be taken over by "private operators and peasant organisations" (Afrique Agriculture, 1986). In the first stage, from 1984 to 1987, SAED was to withdraw from the provision of credit, the supply of inputs, and rice marketing. Agricultural credit was to be taken over by the Caisse Nationale du Crédit Agricole du Sénégal (CNCAS), a mixed state and commercial bank set up in 1984. The supply of fertilisers, pesticides, and agricultural machinery was left to commercial enterprises. Marketing of paddy was to be the responsibility of the *Sections Villageoises* (SV), SAED merely paying for paddy delivered to the rice mills.

Preparations would be made to withdraw, in a subsequent phase, from the operation of the rice mills, machinery repair and maintenance, and from the operation and maintenance of the primary infrastructure on the large canal systems. A first step in these preparations was the formation of four autonomous management units to run these continuing SAED activities until they could be handed over to commercial operators.

4.2 Credit

Although CNCAS was established in 1984, it was not until 1986 that a protocol was signed between CNCAS and SAED establishing the conditions for farm credit. Meanwhile SAED made increasingly drastic efforts to recuperate accumulated debts from peasants on large-scale perimeters, culminating in the refusal to supply water and the effective closure of over 5,500 ha of the irrigation system in 1986 (Dieye, 1985; SAED, 1986; OMVS, 1987). The rainy season of 1987 was the first in which CNCAS credit was used to finance input purchases, with a total of 110 million fr CFA credit extended to farmers' groups in the delta considered to be creditworthy. Of this about half went to SV cultivating the large-scale perimeters, with the remainder going to 12 *Groupements d'Intérêt Economique* (GIE). These credits, together with smaller loans advanced for growing cool season tomatoes and a dry season rice crop, were all repaid in full, a total of 174 million fr CFA over the whole 1987-88 agricultural year. In the following rainy season of 1988, a total of 550 million fr CFA was advanced in credit for the rice crop, of which only 126 million was to farmers in the middle valley through CNCAS branches opened in Podor and Matam. The remaining 424 million was used in the delta, with approximately 40% going to SV, 40% to GIE, and 20% to *foyers*.

The terms of CNCAS credit are that, firstly the borrower must deposit 15% of the value of the loan, secondly that interest is paid at 14% on the loan, and thirdly that farmers' organisations are collectively responsible for repayment. Thus each organisation must recoup debts from its individual members. All applications for CNCAS credit must first be checked by the local SAED delegate and must carry written SAED approval. Given the large number of organisations in debt to SAED, the CNCAS loans have frequently been granted on the condition that outstanding debts to SAED be repaid over a three year period. Some evidence emerged from interviews, however, that repayment priorities were likely to be given to (current) CNCAS loans, and that, if these were repaid, CNCAS was unlikely to press hard for the repayment of SAED arrears. At the time that field work was undertaken, final records of credit used and repaid were not available. Analysis of credit notes used to pay suppliers of goods and services (who later cash these at CNCAS), indicate, however, that about 75% of the credit agreed by CNCAS with farmers organisations in the delta was actually used, and that about 40% of this was used to pay for machinery hire, 45% for fertiliser, and the remainder for herbicide.

As shown, CNCAS credit plays a larger role in financing input purchase in the delta than elsewhere. This is for a number of reasons. Firstly, following the announcement of SAED withdrawal, a number of foreign development agencies[3] involved in assisting irrigation in the middle valley, financed a fund of working capital for each farmers irrigation group within their project area, thus reducing the need for CNCAS credit in some areas. Secondly, alternative income sources, from livestock sales and from non-farm sources had previously played a significant role in financing input purchases, so that withdrawal of SAED credit was less important. Thirdly, mechanised tillage is not generally used on PIVs so that direct production costs are lower. Finally, on small-scale perimeters payments were often spread throughout the growing season because inputs were only purchased when they were needed.

Withdrawal of SAED from the supply of inputs such as fuel and fertiliser, seems likely to make credit more important, however, because although commercial suppliers may have facilities for storing fuel (where they also sell to transport operators, for example), it is unlikely that they will store fertiliser in advance of sales (Woodhouse and Ndiaye, 1990). Absence of local fertiliser stocks will mean that groups must order all their inputs from traders in advance, tying up more cash for the whole growing season. However, long lines of communication between the CNCAS in St Louis and the villages of the middle valley have caused delays in the release of credit. As a result of delays in CNCAS credit, one village irrigation group contacted, that of Boké Mbaibé and Salsalbé, had sought and obtained an alternative source of working capital by negotiating to use cash deposits made under the World Food Programme (nominally reserved for capital investment projects) for this purpose. However, not all farmers in the village were prepared to accept the risk of paying for a whole season's fuel and fertiliser in advance, and only 10 ha out of the total perimeter area of 18 ha was to be cultivated. This highlights the important point that the

---

[3] FED-European Community in Podor, KFW-Germany in Nianga, Netherlands government in Ile à Morphil.

withdrawal of SAED has shifted the burden of risk decisively onto farmers. It may also be noted that, since traders supply no goods on credit, the CNCAS loans paid for (in the form of interest) by farmers effectively increase traders' sales at no cost or risk to traders themselves.

4.3 Input Supplies

SAED stopped supplying pesticides immediately in 1984, as an "experiment" to assess the capacity of commercial suppliers and farmers to take over. The result was a collapse in pesticide use with serious reduction in yields, particularly in the tomato crop in 1985-86 (SAED, 1986). The following year SAED began supplying pesticides again, and continued to do so until the 1988 rainy season, which was the first occasion on which fertiliser and pesticides were supplied by commercial enterprises.

Fertilisers used in the principal (rice) crop in the Senegal river valley are urea (46% nitrogen) and diammonium phosphate (DAP: 18% nitrogen, 46% P_2O_5). Although widely claimed that the withdrawal of SAED would significantly reduce the amount of fertiliser applied by farmers, with negative effects on rice yields, available evidence suggests that this has not happened in general terms. However, at the level of individual farmers it seems that fertiliser rates depend on farmers' assessment of the other constraints on crop growth. Thus, where growing conditions are good (e.g. SV Thilene, in the Lampsar perimeter) fertiliser rates are above those recommended, but where irrigation is problematic, as in the case of the SV Tellel Peuhl, who occupy land at the tail-end of the Grand Digue-Tellel-Kassak perimeter, fertiliser use is less than half that recommended, and in individual cases is zero.

As in the case of credit, fertiliser supply differed markedly between the delta and the middle and upper valley. In the delta, fertiliser availability does not seem to have been a problem for farmers growing the 1988 rainy season rice crop. The concentration of farmers, and relatively easy access (300 km by tarmac road) to Dakar, present traders with a good prospect of finding buyers for large consignments of fertilisers. In the middle valley, however, irrigated perimeters are small and dispersed, and access is limited by bad roads which may become impassable during the rainy season. So trading incentives are fewer. In Ile à Morphil, for example, the local SAED administration had to intervene to secure fertiliser supplies in the 1988 rainy season. However, the SAED director in Ile à Morphil feels that in future individual PIVs will need to combine their fertiliser orders and delivery points in order to make the deal sufficiently attractive to traders.

Therefore, after the first season of SAED withdrawal there has been a fairly ready development of commercial trade in fertilisers and pesticides in the delta, but not in the middle valley. Overall, there is no evidence of declining fertiliser use in irrigated agriculture, but there is a great deal of variability in fertiliser use which seems to reflect farmers' assessment of the potential productivity of their crop. Two key factors condition this potential: firstly, the reliability of irrigation, and, secondly - relevant in the delta rather than in the middle valley - the availability of agricultural machinery.

4.4 Machinery Use

Mechanised tillage has always been practised on the large perimeters of the delta. In the middle valley farm machinery has been less important because of the small plot size (0.2 - 0.3 ha) and the lighter texture of the soils. The large plot size of the new "intermediate" perimeters now coming into production makes it likely that the impact of mechanised tillage will soon be more widely felt in the middle valley, but the following remarks refer principally to the delta.

The withdrawal of SAED from the provision of agricultural machinery was implemented through two procedures. Firstly, equipment operation and maintenance was centralised under the new organisation called Unité Atelier Central (UAC) at Ross Bethio to improve efficiency and to prepare for privatisation (SAED, 1986). Secondly, maintenance to the tractor fleet was reduced in order to allow commercial tractor hire to take over. In the 1988 rainy season UAC estimated that about 85% of tillage in the delta was undertaken by private tractor operators (approximately 10,700 ha). About 60% of this was financed with CNCAS credit.

Although many individuals and organisations in the delta operate tractors, the bulk of the hiring is done by a few companies. One of these, SOGEC based in St Louis, operates a fleet of four tractors which were hired to cultivate a total of 3,700 ha for the 1988 rainy season. This corresponds to almost a third of the area cultivated in the delta. By comparison, SAED has some 30 tractors currently out of service awaiting repairs prior to transfer to the private sector. The precise form of such transfer was still under study in 1989, but two consequences may be identified. Firstly the eventual re-entry into service of this equipment will have a major impact on the hire market. Indeed, SOGEC managers stated that they were unwilling to expand their own fleet until the future of the SAED fleet had become clear. Secondly, the existing equipment for hire is extremely scarce, which makes it more difficult for farmers to carry out tillage at exactly the right time.

Timing of tillage is critical because it must take place before the release of irrigation water into the main canals, usually timed for late July or early August. Tillage carried out too early carries the risk of weed growth in the fields following early rains in July. This, coupled with the shortage of tractors, has placed a strong emphasis on speed in tillage operations. As a result, ploughing - harrowing practices have been abandoned in favour of a single pass with an offset disc harrow. This may have a detrimental effect on rice output. Several of the farmers interviewed lamented that they would prefer to plough their fields. Although twice as expensive, ploughing would deal more effectively with perennial weeds, and in particular the *riz au rhizome (Oryza longistaminata)* which had become so bad that whole fields had been abandoned to it[4]. Other farmers, notably in Thilene, pointed to reduced drainage as a more fundamental factor causing weed infestation. This can also keep the soil too wet for mechanised cultivation.

Until the SAED tractor fleet has been finally transferred to private hands, it will not be possible to see the final pattern of machinery use. A preferred option appears to be to equip the *Sections Villageioses* with their own machinery for hire to their own members, along the lines followed with some success for five years by the "Sections d'Utilisation de Machines Agricoles" (SUMA) on the Nianga perimeter (Podor). However, it is clear that irrigation and drainage conditions will have a major impact upon the efficiency of machinery use.

4.5 Irrigation

Within the plans for SAED withdrawal, no timescale has been established for the transfer of irrigation water management to the private sector. Instead, SAED began a three-year programme in 1987 to charge farmers the "true cost" of its services. The role of SAED in the supply of irrigation differs between large perimeters and the PIVs. On the PIVs of the middle and upper valley SAED carries out the maintenance and supplies spare parts for the diesel pumpsets which supply water from the river. Farmers' organisations pay for the cost of all parts and materials (oil, filters, etc) but

---

[4] Research by WARDA/ADRAO indicates that the offset harrow may in fact be quite effective in controlling this weed, but only if used twice, with an interval sufficiently long to allow the drying out of the rhizomes and their physical removal from the field (van Brandt, 1982). In short, a practice which requires considerable time and labour.

not for the mechanic's time. By 1989 there was no stated change in this policy.

On the large perimeters SAED has a more central role, with responsibility for operation and maintenance of the large pumping stations and the main water distribution and drainage canals. For this service farmers pay a fixed charge each growing season, which was increased in 1985 from 25,000 fr CFA/ha to 41,000 fr CFA/ha for rice. This increase coincided with a reorganisation which shifted the operation and maintenance of water supply from perimeter level, to delegation level. In practice this only affected the large perimeters in the delta, as the two large perimeters in the middle valley, Nianga and Guedé, were allowed to retain their autonomy.

In the delta a Unité de Gestion d'Eau (UGE) was formed, with two principle divisions based at Ross Bethio. The "Gestion Hydraulique" has responsibility for planning water distribution and invoicing farmers, and the "Exploitation" division was charged with operation and maintenance of the large (electric) pumping stations supplying the canal network, and with planning the annual programme of canal maintenance. However, the execution of canal maintenance was to be contracted out to another new Unité based at Ross Bethio. The l'Unité de la Régie d'Aménagement et d'Entretien (URAE), was awarded all the canal maintenance equipment previously under the control of individual perimeter management. As with the formation of UAC, the centralisation of earthmoving machinery into a central URAE appears to have been motivated partly by a desire to improve the efficiency of equipment use and partly by the intention of forming a unit suitable for privatisation.

However, the outcome for canal maintenance appears to have been little short of disastrous, with weed growth so serious in the principle drains that farmers at Thilene (Lampsar) complained that their cultivable area was reduced by waterlogging. At Debi Mboundoum perimeter some 400 ha were so waterlogged that the rice crop could not be harvested. Under these circumstances SAED has acknowledged that it can hardly expect farmers to pay the "true cost" of canal maintenance - commonly given as 30,000 fr CFA/ha in addition to the existing 41,000 fr CFA/ha charge - which SAED is unable to guarantee will be carried out (SAED, 1986). It is not clear whether reduced activity by the URAE reflects competing commitments in irrigation construction or shortfalls in funding after the fall of the dollar in 1985.

4.5 Rice Marketing

The major step taken in marketing is to transfer to farmers the responsibility for loading and transport of paddy to the mills. SAED remains in charge of the three rice mills in the Senegal river valley, pending their refurbishment and transfer to the private sector. In principle SAED only buys rice delivered to the mills. However, this principle is fully implemented only in the delta, where the farmers' organisations record the amounts marketed by individual members, and organise bagging and transport to the mill. Withdrawal has not been implemented with the PIVs due to transport scarcity and the relatively small quantities of paddy marketed by individual villages. On the Ile à Morphil, for example, SAED buys paddy in the villages and undertakes the transport to the mills.

SAED purchases paddy for 85 fr CFA/kg, payment being made 10-14 days later. This price, increased from 66 fr CFA/kg in 1985, leaves practically no milling margin with the consumer price fixed at 130 fr CFA in April 1988, and thus reduces the attractiveness to commercial traders. This, together with prompt payment in recent years, has sharply increased the percentage of paddy marketed through SAED. SAED is able to pay the higher price for paddy because it receives 180 fr CFA/kg for milled rice (38% above the consumer price) from the government Caisse de Péréquation et de Stabilisation des Prix, which in turn finances its purchases from profits made on handling cheaper imported rice.

4.6 An Overview of Disengagement

Where the withdrawal process has advanced most, as in the provision of credit, agrochemicals supply and rice marketing, there has developed a discernable advantage in favour of the delta, where communications are better. Here, a market in agrochemicals supplied by commercial traders has effectively been established, although all the cost of credit for this trade is paid (at 14% interest) by farmers. In the middle valley, however, the privatisation process has not yet generated a commercial alternative to intervention by SAED or development agencies, particularly for the PIVs. Where state withdrawal has been less complete, as in farm machinery rental and in the operation and maintenance of irrigation, there is evidence that the pre-privatisation reorganisation of SAED has resulted in a deterioration and greater scarcity of provision of these services. This is particularly apparent on large perimeters, where inequity in access to water and, to a lesser extent, machinery, can be seen to cause great disparity in agricultural productivity.

In the following section we will discuss how these changes have influenced trends in irrigated farming systems in the delta and middle valley, and assess whether the "disengagement" of the state is likely to achieve its objective of promoting a rapid increase in irrigated food output from the Senegal river valley.

5. IRRIGATED FARMING FOLLOWING STATE DISENGAGEMENT

5.1 Effects on Farmers' Irrigation Organisations

Table 1 shows how the distribution of irrigated area between different types of perimeters has changed over time.

TABLE 1: Net irrigable area (ha) in totals for different types of perimeter

Year	1976	1980	1984	1987	1988
large perimeters	7083	9465	12577	12989	12940 ha
small perimeters (upper/middle valley)	352	3577	7271	11991	12783 ha
small perimeters (delta)	691	1191	2191	4315	5853 ha
Total	8126	14233	22039	29295	31576 ha

Source: OMVS 1988

Table 1 shows that the area of large perimeters remained static between 1984 and 1988. However, small-scale irrigation has extended, and now accounts for more than half of the total irrigated area on the southern bank of the Senegal river. Although the largest absolute increase in small-scale irrigation took place in the middle and upper valley, the fastest expansion rate (160% in four years) was in the delta, where small diesel pumpsets now irrigate an area corresponding to 45% of the total surface under large-scale irrigation. This is of particular interest because the organisations responsible for these small perimeters are generally *non-encadré*, that is, outside the responsibility of the SAED. This sector, which the policy of state withdrawal is intended to encourage, is made up of three different forms of organisation, which are distinct from the *Sections Villageoises* on SAED perimeters. They are: *foyers, groupements d'intérêt économique* (GIE), and private farmers. The private farmers are often urban-based and/or have trading activities. Their farming interest centres on high-value fruit and vegetable production. The *foyers* and GIE seem more based in rural communities, and more concerned with growing rice. The GIE are a variable form of organisation, the name being widely applied to any form of cooperative or business partnership (on closer inspection some GIE have occasionally been found to have only one member). In the three cases visited on the Grand Digue-Tellel-Kassak perimeter, the formation of a GIE to run small-scale irrigation was a means whereby wealthier members of the *Section Villageoise* provided access to irrigated land for their less wealthy or landless relatives.

The role of irrigation infrastructure in establishing "irreversible" land tenure was noted earlier in the context of the middle valley. It is possible to see in the recent proliferation of small-scale irrigation in the delta a similar and accelerating struggle for land tenure in which wealthy individuals from urban areas are active.

Many younger people participating in new irrigation through *foyers* or GIE are members of families which have plots in large perimeters. Therefore, a multiplicity of irrigation organisations may exist within a single village. The example of the village of Thilene may illustrate this. The village has a *Section Villageoise* with 66 members with rights to farm 105 ha of irrigated land within the (large-scale) Lampsar perimeter run by SAED. The village youth association (*foyer*), formed in 1976, acquired a perimeter of 20 ha, irrigated with a diesel pumpset and with infrastructure constructed with SAED assistance in 1981. This was subsequently extended to 30 ha and farming diversified to include tree plantations, bananas and market gardening, as well as rice production. In 1987 the SV and the *foyer* both invested in another small perimeter of 35 ha, on which 32 participants occupied plots of 0.5 - 1 ha each to grow rice in the 1988 dry season. Significantly, the arrangements for credit (with CNCAS), input supply (with traders), and rice marketing (with SAED) are formally handled for all three irrigation organisations in Thilene village by the SV. In this case the organisation of small-scale irrigation adjacent to the large schemes may be thought of as constituting additional autonomous *groupements* which use a single village-level entity (the *Section*) to administer commercial transactions.

It is not clear that such a close link between large-scale and small-scale irrigation exists in all other villages, but the emergence of such an organisation suggests that the disengagement of SAED has added a logic of financial administration to the logic of organisation for water management. Thus, a distinction is emerging on large perimeters between the *groupement*, concerned primarily with irrigation management on areas of 15 - 30 ha, and the *section*, concerned with administering the commercial activities of farmers at village level, thus embracing several *groupements*. A further development along the same lines is the SUMA on the Nianga (Podor) perimeter, where the *section* also has responsibility for operating and hiring agricultural machinery.

The separation of day-to-day irrigation management from input supply and crop marketing finds echoes in developments in the middle and upper valley: a regional federation of small-scale irrigation groups in the Bakel area; the proposal by a SAED director that villages on the Ile à Morphil should collaborate in groups of 10 - 15 to improve their bargaining power with traders and transporters. Evidently, such collaboration between villages will be more difficult than the administration of the same activities within a single village, but there may be no alternative if input supplies are to be secured, given the lack of interest on the part of traders.

However, there are two features of the disengagement process which may open the way for greater differentiation among farmers within the same *groupement*. Firstly, the available evidence indicates that present systems of distribution of water within the *groupement* do not ensure equity.[5] It is not uncommon for one or more members of a *groupement* on either large or small perimeters to lose their crop entirely because of inequitable water distribution within the *groupement*. With the advent of collective responsibility for loan repayment, such inequity in irrigation is translated into indebtedness of disadvantaged farmers towards other members of the *section*. Failure to pay these debts can and does result in the debtors' loss of cultivation rights, which are generally taken over by somebody prepared to pay off the outstanding debt. The question of whether such a process is leading to the accumulation of cultivation rights in the hands of fewer landholders requires further detailed study.

---

5 A discussion of inequitable water distribution in formally equitable water supply systems can be found in Woodhouse and Ndiaye (1990).

Secondly, the scope for inequitable accumulation is enhanced by reduced availability of both land and water caused by the deterioration of main canals on large perimeters in the delta, seen as a result of disengagement by SAED.

5.2 Production Costs

A detailed summary of production costs is given in our earlier paper (Woodhouse and Ndiaye, 1990), from which we have drawn the main points presented here.

Using data from interviews with farmers and from secondary sources, our study attempted to calculate the costs of production (defined as cash costs, i.e. excluding family labour) in relation to different levels of crop yield. For this purpose, a high paddy yield was considered to be over 4.5 t/ha and a low yield under 2.25 t/ha.

On large perimeters, average production costs on high yield plots accounted for 42% of yield value in 1989 compared to 26% in 1982/83. Agrochemicals and harvest expenses have caused the bulk of this increase. However, our study also suggests that, in addition to rising production costs, low yields are a widespread source of low returns on large perimeters. On low yield holdings, production costs were equivalent to about 90% of the crop value, compared to 42% on high yield holdings, despite the fact that 77% more was spent per hectare on inputs on high yielding holdings. This reflects the effect of elements such as water and tractor hire, whose cost is fixed but the efficiency of which is crucially determined by timing. The possibility of low yields seems to have been ignored in most studies of rice production costs, which assume that yield is dependent on input level alone, and ignore constraints on input effectiveness once supplied.

The production costs of new PIVs in the delta are variable depending on whether pump amortisation is included; but figures suggest that while this irrigation is not cheaper it may be more reliable than on large schemes. With PIVs elsewhere, evidence suggests that production costs have remained more stable in relation to yield value, rising by about the same proportion as paddy prices. This reflects lower commitment in inputs and mechanisation. However, far less data is available. In the mid-yield range (3.5 - 4t/ha) production costs were 25 - 33% of crop yields in 1989 on the Ile à Morphil. Engelhard et al (1986) cited a ratio of 18% on PIVs in 1982/83, but for a high-yield level (5t/ha).

Thus, this study indicates that the greatest problems for farmers occur not in the area of prices but in avoiding a disastrous drop in yields. Variation in water management plays a central role in determining agricultural performance of individual farmers on both large and small perimeters. The disengagement of SAED has resulted in a deterioration in the delivery and drainage of water on large irrigation schemes, which has increased the incidence of unfavourable moisture conditions, and hence increased the number of farmers experiencing low yields.

5.3 Effects on the Productivity of Irrigation Infrastructure

Table 2 compares the irrigable area and the area cultivated for rice production in the years 1984 and 1987.

TABLE 2: Irrigable area and area sown with rice in 1984 and 1987, Senegal river valley, left (Senegalese) bank

Agricultural year, starting July	1984	1987
total irrigable (ha)	21973	29295
area sown in rainy season	16959	13883
area sown in hot dry season	465	3852
total rice area	17425	17735
rice area as % of irrigable area	79%	60%

Source: OMVS and SAED

It indicates that the rice area has remained static, and this underlies the relatively small (10%) increase in rice production over the period. However, Table 2 also shows that rice area is declining as a proportion of the total irrigable area, and is increasingly distributed over the two growing seasons. There are two principle reasons for this overall pattern. Firstly, the major redistribution of rice growing from rainy season to dry season is the direct consequence of the completion of the Manantali dam. This dam, together with the barrage at Diama, now ensures a year-round supply of fresh water for irrigation in the delta. Thus, the spread of rice cultivation to the dry season is an anticipated outcome of *l'Après-barrage*. However, the decline in rice area relative to the total irrigable area indicates a second, unanticipated effect: that land is being used less intensively. This shift in cultivation intensity shows farmers on large schemes in the delta to be following a pattern of farming apparent several years earlier on the PIVs of the upper and middle valley, where dry season irrigation has always been more common than in the delta. To illustrate this land use pattern more clearly, Table 3 sets out the cropping history of different perimeters visited in 1989, for the previous three seasons.

TABLE 3: Proportion of land cultivated in three successive seasons in different irrigation perimeters, Senegal river valley

Season and starting month		cool dry nov 87	hot dry mar 88	rainy july 88	total
Perimeter	**net irrigable**	**% of area cultivated, and crop**			
SV Diagambal (Lampsar)	350 ha	11% tomato	55% rice	27% rice	93%
Guedé	343 ha	44% tomato	16% rice	43% rice	103%
Ile à Morphil Zone Demet (18 PIVs)	421 ha	40% maize	16% rice	65% rice	121%
Zone Pété (22 PIVs)	454 ha	1% maize	36% rice	22% rice	59%

Source: Woodhouse and Ndiaye, 1990.

The table gives two examples from large perimeters (Diagambal and Guedé) and two of irrigation organised in PIVs. With one exception, the irrigable land is fairly completely used during the year, but is not all cultivated at the same time. Instead, part of the area is cultivated each season. In the case of the PIVs in the Ile à Morphil, it is more usual for an entire perimeter (15 - 40 ha) to be cultivated in any one season. However, since a single village often has more than one perimeter, production may be undertaken in different perimeters in successive seasons. We can note that within this system farmers may also switch in and out of cultivation of rainfed crops (in the upper valley) or flood-recession cultivation of the *cuvettes* (in the middle valley), whenever rainfall is sufficient.

It is important to note that this multi-season farming does *not* correspond to the double cropping (two crops per year from the same land) which *l'Après-barrage*, through year-round provision of irrigation, was intended to promote.

Bastiaansen (1988) links the decline in intensity of land use in the Ile à Morphil to the increase in price of inputs in the early 1980s, which he feels was a disincentive to produce rice and which encouraged farmers to grow a cheaper (but less productive) crop of maize, particularly on lighter soils. However, there is evidence that farmers in the middle valley are also interested in maize and sorghum because they provide better livestock fodder than rice straw. Dry-season livestock fodder in the Sahel is more valuable than planners of irrigated crop production have recognised: farmers in Dioudé Diabé (Ile à Morphil) claimed that the sale of a single sheep could pay the pumping and fertiliser costs of growing rice on a 0.2 ha plot on their PIVs.

As discussed, production costs did increase relative to the value of the rice crop, particularly in the delta, but without much reduction of input use. More fundamental factors appear to block the more intensive use of land.

Firstly, double-cropping creates intense labour bottlenecks. Secondly, water management is insufficiently coordinated at local level to allow tillage of the soil within the very tight timetable required by double cropping. Studies by ISRA (Le Gal, 1989) indicate that the harvest of the 1987 rainy season rice crop took four months from the start of the first field to the completion of the last, using seasonal hired labourers and diesel-powered threshers. Dokit Thonon and Bruyère (1988) have suggested that complete mechanisation of the rice harvest may be the only way to resolve the bottlenecks presented by double-cropping. In practice, farmers, unlike development finance agencies, are not primarily preoccupied with maximising the annual output from each plot of land, but rather with maximising the return on their investment of labour and cash in production. The advantage to farmers of dividing their land and cultivation over more than one season is that one crop need not be cleared before the next crop is planted. This allows (particularly family labour), to be used more flexibly and reduces the need for extra seasonal labour[6].

Another poorly-studied problem is the need to synchronise farming operations in adjacent fields, so that drainage can be carried out in time to dry the soil sufficiently to allow tillage for the next crop. Such synchronisation is difficult if irrigation rotations create a substantial interval between the establishment dates of crops in adjacent fields. The need for tighter local coordination of farm operations (i.e. at *groupement* level) implied by double rice cropping may therefore call into question the existing practice of water supply on large perimeters in the delta. Further, the deterioration in canal maintenance which has accompanied SAED disengagement has greatly reduced the control of water delivery and drainage on large perimeters. This, coupled with the scarcity of agricultural machinery, severely diminishes the prospect of double-cropping on large perimeters.

A final point on the productivity of irrigation concerns the proliferation of small-scale irrigation in the delta, whose construction, while cheap, is also rudimentary. Small perimeters constructed without drainage will increase the risks of secondary salinisation of the saline delta soils, especially when situated on the periphery of large perimeters whose own drainage system has deteriorated. Avoidance of this risk requires both a regulatory body to enforce adequate drainage measures, and engineers with the necessary skills and experience to advise farmers' organisations on irrigation design. The plans for the withdrawal of SAED as yet have no concrete proposals on this last point.

5.4 Summary

In our discussion of irrigated farming in the aftermath of state disengagement, we have tried to identify the main institutional and technological factors at work in a complex, diverse, and rapidly changing situation.

As a result of SAED disengagement, farmers' organisations have become responsible for arranging credit, input supplies, and marketing of the crop,

---

6 Seasonal labourers from the regions to the south of the river valley are already employed in large numbers to harvest the rice crop, particularly the delta.

and this has created pressure towards collaboration between irrigation groups in order to improve their bargaining power with the credit agency, CNCAS, input suppliers, and transporters. This trend effectively reinforces throughout the valley the two-tier model of organisation set up by SAED on large perimeters in 1984. In this model, a *section* coordinates the activity of a number of water management *groupements*. The development of a commercial input supply system is financed by credit paid for by farmers. The credit is unsecured, but the collective responsibility of farmers within a *section* for repayment of the loans offers a guarantee of repayment. However, this arrangement also provides a mechanism by which indebtedness may grow *within* a *section*, with the prospect of wealthier members eventually buying out the cultivation rights of indebted members.

This potential for loss of cultivation rights has increased on large perimeters with the deterioration of infrastructure, which has increased the risk of crop failure within a relatively rigid cost structure. On the small-scale perimeters of the middle valley, there is less potential for this to occur because farmers generally have a more diverse income base, lower cash requirements for production costs, and individual *groupements* have greater control over the water delivery system. However, on new intermediate-scale perimeters currently being constructed in the middle valley larger plot sizes will make mechanisation necessary, and the need to share pumping equipment with other *groupements* will make conditions similar to those on the large perimeters of the delta in the longer term.

The generalised lack of double cropping on both large and small perimeters is attributed to intense labour peaks coupled with lack of appropriate mechanisation. The disengagement of SAED has done nothing to relieve this, and to some extent has made it worse. In the middle valley delays in planting have resulted from difficulties in obtaining credit or inputs; in the delta the deterioration in canal maintenance and reduced availability of tractors - both traced to measures to prepare for privatisation - have further limited farmers' capacity for timely land preparation and planting. The unregulated proliferation of small-scale irrigation by private sector investment in irrigation, raises the prospect of further cultivation difficulties due to inadequate drainage provision and soil salinisation.

Development of irrigation infrastructure has become the principal effective method of transfer of land tenure in the Senegal river valley, provoking the formation of irrigation organisations to gain access to irrigated land for different social groups within the communities of the valley. Under structural adjustment measures this competition for irrigated land has been greatly sharpened by government encouragement to entrepreneurs from outside the valley to seek land allocations from rural councils. The ensuing tension was documented in 1988, in reports in the Senegalese press[7] that competition for land increasingly set the interests of one village against another, leading to violent confrontations between villages on both the Senegalese and Mauretanian sides of the river valley. In April 1989 tensions over land rights exploded after two Senegalese farmers were killed by the Mauretanian military during a dispute over grazing rights. In the weeks that followed, rioting in Nouakchott and Dakar left several hundred dead, and, amid mutual repatriations of Senegalese and Mauretanians, some 60,000 farmers were expelled from the northern (Mauretanian) bank of the Senegal river valley to the southern bank, where they remain as refugees to the present.

The early experience of state disengagement from irrigated agriculture in the Senegal river valley indicates that, in contrast to rainfed farming in Senegal (Commander et al, 1989), an irrigated food-farming sector can sustain a commercial input supply system, under conditions of good access (i.e. in the delta) and where the cost of credit is met by farmers. In the less accessible areas of the middle and upper valley it seems likely that farmers' associations will need to bear much of the organisational, as well as financial, burden of securing input supplies.

The hoped-for growth of cereal output through the production of two rice crops on the same land each year in the delta has for the most part not materialised, due to insufficient mechanisation and inadequate and deteriorating irrigation infrastructure. As a result rice production has remained static, despite a rapid increase in the area of irrigated land. While commercial enterprises might in time ease the mechanisation constraint, it is by no means clear that they would improve irrigation infrastructure, whose decline is at least partly attributable to the disengagement process itself. Progress in the liberalisation of markets for agricultural inputs and services seems therefore to be constrained in various ways by inadequate infrastructure - an issue which appears unlikely to be resolved simply by disengagement of the state.

Similarly, our analysis suggests that disengagement will not achieve the intensification of land use through double cropping, which the government hoped would provide the increase in production needed to reduce rice imports. However, a further consequence, of more immediate relevance to the farmers of the Senegal river valley, is that the persistence of single

---

[7] SudHebdo, nos 23 (20.10.88), 24 (27.10.88), and 25 (3.11.88).

cropping of the land will sustain the pressure to increase production through extension of the area under irrigation schemes, which will further inflame the competition for land tenure. The events of 1989 have demonstrated how dangerous such an outcome may prove to be.

REFERENCES

Adams, A., (1977), Le long voyage des gens du fleuve, Maspero, Paris

Adams, A., (1981), The Senegal river valley, in J .Heyer et al, Rural Development in Tropical Africa, Macmillan, London.

Adams, A., (1985), La terre et les gens du fleuve, Editions l'Harmattan, Paris.

Afrique Agriculture (1986), Dossier Sénégal, No 125, Jan 1986, pp20-36.

Bastiaansen, C., (1988) L'aménagement et l'exploitation de périmètres irrigués villageois, Projet Ile à Morphil, SAED and Université Agronomique, Wageningen.

Bleeker, P., (1987), Etude de systèmes de production, Document de base No 11, Etude de faisabilité de la cuvette de Cascas, Projet Ile à Morphil, SAED and Université Agronomique, Wageningen.

Blijdorp, A., (1987), Rôle des femmes Soninké dans la production irriguée et renforcement d'associations de femmes en vue des cultures irriguées (draft), Document de travail 19b, Projet Gestion de l'eau, West African Rice Development Association, St Louis, Senegal, and Department of Irrigation, Agricultural University, Wageningen, Netherlands.

van Brandt, H., (1982), Rapport sur la campagne d'essais multilocaux en milieu paysan dans le delta et la vallée du fleuve Sénégal, West African Rice Development Association, St Louis, Senegal.

Commander, S., Ndoye, O., and Ouedrago, I., (1989), Senegal, in **Commander, S.**, (ed) "Structural Adjustment and Agriculture", Overseas Development Institute, London.

Diemer, G., and van der Laan, E., (1987), L'Irrigation au Sahel, Editions Karthala, Paris.

Dieye, Cheikhou., (1985), La problématique du développement agricole en milieu rural Sénégalais, (Mimeo).

Dokit Thonon, J., and Bruyere, G., (1988), L'incidence de la mécanisation en milieu paysan sur le revenu des producteurs, Communication aux journées d'études sur le crédit agricole dans la vallée du fleuve Sénégal, Centre de Documentation de Ndiaye, Département de Formation et de Recherche sur le Développement, Société d'Aménagement et d'Exploitation des terres du Delta du fleuve Sénégal (SAED), St Louis (Sénégal).

Engelhard, P., Ben Abdallah, T., et al (1986), Enjeux de l'Après-Barrage, ENDA Tiers Monde (Dakar) and Ministère de la Coopération (Paris).

Flavigny, C., and Cousin, R., (1982), L'OMVS et le développement agricole, Afrique Agriculture No 77, January 1982, pp 16-28.

Le Gal, P., (1989), Double culture et riziculture de saison sèche, Communication présentée à l'atelier sur la problématique de la double culture et ces implications pour la vulgarisation agricole, Ndiaye, 23-25/1/1989, Institut Sénégalais pour la Recherche Agricole, St Louis, Sénégal.

Gaudet, J., (1988), Rôle et place des femmes dans le futur aménagement intermédiaire de Cascas, Document de base No 7, Etude de faisabilité de la cuvette de Cascas, Projet Ile à Morphil, SAED and Université Agronomique, Wageningen.

Horowitz, M., (1989), Victims of Development, Development Anthropology Network Bulletin, 7(2): 1-8, Institute for Development Anthropology, Binghampton, NY.

Matlon, P., (1987), The West African Semi-Arid Tropics, in Mellor, J., **Delgado, C., and Blackie, M.**, (eds) Accelerating Food Production in Sub-Saharan Africa, Johns Hopkins, Baltimore.

OMVS (1984), Etude socio-économique du bassin du fleuve Sénégal, Organisation pour la Mise en Valeur du fleuve Sénégal, St Louis (Sénégal).

OMVS (1985), Bilan des campagnes agricoles sur les périmètres irrigués du fleuve Sénégal, Hivernage, contre saison froide, et contre saison chaude, 1982/83 et 1983/84, Cellule d'Evaluation et de Planification Continue, Organisation pour la Mise en Valeur du fleuve Sénégal, St Louis (Sénégal).

OMVS (1987), Bilan de campagne, Hivernage 1986, Cellule d'Evaluation et de Planification Continue, Organisation pour la Mise en Valeur du fleuve Sénégal, St Louis (Sénégal).

Schmitz, J., (1986), Génie rural et Genie social: la culture irriguée chez les Halpulaar de la moyenne vallée du fleuve Sénégal, Document de base No 1, Etude de faisabilité de la cuvette de Cascas, Projet Ile à Morphil, SAED and Université Agronomique, Wageningen.

Scudder, T., (1989), River Basin Projects in Africa, Environment, 31(2): 4-32.

SAED (1986), Rapport Annuel Exercice (85/86, Bilan de deux années d'exécution, Centre de Documentation de Ndiaye, Département de Formation et de Recherche sur le Développement, Société d'Aménagement et d'Exploitation des terres du Delta du fleuve Sénégal (SAED), St Louis (Sénégal).

van Tilberg, A., (1989), Food security in relation to the production and marketing of local cereals in Senegal (draft), Department of Marketing and Marketing Research, Agricultural University, Wageningen.

Woodhouse, P., and Ndiaye, I., (1990), Structural Adjustment and Irrigated Food Farming in Africa: The 'Disengagement' of the State in the Senegal River Valley, Open University DPP Working Paper No 20.

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 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.

Technical Centre for Agricultural and Rural Co-operation (CTA)
The Technical Centre for Agricultural and Rural Co-operation (CTA) was established in 1983 under the Lomé Convention and is based in Ede-Wageningen in the Netherlands. Its mandate is to help the African, Caribbean and Pacific countries which comprise the ACP group achieve greater food security by providing them with better access to scientific and technical information on all issues related to agricultural and rural development. Working in close cooperation with ACP and EEC countries and with international, regional and national institutions, CTA fulfils its mandate through a range of activities, including seminars, studies, publications and support to ACP documentation centres.

The ODI Irrigation Management Network is sponsored by **The Overseas Development Administration (ODA)**, 94 Victoria Street, London SW1E 5JL; and **The Ford Foundation**, 320 E 43rd Street, New York, NY 10017, USA.

The African Edition of Irrigation Management Network is sponsored by the ACP-EEC Technical Centre for Agricultural and Rural Co-operation (CTA), Postbus 380, 6700 AJ Wageningen, The Netherlands

© Overseas Development Institute, London, 1991. Photocopies of any part of this publication may be made without permission. (Requests for commercial reproduction of Network material should be directed to the copyright holders.)

This African edition is sponsored by the Technical Centre for Agricultural and Rural Co-operation (CTA), Postbus 380, 6700 AJ Wageningen, The Netherlands

Overseas Development Institute
Regent's College, Inner Circle.
Regent's Park. London NW1 4NS
England.
Telephone: (071) 487 7413
Telex: 94082191 ODIUK
Fax: (071) 487 7590

odi

IRRIGATION MANAGEMENT NETWORK
(African Edition)

Network Paper 8

LARGE-SCALE IRRIGATION SCHEMES IN NORTHERN CAMEROON: DEVELOPMENT AND DISENGAGEMENT

Achille Bikoi

CTA

The African edition of the
Irrigation Management Network
is supported by the Technical
Centre for Agricultural and
Rural Co-operation (CTA)

October 1991

Papers in this set:

6 *Promoting a Smallholder-Centred Approach to Irrigation: Lessons from Village Irrigation Schemes in the Senegal River Valley* by Geert Diemer, Boubacar Fall and Frans P Huibers

7 *Structural Adjustment and Irrigated Agriculture in Senegal* by Philip Woodhouse and Ibrahima Ndiaye

8 *Large-Scale Irrigation Schemes in Northern Cameroon: Development and Disengagement* by Achille Bikoi

9 *Design and Operation of a Small Irrigation Project in Zimbabwe to Minimise Schistosomiasis Transmission* by M Chimbari, R J Chitsiko, P Bolton, and A J Thomson

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

Linden Vincent, Editor, Irrigation Management Network (African Edition), Overseas Development Institute, Regent's College, Inner Circle, Regent's Park, London NW1 4NS

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

The opinions represented are those of the author and do not necessarily reflect the policies of the Overseas Development Institute, or any organisation with which the Institute or author is connected.

AAU 116

HYDRO-AGRICULTURAL SCHEMES IN THE LOGONE FLOODPLAIN, NORTHERN CAMEROON (1954-1989)

Achille Bikoi

Contents **Page**

FUNCTIONS, POSITION AND ASSESSMENT OF THE CURRENT EXPERIENCES OF GROUPS OF RICE-GROWERS IN MANAGING SEMRY SCHEMES

HYDRO-AGRICULTURAL SCHEMES IN THE LOGONE FLOODPLAIN, NORTHERN CAMEROON (1954-1989)

Achille Bikoi

1. INTRODUCTION

The Logone Floodplain in the far north of Cameroon has been the scene of a series of more or less successful schemes over the last three decades. The experimental project to modernise rice-growing in Yagoua (SEMRY)[1], which was established in 1954 to implement and manage these schemes, became a public development institution in 1971 (retaining its French acronym, SEMRY[2] - agency to expand and modernse rice-growing in Yagoua). SEMRY was provided with substantial financial and technical resources[3] to implement its schemes, with the following objectives:

- Increase Cameroon's rice production to supply the national market and gradually phase out imports;

- Involve small farmers in this process with a view to increasing their income and raising their living standards.

After 30 years, how should we judge and assess the hydro-agricultural schemes implemented by SEMRY? Such an evaluation clearly demands that we consider not only the level of success attained in physical terms (water control, inability of infrastructure, etc), but also two other aspects:

- How the schemes operate;
- How the system fits in with its economic surroundings.

[1] Le SEMRY: le Secteur expérimental de modernisation de la riziculture de Yagoua.

[2] La SEMRY: la Société d'expansion et de modernisation de la riziculture de Yagoua.

[3] Funding came from the Republic of Cameroon and external donors (BIRD, EDF, CCCE, FAC).

We shall thus approach these schemes from three angles, relying mainly on SEMRY secondary information sources[4] from 1981 to 1984.

1. MASTERING THE PHYSICAL DIFFICULTIES

Before looking into the detail of these hydro-agricultural schemes, their constraints and the efforts undertaken or planned for lifting the latter, we should point out that they were not initially designed to provide complete water control. This led to many approximations in implementation, resulting in failures (at the time of the experimental project), or expensive corrective measures (with the advert of modern-day SEMRY).

1.1 Rudimentary Schemes Implemented by the Original SEMRY (1954-1971)

The experimental project was mainly directed in the lands situated between the Logone and Mayo Guerléo rivers from East to West, and between Yagoua and Ojafga from South to North. A 40 km long dyke was constructed along the Logone to protect the Western plain against the river's spate. Inlet valves were also installed along the dyke to regulate water flow, drainage for the rice-fields provided by a thakweg directed towards the Mayo Guerléo.

Although these initial efforts did afford some protection against the spate, they did not allow for total water control. In fact, if the spate was insufficiently strong, the rice-fields had to rely on rainfall (which was rarely adequate).

1.2 Corrective Measure and Establishment of New Schemes by Modern-Day SEMRY

When the new-style SEMRY took over the administration of rice-growing in the Logone flood-plains, studies designed to renovate and extend former rice-growing schemes (SEMRY I - 5300 hectares in Yagona arrondissement), and to establish a new irrigation schemes (SEMRY II - 6226 hectares in

[4] Refer to Bibliography.

Maga)[5] had been completed and were ready to be put into practice (Roupsard, 1987).

1.2.1 SEMRY I

The project worked on four points:

- Establishment of an irrigation network supplied by four electric pumping stations, allowing two annual crops to be grown;

- Reinforcing and raising the height of the dykes protecting the fields against the Logone's spate;

- Improving drainage of the rice-fields by means of culverts directed towards the Mayo-Guerléo;

- Conversion of land formerly managed by SEMRY into larger, better organized rice-fields.

The area covered by the scheme was 5300 hectares in 1977, but it was possible to irrigate only 3000 hectares in the dry season (due to the water-sharing agreements between Chad and Cameroon in respect of the Logone. Nevertheless, this means that up to 8300 hectares may be cultivated per year (Roupsard, 1987).

The SEMRY I scheme paid too much attention to cost-cutting (incomplete levelling, inadequate access tracks), and the sluices received little or no maintenance until 1983. Moreover, the Logone dykes were damaged in places by the vigorous spate in 1981.

This state of affairs meant that overhaul was essential. Begun in 1984, this operation has now been completed at a cost of 540,000 FCFA per hectare of rice-field within the rehabilitated scheme (CCCE, 1989).

---

[5] SEMRY was also in charge of managing two other projects SEMRY III (around Koussén) and SEMRY IV (Moulsoudage). We just mention these in passing, as they have very specific objectives (production is not primarily intended for sale to supply the national market, but mainly to provide food security for local people through small village-level irrigation schemes, with complete water control for 1300 hectares in the case of SEMRY III and partial water control for around 250 hectares in the case of SEMRY III).

1.2.2 SEMRY II

Work began in 1978, concentrating on the creation of an artificial lake (36,000 ha) by constructing a dam dyke, to be fed by the Logone.

The aim of the schemes is to provide gravity irrigation for 7000 hectares of rice-fields producing two annual crops. The 27 km long earthen dyke, completed in 1979, had been seriously affected by wave erosion by 1985. It was reinforced with rocks along 14 kms of its length.

The lake flooded areas traditionally used for livestock-rearing, as well as about twenty villages. The displaced people (about 7500) were settled in new villages within the scheme. To compensate for the loss of grazing land, experiments are being undertaken with fodder crops and the use of rice by-products is planned.

The lake did, however, open up substantial opportunities for fishing (an estimated 1000 tons of fish per year). Originally the responsibility of SEMRY, management control of the fishery sector was transferred in 1987 to an autonomous structure supported by the Japanese cooperation service.

Rice growing therefore continues to be the main activity within the SEMRY scheme. Let us now consider how it is undertaken and what results it obtains.

2. THE OPERATION OF SEMRY SCHEMES

We shall present the operational modalities of the schemes first of all, before dealing with the results obtained by the two operators directly involved in the production process before small farmer groups came into being.

2.1 Modalities

The different aspects of rice production are partly under the control of SEMRY and partly the responsibility of the farmers within the scheme.

SEMRY deals with:

- Training and supervision of the rice-growers (instructing them in new techniques);

- Mechanical digging/levelling operations;
- Supply and distribution of irrigation water and fertilizers;
- Preparation of nurseries;
- Scheme maintenance;
- Purchase, storage and processing of paddy rice marketing.

For their part, the rice-growers undertake to:

- Control water-flow into their plots;
- Plant out the seedlings taken from the nursery;
- Weed the crops;
- Spread fertilizer;
- Harvest the rice (cutting, placing in stooks and ricks, threshing and winnowing);
- Bring the paddy to the point of sale.

These farming activities require an average of 145 person days per hectare (CCCE, 1989).

In return for services rendered, the rice-growers have to pay dues in kind to SEMRY - 2 tons of paddy per hectare farmed - and sell what is left of the crops after setting aside sufficient rice for domestic consumption to SEMRY at the government-fixed price.

2.2 Results

Based on the objectives set for the schemes, we shall take as indicators the annual income gained from rice production by the individual farmers and, for SEMRY, the unit cost of the finished product and its share of the national market.

2.2.1 Progression of Income Form Rice-Growing

Individual farmers generally receive an irrigated plot of 0.5 hectares (known as a 'piquet'). Their income from rice-growing is calculated by subtracting costs (mainly dues paid to SEMRY) from the total value of the paddy they produce. The latter is calculated at SEMRY's purchase price, when it is buying, or the price of paddy on the local market when it is not.

Income from rice-growing, which has progressed greatly since the 1950s, has been calculated for five phases, as per Table 1:

Table 1: Income from Rice-Growing*

Period	Characteristics	Yield T/ha	Price of Paddy/ha	Dues .000 FCFA/ha	Income from Rice .000 FCFA ha	plot
1954-73	Single Intensive annual cropping (no water-control, no fertilizer or planting-out). Stagnation of yields and price of paddy.	1.4	16	8.8	13.6	6.8
1974-79	Double intensive annual cropping (water-control, fertilizer, planting out)	8	32	256	256	128
1980-86	Double intensive annual cropping and substantial increase in price of paddy.	10	65	260	390	195
1987	Single Intensive annual cropping	5	78	152	234	117
1988	Single Intensive annual croppng. Paddy not bought by SEMRY; sold on local market	5	40	152	120	60

* Table based on data obtained from SEMRY documentation

During the 1954-73 period, income from rice-growing is strikingly low and roughly corresponds to the monthly wage of a labourer or domestic servant in town (Roupsard, 1987). The advent of double cropping (1974-1986) and the substantial increase in the purchase price of paddy enabled rice-growers to earn an income equivalent to the annual income of a labourer in town. Under the conditions obtaining in 1988, income from rice-growing per working day stabilised around 600-700 FCFA, about the same as earned from rain-fed agriculture in the region (CCCE, 1989).

2.2.2 Unit Cost of the Finished Product

The only data available on the unit cost of the finished product refer to the 1986-87 financial year, but nevertheless appear representative of the present day.

According to SEMRY, this cost may be calculated on the basis of Table 2.

If we take a (theoretical) yield of 70% on processing, we obtain, according to SEMRY, a unit cost per kilo of finished product of:

$$\frac{153.12}{0.7} = 218 \text{ FCFA}$$

This result should be treated with caution:

- The method of calculation does not take account of the real performance of the industrial factor (the actual yield on processing);

- The financial costs mentioned by SEMRY do not relate only the 1986-87 financial year, as they also include interest from previous years;

- The cost of processing does not relate to the total quantity of paddy purchased during the season, but only the quantity processed calculated against the former, the unit price of the finished product rises from 218 to 430 FCFA.

While it is true that the unit cost has only relative significance (in connection with market prospects), it is still a fact that SEMRY urgently needs to reduce this cost if it wishes to increase its share of the Cameroonian market, which is presently extremely limited by competition from imported rice, whose price on arrival at the port of Donala is often under 80 FCFA (CCCE, 1989).

2.2.3 SEMRY's Share of the National Rice Market

In seeking to ascertain this, we:

- Took the annual national demand to be around 160,000 tons of rice as 1985 (CCE, 1989);

- Assumed that all the rice sold by SEMRY is consumed in the country (which is far from the case).

Table 3 shows that:

- SEMRY barely covers 20% of the national market;

- Its market share is not increasing and does not seem to bear much relation to its production, i.e more than 80% of Cameroon's rice production (and SEMRY's production could supply 50% of the national consumption requirements).

3. SEMRY SCHEMES AND THEIR ECONOMIC SURROUNDINGS

SEMRY's establishment is part of the national policy to promote food self-sufficiency. For a long time, it was thought that mere import substitution would deliver the Cameroonian market to SEMRY. The authorities did not expect the distribution of SEMRY rice to cause problems, as they were convinced that private traders would do this effectively. However, the State's aim to achieve self-sufficiency in rice production does not fit well with private traders' concern to maximise their projects; the latter preferring to concentrate on imported rice which provides them with higher profit margins than they could obtain from distributing local rice (Engola, 1989).

The failure or inadequacy of measures taken to give priority to selling local rice shows the difficulty of integrating SEMRY within the national economy.

Table 2: Cost in FCFA per Kilo of Rice Purchased 1986-87*

Item	Fixed Cost	Depreciation	Variable Cost	Total
Purchase of Paddy			44.00	44.00
Collection	0.58	0.11	6.25	6.94
Agricultural Production	7.85	12.12	11.92	34.79
Industrial Production	5.94	12.56	17.43	35.93
Maintenance	7.50	1.16		8.66
Public Services	0.56	0.18		0.74
Technical Services	4.35	1.07		5.42
General Administration	8.05	1.80		9.85
Financial Expenses	9.79			9.79
Total	44.62	28.90	79.60	153.12

Table 3: SEMRY's Share of the National Rice Market*

Years		1984/85	1985/86	1986/87	1987/88	1988/89
SEMRY	Paddy	78887	102965	80403	61392	-
Production (tons)	Rice equivalent	55220	75075	26282	42974	-
SEMRY rice sales (tons)		28319	8198	25763	29551	17823
Share (%) of national rice requirements		18	5	16	18.5	11

* Table prepared on the basis of data given in SEMRY documentation.
This table shows how badly the SEMRY schemes fit in with their economic surroundings

First of all, let us consider the device of raising customs duties: the minimum customs duty plus the additional tax on rice amounts to 20.5% of the CIF (cost, insurance and freight) price. This low rate allows authorised dealers to take advantage of times when the world price is low to flood the local market with large quantities of rice.

Secondly, there was the so-called 'twinning' rule, whereby a merchant wishing to obtain an import licence must first order from SEMRY to proportionate amount of rice to the purchases he wished to make abroad. This rule did not achieve the authorities' objective. What happened was that most merchants place their orders but did not take them up, or preferred to sell them on to Nigerian or Chad to avoid the high cost of transport to the South.

Thirdly, there were *ad hoc* measures such as:

- Partial state subsidy (25 and then 35 F/kg) of the transport costs of SEMRY rice delivered to the South;

- Temporary suspension of import permits for rice (from 1986 to early 1987).

Like the twinning rule, these economic measures did not achieve the desired result.

The most recent measure is 'balancing out', whereby the state seeks to subsidise national production by means of levies on imported rice. So far, the operation of the fund set up for this purpose has not been promising: the substantial volume of rice imports bearing no relation to the very small amount of tax collected. In 1988-89, only FCFA 130 m. were made available to SEMRY, although the levy is FCFA 20 per kg of imported rice and, according to customs, 71,000 tons were placed in store (CCCE, 1989).

CONCLUSION AND EPILOGUE

As SEMRY's resources have to come from the sale of rice and the recovery of dues from the rice-growers, it is easy to understand why the slump in its sales and the accumulation of unpaid dues (FCFA 900 m between 1983 and 1987) have recently led it into severe financial difficulties. While it was possible to keep these difficulties within reasonable bounds, or hide them by means of state subsidies, until the beginning of the 1980s, the country's present economic and financial crisis no longer allows for such transfers of budgetary resources. It was thus up to the Cameroonian authorities to decide on SEMRY's fate. They chose to release it gradually from its functions and hand these over to groups of rice-growers and private structures.

Apart from the programme to give increased responsibility to small farmer groups, which is already under the way (see below), the other aspects and modalities of SEMRY's disengagement are still under review.

SEMRY can also take credit for successfully mastering the technical side of the schemes (which at least represent progress in comparison with the present situation). However, this success will remain fragile and indeed potentially self-destructive of regular outlets for its rice cannot be guaranteed.

FUNCTIONS, POSITIONS AND ASSESSMENT OF THE CURRENT EXPERIENCES OF RICE-GROWING GROUPS IN MANAGING SEMRY SCHEMES

INTRODUCTION

Begun in 1984 by SEMRY when rehabilitating a rice-growing scheme, the establishment of rice-growing groups was subsequently encouraged and supported by the state with a view to its gradual disengagement from the operational side of the rice production sector.

The number of groups has risen from 27 in 1987 to about 100 now, with around 12,000 members (from a total of 22,000 rice-growers). This expansion comes at a time when SEMRY is experiencing serious difficulties and the socio-economic context is undergoing profound changes in relation to agricultural production.

SEMRY was able to sell only a small proportion of its production on the Cameroonian market and at a price far below its cost price (see above).

This resulted in:

- A substantial rise in paddy stocks (close to 100,000 tons in 1987);
- Deterioration in its financial situation;[6]
- Deterioration in its means of production (schemes, equipment, factories).

The recovery plan for SEMRY (endorsed in 1989 by the signature of a performance contract with the state) provides for:

- An adjustment in SEMRY's production to bring it in line with the market in Northern Cameroon (30,000 tons of rice), by returning to single annual cropping and abolishing its paddy purchasing monopoly with the rice-growers;

- Transferring responsibility for the depreciation of major investments (dykes, access tracks, sluices to the states;

[6] Characterised by debts to the tune of 13.5 billion FCFA in 1988, owed to banks, suppliers and rice-growers.

- Organising rice-growers by continuing to set up groups (to whom SEMRY will gradually hand over some of its functions).

In this section, we propose to look into the origins, organisation, operation and current status of these groups. It should be pointed out that we collected information by consulting the available documentation (indicated in the bibliography) and holding informal talks with SEMRY officials and some group members.

1. ORIGINS OF THE SEMRY GROUPS

The existence of SEMRY groups far pre-dates the recovery plan which, in fact, was designed to strengthen them. In 1981, concern began to be expressed at the fragility of SEMRY's technical achievement in view of the deterioration of its relationship within the farmers,[7] illustrated by:

- The abandonment of certain plots;
- Increasing numbers of acts or vandalism (damage to sluices, theft of secondary gates);
- Decreasing rate of payment of dues;
- Difficulty in getting new methods accepted (spreading straw, placing in stooks);

The solution to these problems seemed to lie in gaining the trust of the rice-growers and empowering them through organising them into groups.

In 1984, SEMRY's management decided to combine the physical rehabilitation of the SEMRY I project with the establishment of groups. For this purpose, they relied on a traditional form of organisation in Masaa society:[8] the 'Farana', which is a group of families which herd their animals together. The physical rehabilitation work includes land consolidation and the management of the irrigation blocks[9] is entrusted to the Farana.

---

[7] According to R Nyonse, the extension workers were responsible for this deterioration, which they provoked, maintained or exacerbated by abusing their position, arbitrarily withdrawing or handing out plots (R Nyonse, communicated to the Yamoussoukro Conference, 1985).

[8] The Masaa are the dominant ethnic group in the SEMRY I scheme (more than 90% of the population).

[9] All the rice-fields watered by the same secondary network.

2. GROUP ORGANISATION

To enable the groups to function, SEMRY began to structure them by defining tasks, distributing roles, choosing a method for appointing leaders and working out a training programmes.

The groups are organised along classical lines with a general assembly (gathering of all members) and a council comprising a delegate, a secretary/book-keeper, a treasurer and a store-keeper.

- The assembly appoints and may recall the members of the Council;
- The delegate is the group's representative in dealings with the outside (traditional or administrative authorities, SEMRY);
- The secretary/book-keeper does the accounts and orders fertilizers, sacks and other inputs;
- The treasurer holds the group fund and the cash-flow vouchers;
- The store-keeper manages the group store and weighs the sacks before they are sold.

Training for these officials takes place over four 12-day sessions. The first two are devoted to learning to read and write the Masaa language[10] and the last two to management techniques (bookkeeping and accounts).

3. FUNCTIONS TRANSFERRED TO THE GROUPS

These include:

- Production of seedlings in the nursery;
- Ordering and distributing fertilizer;
- Water management;
- Paddy marketing.

3.1 Production of Seedlings

SEMRY allocated to each group a number of seed-beds corresponding to the area of rice-field to be planted out, provides a production plan and

[10] Use of the Masaa language within the groups and in communications between the group and SEMRY has made it possible to speed up the literacy training of future officials (3 months) and to get around the difficulties caused by the lack of educated adults (R Nyonse, 1985).

supplies the necessary for establishing the nurseries (ploughing, water supply, seeds).

The group members are obliged to respect the schedule for the relevant operations.

3.2 Ordering and Distributing Fertiliser

The group secretary records members; requirements and passes an order form to SEMRY. Delivery is schedules: at the agreed date, the fertilizer is brought to the group warehouse by a SEMRY truck. A delivery note is signed by the secretary and the members unload and stack the fertilizer. The officials are responsible for distribution at the appropriate time.

3.3 Water Management

The objective of entrusting management of the irrigation blocks to the groups is to be able to invoice them on a pro-rata basis for the actual quantities of water consumed.

This means that the officials must ensure that the irrigation water is properly used by the members.

3.4 Maintenance of the Network

The network consisted of canals, drains, dykes and spoil-banks. The groups must ensure that there are no:

- Weeds or mounds of earth in the canals and drains;
- Termite mounds on the banks.

3.5. Delivery of Paddy to SEMRY

For this purpose, the group officials must arrange:

- Distribution of sacks to bag the paddy;
- Transportation of the sacks from the plots to the delivery point;
- Management of the collection/delivery operation.

This last point deserves further elaboration. The secretary works out a schedule, advising each member of the delivery day. As soon as the paddy is weighed and removed, a receipt is given to the member. SEMRY arranged for the sacks to be taken away and a group official accompanies the truck to the factory to check the volume of paddy actually collected (on the weigh-bridge) and its quality.

This latter check is done at the factory, where a technician takes a sample (of a few sacks) to determine the percentage of impurities and the yield on processing.

If the quality of the paddy proves to be:

- Up to standard, SEMRY, returns part of the hold-back[11] retained at the time of purchase;
- Below grade, SEMRY keeps the hold-back.

It should be stressed that the group is collectively responsible for payment of dues. Until the required quantity of paddy has been delivered, SEMRY retains the hold-back and the collection premium (FCFA 2 per kilo delivered).

4. ASSESSMENT OF THE CURRENT EXPERIENCE OF SEMRY GROUPS

Rice-growing groups vary in size (from 50 to 200 members). In August 1987, there were twenty-seven groups within the SEMRY I Scheme, representing a total of 3500 rice-growers.

In August 1990, there were ninety-two groups, covering the whole scheme. The experiment has also begun within the SEMRY II project, where informal groups are operating in the Pousr rice-fields. SEMRY also plans to extend the establishment of groups to all three schemes.

This rapid expansion of groups is due much more to the pressure from their instigator (SEMRY) than the enthusiasm of the farmer[12].

---

[11] This hold-back amounts to 10% of the value of the paddy delivered.

[12] SEMRY tells the rice-growers: "You have to form a group if you want to continue to receive our support".

4.1 Exercise of Functions Transferred to the Groups

We are primarily concerned with functions which are inadequately performed or not performed at all, indicating in each case who is responsible.

Water Management: In order to be able to invoice the groups for the water they use, SEMRY installed lockable gates between the plots; this system implies that the farmers will respect the irrigation turns, but those who do not feel so inclined prefer to break the lock and irrigate their plots without waiting for their next turn.

SEMRY has gone back to lump-sum invoicing, especially as the new system did not look reliable even in theoretical terms.

Network Maintenance: The rice-growers do not bother unless they can see an immediate benefit. However, if they find that water is not reaching them because of channel blockage, they get moving and may even go to clean out the feeder canal well beyond their own rice-fields.

Ordering and Distribution of Sacks: This function is relatively well mastered in technical terms. In human terms, on the other hand, there have been cases of misappropriation of sacks by certain group officials[13].

Delivery of Paddy: While SEMRY can adequately check the volume of paddy entering its factory since the repair of the weigh-bridge in 1988, the same cannot be said for the quantity, since to date no reliable checking has been set up.

4.2 Results Expected and Results Obtained

SEMRY *expects* group formation to lead to:

(a) Firstly for itself:

- Better payment rates of dues as a result of collective responsibility shared by members;
- Reduction in production and collection costs now that various

---

[13] This happened with the Djadikreo group (in 1985), whose assembly apparently demanded and obtained the replacement of the officials concerned.

functions are performed by the rice-growers themselves;
- Better maintenance of schemes;[14]
- Better quality production.

(b) Secondly for the rice-growers:

- Achievement of new status (becoming 'partners' instead of mere underlings of SEMRY);
- Reduction in paddy production costs;
- Siphoning-off of the additional income thus generated (especially by the collection premium) for community projects.

Results *obtained* by SEMRY:

(a) In terms of payment of dues:

- No significant difference between farmers in groups or operating individually;
- Serious drop in recovery rates (in 1989/90 - 65.5% - the lowest in SEMRY's history).

In fact, the abolition of SEMRY's purchasing monopoly and the attractive prices offered on the market make it difficult (if not impossible) to bring collective responsibility into play in collecting dues. Good farmers, in order to avoid paying for defaulters, pay their dues in cash or only deliver the equivalent in paddy (and nothing more).

(b) There has been a reduction in production and collection costs, but SEMRY has not been able to take full advantage of this as a result of the declining rate of payment of dues.

(c) In the absence of an adequate checking system, incentives to improve quality (premiums, purchase according to quality) could not be applied.

(d) With regard to scheme maintenance, we have obtained no evidence that rice-growers in groups behave better than others.

---

[14] The Schemes cannot be properly maintained unless all the people concerned become aware of the need to take part in preserving them (Samangassan, 1987).

By the rice-growers:

(a) In relation to the previous situation (i.e no groups), there has been progress towards acquiring new status. Dialogue is easier for SEMRY now that it is dealing with group officials.

There is certainly social recognition for groups, but this has unfortunately not so far been accompanied by legal recognition. In fact, the groups do not yet enjoy any official legal existence; they cannot therefore open a bank account, approach a court of law[15] or deal with outside agencies.

(b) There has been a reduction in dues for rice-growers in groups, but not necessarily in total production costs (in view of the increase in work load, which might necessitate resorting to paid labour);

(c) With regard to the use of collective savings, some groups have carried out community projects (schools, village mill) whereas others (much more numerous) have done nothing so far. SEMRY's cashflow difficulties mean that a large part of the groups' assets held by SEMRY cannot be easily mobilised. There has also been a considerable drop in savings as a result of the fall in revenue generated by the collection premium (in accordance with the decrease in the volume of paddy delivered to SEMRY).

CONCLUSION

The groups set up by SEMRY do not seem to us to meet the expectations of their promoter in a satisfactory manner. It would be useful to carry out an in-depth evaluation, particularly to look into:

- **The Objectives of these Groups:** The way these are set at the moment clearly shows that SEMRY's concerns take precedence over those of the rice-growers. Restoring the balance to ensure that small farmer's interests are taken into account would be desirable.

- **The Worth of their Officials (competence, probity, etc):** The latter seem to have copied the behaviour of the former extension workers

---

[15] Groups have assets which could be stolen. In the event of theft, is SEMRY legally entitled to approach a court of law in the name of the group?

and to enjoy a degree of immutability which prevents them from being replaced or sanctioned regularly.

- **The Relationship between SEMRY and the Groups:** Because of its financial difficulties, SEMRY cannot adequately meet its commitments towards the groups. Perhaps SEMRY should review these in order to adjust them to its resources and the policy of disengagement which, in any event, cannot be effective unless the groups can exist by and for themselves. SEMRY's supervision, however necessary at the beginning, should therefore take the form of support entirely devoid of paternalism. The question of legal recognition of the groups cannot of course be evaded.

BIBLIOGRAPHY

Belloncle, G. (1983), Propositions pour la mise en place des organisations des producteurs 'partenaires' dans le cadre de la SEMRY, Rapport de mission.

Berut, F. (1990), Le rôle des groupements villageois dans le développement local du Nord Cameroun, Thèse de Doctorat INA Paris-Grignon.

Bikoi, A. (1984), Impact de SEMRY I, Aspects agro-économiques. *Revue Science et Techniques*, Série Sciences Humaines, vol III, Yaoundé.

Bikoi, A. (1984), Les conditions de production du riz SEMRY. Mémoire DDA, ENSA, Montpellier.

CCCE (1989), Proposition pour un plan de redressement de la SEMRY, Paris, 80p.

Engola Oyep (1989), Approvisionnement en riz du Cameroun ou les limites d'une politique d'autosuffisance alimentaire, *Revue de Géographie du Cameroun*, vol VIII no 1, Yaoundé.

Nyonse, R. (1985), Passage d'un système d'encadrement directif à la prise en charge progressive des différentes fonctions du développement par les associations de producteurs (l'expérience de la SEMRY), Colloque de Yamoussoukro.

Nyonse, R. (1987), Associations villageoises et aménagements hydro-agricoles de la SEMRY (Cameroun), Colloque de Yamousoukro, Ministère de la Coopération, Paris.

Roupsard, M. (1987), Le Nord du Cameroun, ouverture et développement, Valcanville, 516 p.

Samangassou, P. (1987), L'animation des groupements villageois dans le processus de développement rural (les GV de SEMRY I), Mémoire INIS.

SEMRY, Rapports d'activités Exercices 1983/84, 1984/85, 1985/86, 1986/87, 1988/89, 1989/90.

SEMRY (1984), Etude de l'impact des aménagements de SEMRY I et SEMRY II, Doc 84-250, Yagoua, 185 p.

SEMRY (1986), Rapport de collecte de la production des groupements SP 1985.

SEMRY (1986), Mémento du responsable des groupements (2e édition).

SEMRY (1988), Plan de redressement de la SEMRY (éléments d'analyse).

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 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.

Technical Centre for Agricultural and Rural Co-operation (CTA)

The Technical Centre for Agricultural and Rural Co-operation (CTA) was established in 1983 under the Lomé Convention and is based in Ede-Wageningen in the Netherlands. Its mandate is to help the African, Caribbean and Pacific countries which comprise the ACP group achieve greater food security by providing them with better access to scientific and technical information on all issues related to agricultural and rural development. Working in close cooperation with ACP and EEC countries and with international, regional and national institutions, CTA fulfils its mandate through a range of activities, including seminars, studies, publications and support to ACP documentation centres.

The ODI Irrigation Management Network is sponsored by **The Overseas Development Administration** (ODA), 94 Victoria Street, London SW1E 5JL; and **The Ford Foundation**, 320 E 43rd Street, New York, NY 10017, USA.

The African Edition of Irrigation Management Network is sponsored by the ACP-EEC Technical Centre for Agricultural and Rural Co-operation (CTA), Postbus 380, 6700 AJ Wageningen, The Netherlands

© Overseas Development Institute, London, 1991. Photocopies of any part of this publication may be made without permission. (Requests for commercial reproduction of Network material should be directed to the copyright holders.)

This African edition is sponsored by the Technical Centre for Agricultural and Rural Co-operation (CTA), Postbus 380, 6700 AJ Wageningen, The Netherlands

Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England.
Telephone: (071) 487 7413
Telex: 94082191 ODIUK
Fax: (071) 487 7590

IRRIGATION MANAGEMENT NETWORK
(African Edition)

Network Paper 9

DESIGN AND OPERATION OF A SMALL IRRIGATION PROJECT IN ZIMBABWE TO MINIMISE SCHISTOSOMIASIS TRANSMISSION

M Chimbari, R J Chitsiko, P Bolton, A J Thomson

LIBRARY
OVERSEAS DEVELOPMENT INSTITUTE
REGENT'S COLLEGE
INNER CIRCLE REGENT'S PARK
LONDON NW1 4NS

The African edition of the Irrigation Management Network is supported by the Technical Centre for Agricultural and Rural Co-operation (CTA)

October 1991

Papers in this set:

6 *Promoting a Smallholder-Centred Approach to Irrigation: Lessons from Village Irrigation Schemes in the Senegal River Valley* by Geert Diemer, Boubacar Fall and Frans P Huibers

7 *Structural Adjustment and Irrigated Agriculture in Senegal* by Philip Woodhouse and Ibrahima Ndiaye

8 *Large-Scale Irrigation Schemes in Northern Cameroon: Development and Disengagement* by Achille Bikoi

9 *Design and Operation of a Small Irrigation Project in Zimbabwe to Minimise Schistosomiasis Transmission* by M Chimbari, R J Chitsiko, P Bolton, and A J Thomson

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

Linden Vincent, Editor, Irrigation Management Network (African Edition), Overseas Development Institute, Regent's College, Inner Circle, Regent's Park, London NW1 4NS

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

The opinions represented are those of the author and do not necessarily reflect the policies of the Overseas Development Institute, or any organisation with which the Institute or author is connected.

DESIGN AND OPERATION OF A SMALL IRRIGATION PROJECT IN ZIMBABWE TO MINIMISE SCHISTOSOMIASIS TRANSMISSION

M Chimbari, R J Chitsiko, P Bolton, A J Thomson

Contents **Page**

This paper was written to be presented in February 1991 in Alexandria, Egypt at the 5th African Regional Symposium, postponed until September 1991 because of the Gulf War. The paper is published in the compilation of the Symposium papers, 'Techniques for Environmentally Sound Water Resources Development' (1991), Woodridge, R (ed), Overseas Development Unit, Hydraulics Research, Wallingford, UK, Pentech Press.

M Chimbari of the Blair Research Laboratory, Harare, Zimbabwe
R J Chitsiko of Department of Agricultural, Technical & Extension Services, Harare, Zimbabwe
P Bolton and A J Thomson of Hydraulics Research, Wallingford, UK.

DESIGN AND OPERATION OF A SMALL IRRIGATION PROJECT IN ZIMBABWE TO MINIMISE SCHISTOSOMIASIS TRANSMISSION

M Chimbari, R J Chitsiko, P Bolton, A J Thomson

SUMMARY

A pilot study was initiated in 1984 on the 600 ha Mushandike Irrigation Project near Masvingo, Zimbabwe, with the objective of developing and field-testing practical guidelines to reduce the risk of schistosomiasis transmission for use by those involved in planning, designing, constructing and operating small-holder irrigation projects in Zimbabwe.

A number of important phases of the project are complete. These include formulating criteria for schistosomiasis control, implementing these criteria within the design and construction processes, establishing regular monitoring of the human and snail populations and introducing micro-computer assisted irrigation scheduling to reduce the likelihood of snail colonisation in parts of the system.

Interim results from the monitoring exercise are now available which enable comparisons to be drawn between different zones of the project and with irrigated land nearby on which control measures have not been introduced. These results indicate that a combination of concrete lining, irrigation scheduling and using innovative control structures on the infield works has had a major impact on the snail hosts. Some disease transmission is, however, occurring in the pilot areas. This is apparently associated with some unsuitable village locations, inadequate access to safe domestic water supplies and enhanced flows in some natural drainage channels.

The paper reviews the recommended control measures in the light of interim results obtained and discusses what modifications to the guidelines may be required and what further studies are needed to establish their effectiveness.

1. INTRODUCTION

1.1 Schistosomiasis and Irrigation in Zimbabwe

Schistosomiasis (bilharzia) is one of the most widespread water-related diseases in tropical regions and is caused by small parasitic worms (schistosomes). In Africa, humans are susceptible to two main forms of the disease in which the worms infect the tissue of the human bladder or bowel respectively. The mature worms produce eggs which pass out of the body in urine or faeces. These eggs hatch into water, producing free-swimming organisms (miracidia) which penetrate certain species of small aquatic snails forming cysts within them from which cercariae, another form of the parasite, are released in large numbers. The life cycle is completed when cercariae penetrate human skin exposed to the infested water. The different forms of the parasite each rely on different species of snail as their intermediate host.

Irrigation has long been recognised as an important factor in promoting increased rates of schistosomiasis transmission in Zimbabwe as in other arid and semi-arid regions (Taylor, 1986). The Department of Agricultural, Technical and Extension Services (AGRITEX) is responsible for the management and operation of approximately 65 small-holder irrigation schemes in Zimbabwe covering a total area of over 4000 ha and supporting almost 6000 farmers either wholly or partially. The department is concerned to find effective methods of reducing the transmission of schistosomiasis on these schemes and is collaborating with the Blair Research Laboratory and Hydraulics Research in a pilot study to assess the contribution which can be made to the control of the disease through careful design and operation of the irrigation system. The pilot study is located at the 600 ha Mushandike Irrigation Scheme 20km south-west of Masvingo.

1.2 The Scope of the Research

In the past, where engineers have taken seriously their responsibility for farmers' health, the preferred method of control for schistosomiasis in irrigation schemes has been the application of toxic chemicals to the water bodies in which the aquatic snail hosts of the disease thrive. This method of control tends to be expensive and, in many cases, has been of limited effectiveness. Nowadays highly effective therapeutic drugs are available to treat the human population and these have been used in mass control programmes. It is acknowledged, however, that engineering and environmental control measures have an important role to play alongside drug therapy in cutting the cost and increasing the effectiveness of disease eradication (see McCulloch, 1986, and Pike, 1987).

In its broadest terms the aim of the research project is to assess the extent to which the transmission of schistosomiasis and the resulting human morbidity, can be reduced by an agreed package of engineering and environmental control measures covering the design, implementation and operation of a typical small-holder irrigation scheme. It was known that members of the population of the project area would already be infected before entering the project. A limited programme of treatment was, therefore, introduced initially to provide a base-line for studies of the disease incidence and subsequently to control morbidity in cases of heavy infection. Its effect must be considered when assessing the impact of the control measures.

The specific objectives of the monitoring programme developed to evaluate the effectiveness of the control measures under these conditions were to measure:

- the distribution of aquatic snails in different water bodies within the scheme;

- the rate of infection of intermediate host snails;

- the incidence of schistosomiasis in a cohort of school children from villages in the scheme;

- the prevalence and morbidity of schistosomiasis within the total human population bearing in mind the treatment given.

The presence, within the scheme selected for study, of different irrigated blocks in which staged introduction of irrigation took place over a four year period enabled comparisons to be made both spatially and longitudinally.

With the final objective in view of providing AGRITEX with guidelines for the control of schistosomiasis in other small-holder schemes, it had been decided not to implement the control measures in any way that would be impossible to replicate within the context of project design and implementation in Zimbabwe. Thus the research team did not interfere unduly in the implementation to ensure that control measures were strictly applied.

1.3 Initiation of the Research Project

In 1985, a thorough review was undertaken of the procedures currently adopted in Zimbabwe for the design and operation of small irrigation schemes. Careful thought was given to ways of reducing the transmission of schistosomiasis by creating conditions in which no aquatic snails could thrive and by preventing the human population from both polluting and coming into contact with potentially infected water. Ideas for improvement, based on the experience of experts from Zimbabwe and the UK as well as a thorough review of the literature, led to a set of Criteria being drafted for the design and operation of the Mushandike Irrigation Scheme (Bolton, 1987). An important consideration in drafting these Criteria was that the recommendations should not deviate significantly from current practice in Zimbabwe and, in particular, that the cost per farmer of the engineering works should not greatly exceed expenditure on other recently developed schemes.

The Mushandike Irrigation Scheme, Figure 1, is in an area of Zimbabwe where both pastoralism and rainfed agriculture are practised but where returns are generally low and unreliable due to poor soils and erratic rainfall. It is located at an altitude of 875m. The annual rainfall total is 615mm, the land has gradients of 1-2% and the soils are variable shallow and, in parts, stony. The scheme, which is supplied by its own reservoirs, had been operated since the 1930s by a small number of settlers using wild flooding. The majority of farms were brought under the Government's Resettlement Programme and have now been extensively redeveloped, to take 400 small-holder families, using funds from the African Development Bank and the Government of Zimbabwe. At the time when this collaborative research project began, planning for the redevelopment at Mushandike was at an early stage.

Designs for the new works were produced by AGRITEX engineers following the agreed criteria, initially under the supervision of an engineer from Hydraulics Research. Implementation took place from 1986 to 1989 with development teams supervised by AGRITEX using the maximum of local semi-skilled labour for the construction work. Before the arrival of the first settlers a field team from Blair Research Laboratory began a regular monitoring programme to collect data on the distribution of the aquatic snail hosts and the incidence of schistosomiasis in the human population. Two farms fed by the Mushandike Dam remained under their previous ownership using irrigation methods which were not governed by the disease control Criteria drawn up. Data collected from these farms provide a comparison against which results obtained from the pilot farms are being judged.

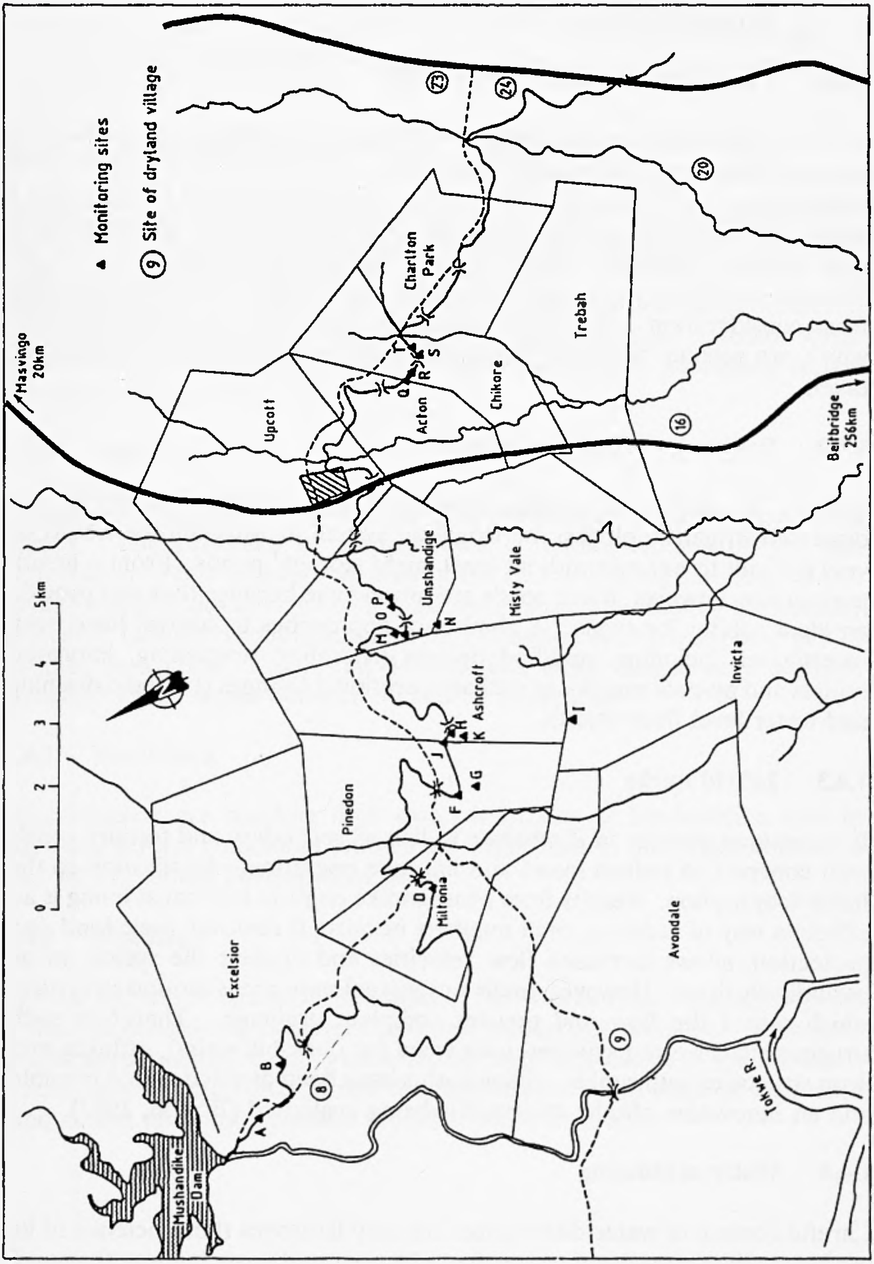


Fig 1 Mushandike Irrigation Scheme:: General plan

1.4 Outline of Control Methods

1.4.1 The water source and main canal

Water for the Mushandike Irrigation Scheme is provided from a reservoir located 10km from the nearest settler village and is not viewed as a source of infection. From the dam the water reaches the irrigated blocks along a main canal which is unlined for much of its 30km length and provides a potential snail habitat. Unfortunately, under the original terms of the redevelopment, project engineering work on the main canal was excluded from consideration. A decision has since been made to line those parts which are seeping badly but no specific snail control measures have been taken.

1.4.2 Reservoirs within the scheme

Because a considerable length of main canal is required to supply the dispersed irrigation blocks, the irrigation system at Mushandike would be very difficult to operate without local 'night storage' ponds. From a health perspective, however, these ponds are unwelcome because they can provide an ideal habitat for snails. A number of approaches to control have been investigated including modified designs (shoreline steepening, improved outlets and by-pass canals), as well as operational changes (periodic draining and water level fluctuation).

1.4.3 Infield works

It is common practice in Zimbabwe to line all secondary and tertiary canals with concrete to reduce losses and improve operation. Application to the fields is by syphon. Results from Mushandike confirm that canal lining is an effective way of reducing snail numbers because it removes their food and protection, allows increased flow velocities and enables the system to be periodically dried. However, snails can still colonise areas around structures which retard the flow and prevent complete drainage. Therefore such structures as inverted syphons, long weirs (or duck-bill weirs), offtakes and drop structures with sunken stilling basins have been avoided where possible and an innovative offtake structure is being evaluated (Bolton, 1987).

1.4.4 Water scheduling

Careful control of water distribution not only improves the efficiency of its use but enables canals and reservoirs to be operated in such a way that snail colonisation is reduced. At Mushandike, careful water scheduling was set as one of the control measures in the Criteria and micro-computer software has been prepared, in spreadsheet format, to enable the irrigation engineer to study alternative operating schedules at different times during the season (see Goldsmith et al, 1988).

1.4.5 Village location

Because of the way in which departmental responsibilities were divided in planning the Mushandike Irrigation Scheme, the irrigation engineers had little influence over the location of the new villages being built for the farmer settlers. Nevertheless, guidelines for village location were considered based on the fundamental Criterion that an adequate 'safe' domestic water supply should be available closer to the houses than any potentially unsafe water source.

1.4.6 Domestic water

Village water supplies are taken from boreholes using locally produced hand pumps. The existence of a number of boreholes already on the site contributed to this decision. In view of the cost of drilling boreholes in this area the authorities have taken a cautious approach in deciding the number required. Official recommendations for Zimbabwe are for one pump per 20 families (see Geza, 1986). At Mushandike most villages have a single borehole which serves between 40 and 50 households.

1.4.7 Sanitation

Householders are building their own pit latrines at Mushandike and, in addition, several communal latrines are being built in the irrigated zone as part of the capital development costs.

1.4.8 Drainage

For the soil conditions and land slopes of the Mushandike Irrigation Scheme it was not considered necessary to install sub-surface drainage. Open field drains were included to carry away storm runoff and excess irrigation water. These were directed into natural drainage channels and areas of uncleared land rather than into specially provided collector drains.

2. THE MONITORING PROGRAMME

2.1 Introduction

A field team comprising two research technicians and various field assistants was established in 1986, under the supervision of professional staff from the Blair Research Laboratory, to monitor the effect that the environmental and engineering control measures would have on the transmission of schistosomiasis as irrigation became established at Mushandike.

The monitoring programme was divided into components listed below which were conducted in the small-holder schemes and partly on a nearby farm (Chikore farm) which used water from the same main reservoir as the small-holder schemes but had a different irrigation system in which no schistosomiasis control measures were incorporated. It was decided to collect some data on Chikore farm in order to find out if schistosomiasis transmission in the intervention area would be at the same level as at Chikore. The components of the monitoring were:

(i) Snail surveys of selected water contact sites mainly on the unlined main canal and on night storage ponds;

(ii) Snail surveys on infield irrigation structures;

(iii) Snail surveys on a natural stream in the study area;

(iv) Cercariometric surveys of selected sites mainly on the unlined main canal and on night storage ponds;

(v) Human parasitological surveys.

The monitoring programme outlined above was not established in its entirety from the start. Changes were made along the way in order to address specific research questions. For this reason, not all data sets cover the full three years of the monitoring period being reported.

2.2 Design and Methodology of Monitoring

2.2.1 Human parasitological surveys and treatment

All individuals coming to settle in the small-holder schemes were screened for S.haematobium and S.mansoni infections soon after their arrival. S.haematobium was diagnosed from urine specimens by the filtration method described by Mott (1982), and S.mansoni was diagnosed from stool specimens by the Kato technique (Katz et al, 1972). All individuals found infected in this first survey were treated with praziquantel at a dose of 40mg kg^{-1} body weight. In surveys that followed only cases excreting more than 100 eggs per 10ml of urine or 100 eggs per gram of faeces and all the people coming to schemes for the first time were treated. The initial treatment was administered in order to avoid importation of schistosomiasis in the schemes and to increase the number of negative cases for incidence studies. Treatment of heavy cases after the initial survey was done on ethical grounds and also to encourage cooperation for the long-term monitoring as people would inevitably refuse to cooperate if they were aware of having symptoms of heavy infection and they were not treated.

The resettlement exercise was much slower than anticipated and therefore the initial parasitological surveys for the different small-holder schemes were conducted at different times. The repeat surveys were initially undertaken at three-monthly intervals but from January 1988 the interval was increased to 12 months. In addition, a cohort study of school children was begun in July 1987 and monitoring is continuing at three-monthly intervals.

2.2.2 Snail surveys

Monitoring of snail populations and their infection rates in the small-holder schemes and in Chikore farm was focused on regular monthly surveys of the selected index sites shown in Figure 1. Additional surveys were made of selected night storage ponds, part of the main canal, a natural stream and the infield irrigation works. Surveys at Chikore were limited to the main canal sites and infield works. Snail sampling was mainly done by the fractional scooping method described by Shiff and Clarke (1967), except for the infield works, where visual snail searches and random scooping were made. All intermediate host snails above 5mm in size were exposed to artificial light to detect mammalian schistosome infections before being returned to the waterbody while non-intermediate host snails were counted and returned to the waterbody immediately. Snails screened for infection were returned to their habitats to ensure minimum interference with the snail population at the sites.

2.2.3 Cercarimetry

Cercarial densities in water were measured by direct filtration at selected sites from January 1987 to March 1989. A 36 1 sample of water was filtered each month at every site. Hamster immersions were also conducted on the same sites in order to identify the species of cercariae. The method is described by Chandiwana (1987).

2.2.4 Definitions

The prevalence and incidence of schistosomiasis in the human population were calculated as:

(i) Prevalence (%) =

$$\frac{\textit{No. of positive cases}}{\textit{No. of people surveyed}} \; x \; 100$$

(ii) Incidence (%) =

$$\frac{\textit{No. of new positive cases}}{\textit{Initial No. of negatives}} \; x \; 100$$

3. RESULTS

3.1 Human Parasitology

There are a number of complicating factors which affect the results of the human parasitology surveys. First, the settlers on the newly developed small-holder blocks have arrived gradually over a period of several years with school children sometimes arriving later than their parents in order to complete studies at their existing schools. Secondly, at Chikore, the private farm where schistosomiasis control measures have not been introduced, the population tends to be rather fluid making incidence studies difficult and includes very few children. Thirdly, the treatment regime, involving treatment of all heavy cases, has an influence on the prevalence of disease especially when monitoring is being undertaken at three-monthly intervals.

Despite these complicating factors a number of significant trends are emerging from the data.

3.1.1 S. haematobium

Figure 2 shows the prevalence in adults and non-school children in the villages associated with Ashcroft, Invicta and Misty Vale blocks and also the Chikore private farm. The initial high prevalences represent pre-treatment

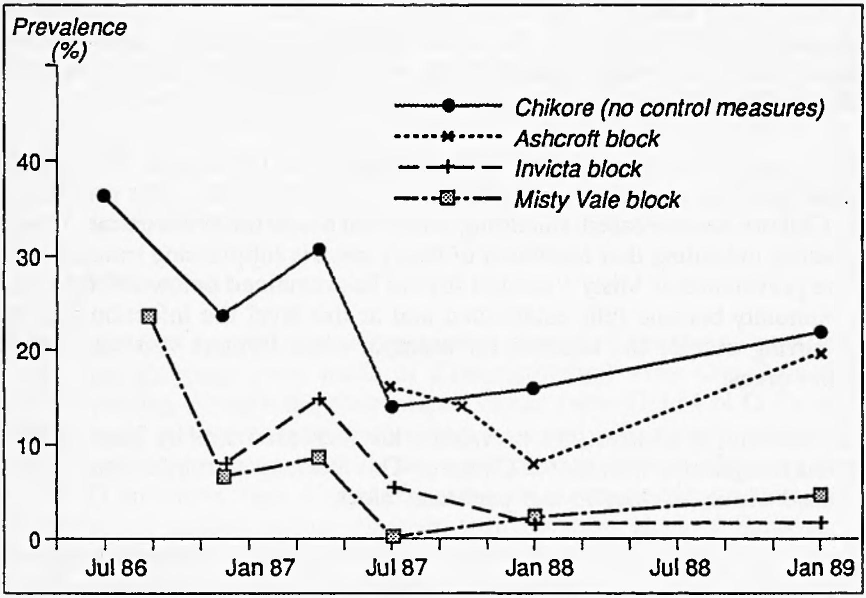


Fig 2 Prevalence of S.haematobium in adults and non-school children

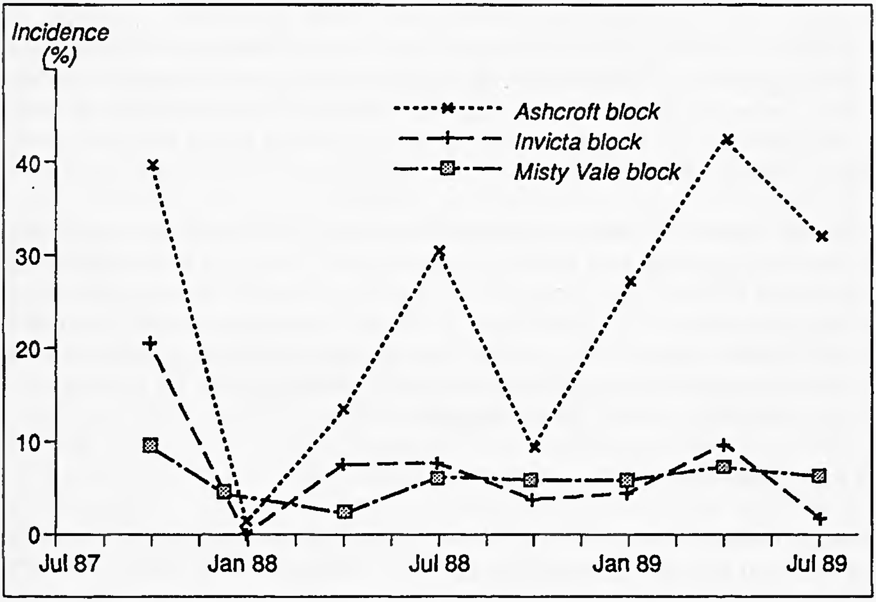


Fig 3 Incidence of S.haematobium in school children

levels. In the case of Chikore the 36% value indicates a typical value under non-improved irrigation in the region whereas the 15-20% values on the other blocks are more typical of the prevalence within the surrounding dryland areas from which the small-holder settlers were taken.

Following blanket treatment with praziquantel, prevalence fell rapidly although new arrivals complicated the picture. Thereafter, the prevalence at Chikore has increased, stabilising somewhat below the pre-treatment level, possibly indicating that treatment of heavy cases is suppressing transmission. The prevalence at Misty Vale and Invicta has remained below 5% once the community became fully established and at this level the infection may be occurring outside the scheme, for example when farmers visit relatives in other areas.

At Ashcroft, by contrast, the prevalence has increased until by January 1989 it was comparable with that at Chikore. This indicates that infection is being caused within or close to this particular block.

Incidence figures are a more reliable indicator of active transmission than prevalence. Unfortunately those for adults are rather incomplete but those for school children (excluding Chikore) are shown in Figure 3 based on a 3-month monitoring interval. Again, transmission appears to be occurring at high rates on Ashcroft with lower rates on the other two blocks. These cohort data suggest that children can be used as a reliable indicator of relative rates of transmission within the whole population, although in absolute terms transmission amongst school children is higher than amongst other age groups. The average prevalence in the period July 1987 to July 1989 amongst school children from the different blocks was: Misty Vale, 7.9%; Invicta, 12.4%; and Ashcroft, 31.3; considerably higher than the values shown in Figure 2 for adults.

For the cohort of school children the intensity of infection is generally rather low (possibly as a result of treating heavy cases on each monitoring occasion), but the higher levels of incidence on Ashcroft are also associated with higher intensities of infection. Of those recorded as positive from the three blocks, the following are the average percentages of children over a two year period with egg outputs exceeding 100 eggs per 10 ml of urine: Misty Vale, 5%; Invicta, 12%; Ashcroft, 22%.

3.1.2 S.mansoni

Both prevalence and incidence data for <u>S.mansoni</u> indicate much lower rates of infection than for <u>S.haematobium</u>. Over the period July 1986 to January

1989 the average prevalence in the different blocks amongst adults and non-school children were: Misty Vale, 0.4%; Invicta, 0.5%; Ashcroft, 0.7%; and Chikore, 6.5%. From this there is no conclusive evidence of S.mansoni transmission occurring on the newly redeveloped land: isolated individuals probably contracted the disease outside the scheme. By contrast, active transmission appears to be occurring at Chikore.

3.2 Snail Surveys

3.2.1 Main canal

In three years of monthly sampling at index sites along the main canal only 12 Bulinus globosus (host snails of S.haematobium) were caught in the reaches passing through the redeveloped blocks (sites H J M N O P), and of these only one was observed shedding cercariae. By contrast, in excess of 600 snails a year were caught in the reach passing through Chikore (sites Q R S T) and more than 12 per year were observed shedding mammalian cercariae. A similar picture emerges with the host snail of S.mansoni, Biomphalaria pfeifferi, being found only three times by the redeveloped land (none of which were observed shedding cercariae), whereas 196 specimens were found by Chikore farm, of which three were observed shedding cercariae. Spot surveys at non-index sites along the main canal have resulted in additional small numbers of both species of host snail being found, especially in the vicinity of Ashcroft.

Since 1989 short reaches of the main canal have been lined with concrete to reduce seepage but it is too soon to tell what effect, if any, this has had on snail colonisation.

Two monitoring sites (A and B) on the main canal close to the main dam (well upstream from the irrigation blocks) were found to be heavily colonised with B.pfeifferi, although numbers observed shedding cercaria were very low.

3.2.2 Night storage ponds

Colonisation of night storage ponds with aquatic snails occurred fairly rapidly after they entered service, although in most cases the snails were of the non-host species Bulinus tropicus. Nevertheless, appreciable numbers of B.pfeifferi have also been caught in the pond at Ashcroft (site K) and a small number of B.globosus have also been found there and at the pond at Misty Vale (site N). None of these were observed shedding cercariae.

3.2.3 Natural stream

A natural stream running between Ashcroft and Misty Vale has become perennial since the start of irrigation on these blocks. This is known to be used by villagers both for washing and as a source of water for brick making. Monthly surveys along the stream were begun in April 1989 revealing a small number of B.globosus and a rather larger number of B.pfeifferi. None of the snails caught were observed shedding cercariae.

3.2.4 Infield works

The lined canals and infield works of the redeveloped land have remained free of aquatic snails, with the exception of one area where duck-bill weirs had to be installed because the gradients were not steep enough to allow the use of free-draining offtakes. Both species of host snail as well as non-host species have been found in duck-bill weir offtakes.

On Chikore, the numbers of aquatic snails regularly found in infield works have been appreciable. The main locations have been in inverted syphons, sumps for the pumps used on areas of sprinkler irrigation, the tail ends of canals where ponding occurs and where canal linings have deteriorated allowing pools to form.

3.3 Cercariometry

Human cercariae have been found regularly in the main canal at Chikore (sites Q and R), but within the redeveloped land only on isolated occasions in the main canal (site L) and in Misty Vale storage pond (site N).

4. DISCUSSION AND CONCLUSIONS

4.1 Effectiveness of Treatment

Praziquantel is an effective treatment for schistosome infection. However, the benefits of blanket treatment are soon lost if this is not combined with other measures. Infection levels can return to pre-treatment or even higher levels after a few years. This can be seen from Chikore and Ashcroft results. Selected treatment of heavy cases for ethical reasons appears to reduce transmission rates but isolating the effects of treatment from those due to the control measures is difficult.

4.2 Effectiveness of Control Measures

The package measures introduced seems to be effective in Misty Vale and Invicta villages at maintaining infection levels of both S.haematobium and S.mansoni well below pre-praziquantel treatment levels. By contrast, at Ashcroft infections with S.haematobium had by January 1989 risen to levels which are comparable with pre-treatment and with infection at the private farm, Chikore. Infection with S.mansoni at Ashcroft, however, remains very low. The package of control measures is aimed at interrupting the life cycle of the schistosome parasites, by:

(a) minimising human-water contact;
(b) trying to prevent faeces or urine entering the water;
(c) diminishing the number of snails.

4.2.1 Minimising human-water contact

In order to reduce human-pathogen contact, wherever possible, settlements (or villages) have been sited sufficiently far away from the main canal and night storage ponds to discourage their use as the main water supply for the village.

Unfortunately, at the planning stage there was insufficient consultation prior to the siting of the boreholes which in turn determined the village locations. As a result, Invicta village has been sited very close to a large night storage pond, and Ashcroft village sited very close to the main canal.

Paradoxically, this may help in identifying the most effective factors for control. Although close a night storage pond, Invicta village is well away from the main canal. The results indicate that of the three villages Misty Vale, Invicta and Ashcroft, re-infection is occurring mostly at Ashcroft. This would tend to indicate that distance from the unlined main canal is more important than distance from night storage ponds at controlling transmission. Snail and cercariae data support the hypothesis that infection is occurring largely at the main canal. However, there is a natural stream near Ashcroft village where, it is suspected, transmission is also occurring: infected snails have been found there.

Chikore, private farm village, is also located close to the main canal. Many intermediate snails were found in this part of the main canal with a number shedding cercariae. The main canal therefore appears to be the main source of transmission in this area as well.

Apart from village location, the other important factor influencing water contact is the availability of a "safe" supply close to or within the village. Although boreholes have been provided for the resettlement villages the number is fairly low (one per 40-50 households), pump breakdowns occasionally occur and users have expressed reluctance to wash clothes in the "hard" water.

4.2.2 Preventing faeces or urine entering the water

The egg to water part of the schistosome life cycle could be significantly reduced if everyone used latrines for urination and defaecating. The provision and use of latrines is therefore a key part in combating disease transmission. The villagers in the new settlements have been provided with cement and other materials to construct a latrine within the land provided to each for housing. Although construction has been slow, most dwellings had a latrine by the end of 1989.

Latrines have been provided in the fields where the farmers and families can spend a large part of the day. In some farms it is a long walk from the fields to the houses. Various layouts have been tried. In Misty Vale, for example, the latrines have been constructed on a grid so that each farmer is never very far away from a latrine. In other farms, the latrines have been built in a line down one side of the fields, usually parallel to the main access road. According to the farm manager, the matrix system seems to be better used.

The parasitological data suggests that the latrines are well used for defaecation as the prevalence of S.mansoni is generally very low in new development areas despite the presence of host snails. However, the persistent high prevalence levels at Chikore private farm point to poor latrine use there. The results show less benefit from latrines in the case of S.haematobium, especially with regard to young children.

4.2.3 Reducing the number of snails

Unfortunately, the design and operation of the main canal have been largely beyond the influence of those engaged in this research. This unlined canal was already in existence and its long length dictates that it must run with a steady discharge 24 hours per day. This method of operation also imposes the need for night storage ponds within the blocks which in other circumstances would have been avoided because of their likelihood of colonisation by snails. Thus snail colonisation in the main canal and night storage ponds had been expected. Monitoring has shown, however, that there are marked differences in the species and rates of colonisation between different reaches of the canal and between different ponds. In the main canal, colonisation appears to be influenced not only by environmental factors but also by the degree of human water contact since the sites most frequently used for washing and bathing are also the sites most heavily colonised by the host snail species.

In the night storage ponds design factors, such as shore-line steepness, and operational factors, such as the rate of drawdown, the frequency of draining and the frequency of weed clearance, are emerging as important parameters but further data are required before conclusions can be drawn as to whether effective snail control can be achieved through a combination of these factors.

The operational hydrology of the ponds also depends on the demand of water for irrigation and the way in which scheduling is undertaken. This also affects the pattern of discharges and draining in the infield channels and the flow of water into the drainage channels. The effect of the scheduling procedures being applied at Mushandike on the snail ecology in the storage ponds is still being assessed, although farmer reaction to the schedules has been favourable making their adoption easier.

The infield canal systems within the new development farms have been designed specifically to discourage snail colonisation. The canals are fast flowing and the various structures free-draining. Comparisons of snail survey results between the new development farms and Chikore private farm, where water ponds permanently in places, is encouraging. In the infield works of the new development farms, very few snails have been found. The periodic drying out of each section of canal is believed to be a significant factor in controlling snails.

However, drawing conclusions from direct comparisons with the private farm, where irrigation has been practised for many years, may be premature. Deterioration of structures with time is likely to result in increased ponding, and more data over a longer period is therefore required.

4.3 Suitability of the Research Method

The pilot study at Mushandike is probably unique in that a package of control measures aimed at reducing schistosomiasis transmission has been introduced in the implementation of an irrigation scheme without additional financial resources or operational staff and has been monitored for a period of over three years. The results are, therefore, of direct relevance to other irrigation projects implemented under similar circumstances.

Unfortunately, the choice of this approach imposes constraints on the research team which complicate the interpretation of the results. Amongst these the most significant are the inability to establish a direct, scientifically controlled comparison between intervention and non-intervention ares, the protracted period over which settlers arrived on the different blocks of the project, the different criteria applied in selecting farmers to different blocks (experienced farmers being preferred initially), the slow rate of implementation of particular project components (household latrines and the lining of the main canal in particular) and the time taken for a regular pattern of human behaviour and cultivation practices to become established.

There has been much debate within the research team as to the extent to which they should become involved in ensuring that the agreed control Criteria are adopted. It is clear that the cause of the S.haematobium transmission which is being observed at Ashcroft can in part be traced to a failure to apply the Criterion regarding village location. Likewise, the area of infield works where snails have been found is one in which duck-bill weir offtakes have been used against the advice to use free-draining structures. Whilst acknowledging the importance of adhering to the Criteria, it is necessary to look more closely at the reasons why particular Criteria have not been applied in such instances since the fault may lie with the Criteria and not with the implementing agency. This can be readily demonstrated in the case of the duck-bill weirs since the free-draining offtake offered as an alternative cannot be used in areas of shallow land gradient. A suitable structure for use in such situations must, therefore, be devised if duck-bill weirs (or long weirs) are to be avoided.

Thus it can be seen that some of the difficulties which have been experienced by the research team in monitoring the effectiveness of the control measures scientifically may, in fact, be a major strength of the research method. They have led to a detailed questioning which goes beyond the biological effects of particular control measures to include an assessment of their appropriateness for widespread application within the constraints of project implementation and operation applying within the pilot project.

4.4 Generalising the Control Measures

The adaptive approach discussed above whereby control measures may be modified to accord more closely with what can feasibly be achieved under the constraints of the chosen type of irrigation development tend to make the conclusions rather location-specific. The work at Mushandike has, for example, been criticised as not being transferable because of the fact that infield canals are concrete lined; a practice which is widespread in Zimbabwe to improve water regulation and reduce seepage but is considered too costly in some other countries in the region.

Similarly, it may be argued that the recommendations arising from Section 4.2.1, that villages should be located as far from the main canal as possible, may apply only due to the particular circumstances of this scheme; for example, because the main canal has to date been largely unlined or because it must carry a constant discharge 24 hours a day. Criticism of this nature is justified and the authors would be the first to caution anyone against lifting results uncritically from this paper and seeking to generalise them. On the other hand, the combination of data collected on human parasitology, snail ecology, cercarial densities and human behaviour, much of which could not be presented in detail here, provides the basis for a thorough understanding of the epidemiology of schistosomiasis transmission on this scheme which will, in due course, allow general conclusions to be drawn.

At this stage the most important conclusion which the authors wish to stress is that, although transmission of S.haematobium is almost certainly occurring at Ashcroft at a level comparable with the transmission on the private farm, Chikore, where no intervention has occurred, this should not be taken as a general indictment of engineering control measures of this nature. Indeed, the fact that the longer-established Misty Vale block is maintaining a very low level of infection so close to this source of transmission may indicate the opposite. This can only be judged following a further period of monitoring.

What is clear, however, is that schistosomiasis being so location-specific in its transmission, there can be no half measures with regard to engineering or environmental control. Inattention to certain details of an agreed package of control measures may result in levels of transmission comparable with those which would have occurred if no intervention had been attempted.

Final conclusions from the Mushandike study will not be available for another year. Further monitoring is continuing in particular to learn more about the effect of various design and operating parameters on snail colonisation in the main canal and night storage reservoirs and to investigate more closely the distribution of snails in the infield works and natural drainage streams. With this additional information it is believed that a more realistic set of guidelines for reducing schistosomiasis transmission in small holder irrigation schemes in Zimbabwe can be developed.

5. ACKNOWLEDGEMENTS

It is not possible to list the large number of individuals who have contributed to this research in many ways over the past five years, but particular mention must be made of the contributions of Mr S Pazvakavambwa, Dr S K Chandiwana, Ms P D Ndhlovu and Mr A J Draper. The dedicated work of the field staff from the Blair Research Laboratory and the interest and cooperation shown by the staff of AGRITEX and the Department of Rural Development are gratefully acknowledged. Financial support was provided by the UK Overseas Development Administration through the Overseas Development Unit of Hydraulics Research.

REFERENCES

Bolton, P., (1987) Investigation of measures suitable for schistosomiasis control on small holder irrigation schemes in Zimbabwe, in W O Wunderlich and J E Prins, eds, Water for the Future, A A Balkema, Rotterdam, 285-293.

Chandiwana, S K., (1987) Technique to detect schistosome cercariae in natural water through exposure of sentinel hamsters, *J Parasitology*, 73, 452-454.

Geza, S., (1986) The role of resettlement in social development in Zimbabwe, *J Social Development in Africa*, 1, 35-42.

Goldsmith, H., Bird, J D., and Howarth S E., (1988) Computerised irrigation scheduling using spreadsheet models, *Irrigation and Drainage Systems*, 2, 211-227.

Katz, N., Chaves, A., and Pellegrino, J., (1972) A simple device for quantative stool thick smear technique in S mansoni, *Revista do Instituto de Medicina Tropicale de Sao Paolo*, 14, 397-400.

McCulloch, F., (1986) Snail control in relation to a strategy for reduction of morbidity due to schistosomiasis, *Tropical Medicine and Parasitology*, 37, 181-184.

Mott, K E., (1982) Control of schistosomiasis: morbidity reduction and chemotherapy, *Acta Leidensia*, 49, 101-111.

Pike, E G., (1987) Engineering against schistosomiasis/bilharzia, Macmillan, London.

Shiff, C J., and Clarke, V de V., (1967) The effect of snail surveillance in natural waterways on the transmission of S haematobium in Rhodesia, *Central African J Med*, 13, 133-137.

Taylor, P., (1986) The importance of schistosomiasis in Zimbabwe with particular reference to irrigation schemes, in Schistosomiasis Control at Mushandike Irrigation Scheme: Proceedings of Seminar, Report OD 88, Hydraulics Research.

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 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.

Technical Centre for Agricultural and Rural Co-operation (CTA)
The Technical Centre for Agricultural and Rural Co-operation (CTA) was established in 1983 under the Lomé Convention and is based in Ede-Wageningen in the Netherlands. Its mandate is to help the African, Caribbean and Pacific countries which comprise the ACP group achieve greater food security by providing them with better access to scientific and technical information on all issues related to agricultural and rural development. Working in close cooperation with ACP and EEC countries and with international, regional and national institutions, CTA fulfils its mandate through a range of activities, including seminars, studies, publications and support to ACP documentation centres.

The ODI Irrigation Management Network is sponsored by **The Overseas Development Administration** (ODA), 94 Victoria Street, London SW1E 5JL; and **The Ford Foundation**, 320 E 43rd Street, New York, NY 10017, USA.

CTA

The African Edition of Irrigation Management Network is sponsored by the ACP-EEC Technical Centre for Agricultural and Rural Co-operation (CTA), Postbus 380, 6700 AJ Wageningen, The Netherlands

© Overseas Development Institute, London, 1991. Photocopies of any part of this publication may be made without permission. (Requests for commercial reproduction of Network material should be directed to the copyright holders.)

CTA

This African edition is sponsored by the Technical Centre for Agricultural and Rural Co-operation (CTA), Postbus 380, 6700 AJ Wageningen, The Netherlands

odi

Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England
Telephone: (071) 487 7413
Telex: 94082191 ODIUK
Fax: (071) 487 7590

IRRIGATION MANAGEMENT NETWORK

NEWSLETTER

April 1992

Agricultural Administration Unit
Overseas Development Institute

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 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 required to provide their own publications in exchange, if possible. This creates the library which is central to information exchange.

The ODI **Irrigation Management Network** is sponsored by:

The Overseas Development Administration (ODA)
94 Victoria Street
London SW1E 5JL
UK

The Ford Foundation
320 E 43rd Street
New York
NY 10017
USA

IRRIGATION MANAGEMENT NETWORK NEWSLETTER

April 1992

Contents *Page*

Network papers in this set:

Credits

Editor:	Linden Vincent
Assistant Editor:	Lorna Campbell
Secretary:	Amanda Barton

Photocopies of all or part of this publication may be made providing that due acknowledgement is made. Requests for large-scale reproduction of Network material should be directed to ODI as copyright holders. The Network Editor would appreciate receiving details of any use of this material in training, research or programme design, implementation or evaluation.

ISSN: 0951 1881

IRRIGATION MANAGEMENT NETWORK NEWSLETTER

April 1992

1. NEWS FROM THE IMN

We have received a large number of membership forms for re-registration, and I would like to thank all of you who have sent in papers and information on your work. We have had a large response, so please be patient in your expectation of longer replies! If you have not sent back your membership form, please do so immediately. We hope to be mailing the new *Register of Members* in September.

We plan to have a special section in the Autumn Newsletter summarising the research information set. We are also amending the focus of the Autumn set of papers because of the diversity of papers received. We will be editing together replies to our mailshot on 'irrigation and poverty alleviation'. However, we will also have more papers on assisting local farmers, and looking at design, technology and management options for different socio-economic conditions.

The Irrigation Management Network *Répertoire des Membres Francophones, Décembre 1991,* is now available. The Register lists details of 250 french-speaking Network members undertaking work and research in Africa.

We held a joint Lunchtime Meeting with the Agricultural Research and Extension Network in January for UK members. Dr Margaret Quin (Chief Agriculturalist of Huntings Technical Services) gave a talk on 'Irrigated Agriculture on the Lower Indus Right Bank, Pakistan: Evidence of Ways to Improve Rice and Wheat Production without Structural (Engineering) Inverventions'. Presenting some of the findings from studies undertaken in 1989-90, she argued that much could be achieved by non-structural interventions which centre upon better field management of fertilisers and water, and improvements in the supply of agricultural inputs.

2. NETWORK PAPERS FOR DISCUSSION

The papers in this edition examine some of the issues in schemes where agencies are currently working with farmers in irrigation management, and the ways they work with farmers. They look at both government agency and NGO work, and at some initiatives in the 'turn over' of programmes from state to farmer management.

The first paper in the set is comprised of two contributions from Indonesia, looking at the issue of 'turn over' of schemes. Bryan Bruns and Sudar Dwi Atmando discuss the process developed in Indonesia to hand back management and development of irrigation systems to farmers in *How to Turn Over Irrigation Systems to Farmers? Questions and Decisions in Indonesia*. Detail is then given of how an Indonesian NGO cooperated with the government agencies to develop and implement these processes in *From Practice to Policy: Agency and NGO in Indonesia's Programme to Turnover Small Irrigation Systems to Farmers* by Bryan Burns and Irchamni Soelaiman.

In *Variation in Interventions, Variation in Results: Assistance to FMIS in Nepal*, Ganesh Shivakoti reviews the successes and problems of a range of implementing agencies in Nepal. These agencies have varied in their approach to farmer involvement in irrigation design and operation, producing different results.

In the third paper, *The Equity Impact of Deep Tubewells: Evidence from the IDA Deep Tubewell II Project*, Mark Aeron-Thomas summarises the results of a quantitative study on the impact of deep tubewells on income of different farm size groups in Bangladesh.

News from the Field continues the new initiative, started in the previous set, of combining a number of shorter contributions from Network members. Two contrasting initiatives to valley development are discussed in Rwanda (Dr M Loevinsohn) and Malawi (Dr C P Mzembe), and Dr Taha El Tayeb Ahmed summaries progress in aquatic weed control in the Gezira Scheme, Sudan.

3. NEWS FROM NETWORK MEMBERS

Professor Lucas Horst is retiring from his post in the Department of Irrigation and Soil and Water Conservation, Wageningen Agricultural University, The Netherlands. However, he will still be undertaking work in association with the Department, and can continue to be contacted there. We wish him every success in his new role.

Are you interested in software for irrigation schemes? Tom Sheng and David Molden have developed a database management system for storing and retrieving data to assist managers in planning and decision-making. It is being tested on minor irrigation systems in Maharashtra and can be used for a variety of data including water needs, water distribution to local sectors, crop data and billing information. If you would like a copy of their paper, write to them at Computer Assisted Development Inc, 1635 Blue Spruce Drive, Suite 101, Fort Collins, Colorado 80524, USA.

The International Irrigation Management Institute (IIMI) is recruiting an Irrigation Specialist for the Institute's country programme in Sri Lanka. The Irrigation Specialist will work closely with the Irrigation Department to plan, establish and develop a Research Management Unit with the Department and assist in developing its plans, procedures and policies. If you are interested, send your curriculum vitae and the names of three references to the International Recruitment Consultant, IIMI, PO Box 2075, Colombo, Sri Lanka.

IMPSA (Irrigation Management Policy Support Activity) is publishing a series of ten Policy Papers, the first three of which have just been released. IMPSA is a USAID-funded programme to assist the government of Sri Lanka in the development and implementation of its participatory management policy in irrigation and settlement schemes, in order to improve productivity and profitability in the agricultural sector. IMPSA aims to develop specific policy statements and suggest implementation strategies to expand on and fill the gaps in the current broad policy framework. Paper 1 looks forward, addressing irrigated agriculture issues in the next decade, especially management issues and policies for participatory management. Paper 2 covers institutional policies for developing farmers' organisations, and Paper 3 tackles the issue of improving performance in operation and maintenance, rehabilitation and modernisation of schemes. For further details contact Dr N G R de Silva, Director, IMPSA Secretariat, 107 Havelock Road, Colombo 5, Sri Lanka. Tel: (94)1-508000, Fx: 508008.

A slide-tape presentation *Coping with Inland Salinity and Waterlogging* (with reference to India) has just been completed. This was produced by Louis Berger International Inc/ Water and Power Consultancy Services (India) Ltd, with the assistance of the Central Soil Salinity Research Institute, Karnal, India. Copies are being distributed to training and educational institutes throughout India and to some international agencies.

Winrock International Institute for Agricultural Development have published results from their first African Rural Social Sciences programme in *Issues in African Rural Development*. From the collection of papers, two are on irrigation in Nigeria; *Efficiency of Agricultural Production in Small- and Medium-Scale Irrigation in Nigeria* by Saa Dittoh, and *Efficiency of Resource Use in Rice Production Systems in Anambra State, Nigeria* by Macaulay A Olagoke. Broader agricultural topics are covered in Ethiopia, Ghana, Liberia, Malawi, Nigeria and Tanzania. Universities or organisations interested in Winrock International funding for research in the rural social sciences field in Africa should contact Ms Vicki Walker, Programme Assistant, Centre for Economic Policy Studies, Winrock International, 1611 North Kent Street, Suite 600, Arlington, VA 22209, USA. Tel: (1)703-525 9430, Fx: 525 1744, Tx: 6491106 WIDC UW.

WHO/UNESCO have published an update, *Water Resources Assessment (WRA)*, on Progress in the Implementation of the Mar del Plata Action Plan and a Strategy for the 1990s. The report establishes the current state of water resources assessment activities globally, and progress made since the UN Water Conference in 1977. These assessments provide the foundation for a UN strategy for water in the 1990s and beyond. WRA is a continuous, long-term activity to support water resources management that is sustainable into the future.

***Water Management News* is the new title of the former *Irrigation Management Newsletter*.** The change in name of this quarterly newsletter reflects the expanding focus of the Water Resources Management and Training Programme (WRMTP). The publication reports on WRMTP activities, primarily in India, in surface irrigation, river basin studies, snow hydrology, and environmental concerns related to water development. If you wish to be added to the mailing list contact Water and Power Consultancy Services (India) Ltd, 213 Ansal Chambers II, 6 Bhikaiji Cama Place, R K Puram, New Delhi 110 066. Tel: (91)11-608587.

Tushaar Shah has published a review paper on *Water Markets and Irrigation Development in India.* This can be obtained from the Institute of Rural Management, PO Box 60, Anand 388 001, Gujarat, India.

A newsletter on groundwater contamination has been developed for Latin America. If you want to receive *Boletin de Informaciones de la Red Latinoamericana de Programas de Prevención de Contaminación de Aguas Subterráneas,* write to RED, Casilla 183, Cochabamba, Bolivia.

Do you receive *Recherche Développement*? The recent edition (No 13) juin 1991, focuses on *'Les Périmètres Irrigués'* with information on Cameroon, Senegal, Burkina Faso, Zimbabwe, Mali and Madagascar, including discussions on state disengagement. Contact Bulletin d'information du réseau recherche-développement, GRET, 213 rue La Fayette, 75010 Paris, France.

A new newsletter, *Farmer Irrigation*, is available from an Indonesia NGO as an English translation, produced for irrigation developers outside Indonesia. In particular it focuses on experiences in farmer participation and state disengagement. Contact the Centre for Irrigation Development and Studies (PSPI-LP3ES), Jalan S Parman 81, Slipi Jakarta 11420, Indonesia. Tel: (62)251-597211/12/13, Fx: 598785.

The Global Applied Research Network (GARNET) for Water Supply and Sanitation, is being coordinated through WASH (Water and Sanitation for Health Project). It is designed to facilitate information sharing on applied research in the water and sanitation sector around the world. It is not an institution or information centre, but a mechanism to develop and strengthen information exchange. For details on the issues covered and participating organisations write to Dan Campbell, WASH Project, Office of Health, Bureau for Science and Technology, USAID, Washington 20523, USA.

Interested in agricultural policy analysis? Then write for *APAP II Technotes.* This newsletter covers all agricultural sectors worldwide. Vol 3(2) focuses specifically on irrigation investments in Asia, with articles on Thailand, Indonesia and Sri Lanka. It can be obtained from APAP II, Abt Associates Inc, 4800 Montgomery Lane, Suite 600, Bethesda, Maryland 20814, USA. Tel: (1)301-913 0500, Fx: 652 7791. Read these together with the comments from *OED Précis* which follow.

Do you work in the humid tropics? The following newsletter may be of interest to you. The Operations Evaluation Department (OED) of the World Bank published two audit reports on Indonesia and Thailand in 1989 and 1990 respectively. These are summarised in the publication *OED Précis*, December 1991, which debates design issues in the humid tropics arising from these audits. Opinions differ about the role public irrigation has played in the dramatic increases in rice production achieved by Indonesia and Thailand over the last two decades and for the future, about what role public irrigation schemes should be expected to play in achieving food security in the rice-growing tropics. The two audits by OED remain agnostic on these questions, but they stress how powerfully Bank lending has been affected by belief in a direct causal link between public irrigation investments and increased rice production. They note that large resource transfers for irrigation, followed up by almost no monitoring of project performance, have perpetuated the use of unsuitable engineering designs, operating under circumstances where they cannot work effectively. Neither country has succeeded in making public irrigation systems work as designed. Over two decades the Bank has financed twenty one irrigation operations in Indonesia, for about US$ 2 billion (1987 prices).

These views may be controversial to those who have recently worked to improve design initiatives, construction quality, and improved monitoring and evaluation in these countries. For a copy of *OED Précis*, December 1991, write to Rachel Weaving, T7-015, World Bank, 1818 H Street NW, Washington DC 20433, USA. If you wish to comment, please let us know.

A Programme for the Humid Tropics, researching water-related issues and problems of the humid tropics and other warm humid regions, is being implemented under IHP (International Hydrological Programme). Four regional centres for Latin America and the Caribbean, Africa, Asia, and one for special problems of small islands, are being established to serve as focal points for network activities and knowledge and technology transfer activities. For further information write to UNESCO, Division of Water Sciences, International Hydrological Programme, 7 place de Fontenoy, 75700 Paris, France. Tel: (33)1-4568 3999, Fx: 4567 5869.

Nosa A Egharevba is presently engaged in research work on the effects of groundwater table on evapotranspiration demand of the wheat crop. He would be grateful for information on related research or field experience from Network members. Contact him at the Department of Agricultural Engineering, Federal University of Technology, PMB 65, Minna, Nigeria.

4. PUBLICATIONS RECEIVED

Aviron Violet, J., Ido, B D., van Steekelenburg, P N G., and Waldstein, A. (1991) ***The Development of Irrigated Farming in the Sahel. Irrigation Policy Limitations and Farmer Strategies.*** **ILRI, PO Box 45, 6700 Wageningen, The Netherlands**
This report provides a review on irrigated farming strategies in Sahelian countries, and the successes and dilemmas of their planning institutions in developing irrigation. It was commissioned by the Club du Sahel and CILSS, to review development and change since the first assessment made by them in 1979. Chapters include: statistical data for Sahelian countries; changes in options for investment and cooperation at the national, sub-regional and international level; and an analysis of ways forward for irrigated farming in the region.

Ball, C., and Ball, M. (1991) ***Water Supplies for Rural Communities.*** **IT Publications, London, UK.**
This study draws on the experience of VSO personnel who have worked in rural water supply projects in countries and regions such as Nepal, Malawi, Kenya and the Pacific. There is a clear correlation between poverty and lack of access to sufficient clean water, and community development in a water project can encourage self-reliance. This book pinpoints the practices which are likely to result in successful water supply through community participation and the use of appropriate technology. In particular, it confirms the importance of health education and good sanitation, and underlines the crucial rôle that good water supplies can play in the balanced and effective development of small rural communities.

Clarke, R. (1991) ***Water: The International Crisis.*** **Earthscan Publications Ltd, London, UK.**
Only 3% of the world's water is freshwater and about one third of that is inaccessible; the rest is very unevenly distributed. Terrible and permanent water stress can be seen in the drylands of Africa caused not just by drought but by poverty leading to poor land-management and overpopulation. This book describes the world's freshwater shortage and examines both the economics and the politics that have led to it. Many of the world's major rivers supply several countries with the bulk of their water and the author looks at the fragile treaties arranged around these supplies. He considers the likelihood of resource wars breaking out over water control, and he looks at the ways in which the development of poor countries is affected by water availability. In the face of an international crisis which few have

considered seriously, this book is hopeful. There are solutions, many of them simple and well tried; they must be extended and used to ensure water security for the whole world.

Curtis, D. (1991) ***Beyond Government: Organisations for Common Benefit.*** **Development Studies Series, Macmillan Education Ltd, UK.**
The central theme of the book is that privatisation is not the only answer to the ineffectiveness of 'big government'; people do organise themselves. How do people organise for their common benefit? The extensive case material presented in this book shows that a variety of successful arrangements have been worked out. Where people cooperate to obtain a common good, sharing solutions have to be found. This applies, for example, to the management of complex irrigation systems, the financing of community schools and clinics as well as to the modern industrial firm. Chapters 5 and 8 specifically discuss examples in irrigation in Nepal, Kenya and Sri Lanka. The implications for political philosophy and development strategy are explored in the later chapters of the book.

Hydrology for the Water Management of Large River Basins, **Proceedings of the Vienna Symposium, August 1991. IAHS Publication No 201, 1991.**
The selection of papers published by the International Association of Scientific Hydrology includes: hydrometeorlogical predictions in the Sudanese Nile Region; water resource developments on the Mekong River; modelling of the regional hydrologic effects of climate change; changes in the hydrological cycle due to global warming; sediment transport from the upper Nile Basin; and water resource management in Sudan.

Krimmel, T., et al. (1990) ***Towards an Institutionalisation of Monitoring and Evaluation of Project Impact. The Example of Projects in the Small-Scale Irrigation Sector in West Sumatra, Indonesia,*** **Schriftenreihe des Fachbereichs No 130. Verlag Josef Margraf Scientific Books, Germany.**
This report is the result of a three-month mission by an interdisciplinary research team from the Centre for Advanced Training in Agricultural Development (CATAD), Technical University of Berlin.

Mathur, P C., and Gurjar, R K. (eds) (1991) ***Water and Land Management in Arid Ecology.*** **Rawat Publications, Jaipur, India.**
This volume on the social ecology of water and land management is based in Thar aridlands. It provides analytical and descriptive evidence about the eco-developmental challenges arising from canal irrigation. Policy planners cannot afford to ignore these issues in the long-term, however impressive the

short-term economic cost-benefit analyses may be. The book seeks to fill the conceptual and empirical void about a territory already experiencing the consequences of public policies framed with great hopes, but little field data and negligible feedback responses.

Reddy, M. V. (1990) ***Dynamics of Irrigation Water Management.*** **Ashish Publishing House, New Delhi, India.**
A major challenge for irrigation systems in India is the management of water to ensure adequate, timely and dependable supply for the entire culturable command areas. It is often held that the performance of major irrigation systems is poor when the objectives and goals are not realised. Therefore, the desirability of promoting major irrigation is debated. This seems to have happened due to a mismatch between the theory and practice of irrigation management. This study examines some of the dynamics involved in theoretical nuances of water use, distribution, localisation pattern, and other related factors in a major irrigation system. The views of farmers and irrigation officials, often neglected, have been sought. The conjunctive use of water is discussed at length and the relative merits of rotational water supply are highlighted.

Sengupta, N. (1991) ***Managing Common Property. Irrigation in India and the Philippines,*** **Indo-Dutch Studies on Development Alternatives 6. Sage Publications, New Delhi, India.**
In this book Professor Sengupta establishes that farmer participation is both feasible in practical terms and has proved beneficial wherever applied. He develops a theoretical model through presentation of an irrigation situation where many farmers benefit from a single irrigation source. Investigations help him identify all the conditions that determine the possibility and nature of cooperation. The theoretical results are supported by thirteen intensive case studies drawn from India and the Philippines, representing different types of irrigation system - traditional or modern, canal and communal. In conclusion he outlines the support measures which are necessary for the formation and improvement of water users' associations.

Somashekhar Reddy, S T. (1991) ***Forfeited Treasure: A Study on the Status of Irrigation Tanks in Karnataka.*** **Prarambha, Bangalore, India.**
Tanks have historically played an important role in irrigation in India. They have been neglected as a result of traditional institutions which cared for the tanks, being by-passed during development of large irrigation schemes. The author explains, after an in-depth study, the harm caused to tanks

themselves and to the environment by their rapid siltation. Suggestions are made for rehabilitation and maintenance of the tanks.

Small, L E., and Carruthers, I. (1991) *Farmer-Financed Irrigation: The Economics of Reform*, Wye Studies in Agricultural and Rural Development. Cambridge University Press, UK.
The fiscal crises that faced the governments of many countries in the developing world during the 1980s focused attention on the shortcomings of existing policies for financing irrigation, particularly with respect to the recurrent costs involved in maintaining an irrigation operation. In this atmosphere, many argued for a greater reliance on the implementation and collection of user fees, despite the fact that the institutional and policy environments prevailing in many countries would lead to user fees becoming just another undesirable tax burden on the farmer.

The authors examine in detail the potentials and limitations of user fees for financing irrigation operation and maintenance. They draw on both of their extensive field experience in irrigation in developing countries, combining this experience with simple concepts of economics. Thus, they examine possible institutional and financial reforms which would not simply ask farmers to pay for an inadequate irrigation service, but would create the potential for significant improvements in the quality of the service provided. The proposed elements of any such reform are discussed in depth: a system of user fees covering the recurrent costs of irrigation; a financially autonomous irrigation agency that can retain and use the fees to operate and maintain the irrigation facilities; and a macro policy environment that is not unduly skewed against the agricultural sector.

Throughout the book the authors draw on their original studies. The findings of Small's studies were originally presented in L E Small., M S Adriano., and E D Martin (1986) *Regional Study on Irrigation Service Fees: Final Report* (2 Vols), submitted to the Asian Development Bank by IIMI, Sri Lanka. More recently, they have been published together with some related case studies in L E Small., M S Adriano., E D Martin., R Bhatia., Y K Shim., and P Pradhan (1989) *Financing Irrigation Services: A Literature Review and Selected Case Studies from Asia*, IIMI, Colombo, Sri Lanka. The reference to those that Carruthers worked on is Carruthers, I., et al, Devres, Inc *Irrigation Pricing and Management*, Report submitted to USAID (Contract No OTR-0091-C-00-4466-00).

Uphoff, N., Ramamurthy, P., and Steiner, R. (1991) *Managing Irrigation: Analysing and Improving the Performance of Bureaucracies*. Sage Publications, New Delhi, India.
Increasing attention has been focused on how the participation of farmers in irrigation management can improve the efficiency, equity and overall performance of irrigation systems in developing countries. A crucial factor in performance that has received less attention is the structure and performance of irrigation agencies that are responsible for managing many or most of these systems in developing countries.

This book addresses this crucial but neglected element in the equation of successful system operation. The authors start from the premise that irrigation management is best regarded as a socio-technical enterprise, where the human dimension interacts with the technical and physical ones. They delineate twelve activities which must be performed in all systems by managers and/or water users. They suggest a series of practical means for improving the way irrigation bureaucracies operate and manage at all levels organise work, incentives and communication. In conclusion, the authors present three frameworks for improving the performance of irrigation bureaucracies: socio-technical analysis, institution building, and institutional development.

van Schendel, W. (1991) *Three Deltas: Accumulation and Poverty in Rural Burma, Bengal and South India*, Indo-Dutch Studies on Development Alternatives 8. Sage Publications, New Delhi, India.
The book is based on an exhaustive comparison of three rural societies in Asia between the 1750s and 1980s. It provides a detailed analysis of the historical development of relations of 'primary' surplus extraction in Lower Burma, Bengal, and the Kaveri delta in southern India. The author's analysis reveals that these relations, which differed markedly in each of the three regions during the pre-colonial period, did not converge after they were incorporated into the single colony of British India. After the colonial power left, stagnation and increasing mass poverty in these three deltas continued to be predicated upon quite different relations of accumulation.

Vennetier, P. (ed) (1991) Eau et amenagement dans les tropicales, Vols 1 and 2 (published as *Espaces Tropicaux* Vols 3 and 4). Paris: Centre d'études de Géographie Tropical (CEGET), Centre National de la Recherche Scientifique, 54 Boulevard Raspail, 75006, Paris, France.
These two volumes provide a cross-section of papers on Francophone research in water management in the tropics, with a strong representation

from African locations. Volume 1 collects papers on the impacts of dam developments (Africa general, Togo-Benin, Burkina Faso, Brazil), and developments in wetland environments along coasts and in valley bottoms (Senegal, Rwanda, Madagascar, Indonesia, New Caledonia). Volume 2 looks at environments where more standard irrigation development has taken place (West Africa, Cape Verde, Réunion, Mauritius, Martinique, India, Mexico, Hawaii). It also incorporates papers on urban water supply which complement the first volume in the *Espaces Tropicaux* series on the peri-urban environment.

5. SHORT REPORTS AND ARTICLES RECEIVED

Abderrahman, W A., and Shahalam, A B M. (1991) Reuse of Wastewater Effluent for Irrigation in Severely Arid Regions: Alternative Schemes - a Case Study, *Water Resources Development* 7(4): 235-246.

Abu-Zeid, M. (1991) Physical Features and Drainage Priorities in Egypt, *Water Resources Development* 7(3): 146-153.

Adams, W M. (1991) Large Scale Irrigation in Northern Nigeria: Performance and Ideology, *Trans Inst Br Geogr NS 16: 287-300.*

Alam, M. (1989) Water Resources of the Middle East and North Africa with Particular Reference to Deep Artesian Groundwater Resources of the Area, *Water International* 14: 122-127.

Alauddin, M., and Tisdell, C. (1991) The Green Revolution and Labour Absorbtion in Bangladesh Agriculture: The Relevance of the East Asian Experience, *Pakistan Development Review* 30(2): 173-188.

Almeida, M Geralda de. (1991) Secheresse au Nord-est du Bresil: Parallelisme avec la situation qui prevaut au Sahel. (Centre Sahel serie notes et travaux No 23). Quebec, Canada: Centre Sahel, Universite Laval, 28 p.

Angeles, H L., Agulto, I C., Marzan (Jr) E G., and Coloma, P S. (1990) The Farmer as Irrigators' Organiser: Lessons from the BPEPIS Experience, *An ISMIP Monograph*. Irrigation System Management Improvement Programme, Dept of Agricultural Engineering, Central Luzon State University, Muñoz, Nueva Ecija 3120, Philippines.

Anstey, T H., Foroud, N., and Jame, Y W. (1991) Evaluating Water Requirements for Crops: A Review, *ICID Bulletin* 40(1): 1-12.

Asian Productivity Organization., and Sharma, B R. (eds) (1991) Farm-Level Irrigation Water Management, Report of a study meeting in Lahore, Pakistan, 7-18 February 1989. Tokyo, Japan: Asian Productivity Organization.

Awadalla, S., and Noor, I M. (1991) Induced Climate Change on Surface Runoff in Kelantan, Malaysia: A Preliminary Assessment, *International Journal of Water Resources Development* 7(1): 53-59.

A Workshop Design for Community Participation: Starting Work with Communities, and Planning and Implementing Sustainable Projects, *WASH Technical Report* No 33, Vols 1 and 2.

Berkoff, D J W. (1990) Irrigation Management on the Indo-Gangetic Plain, World Bank Technical Paper No 129. Washington DC, USA: World Bank, xii, 53 p.

Bezdina, S Y. (1991) Using Drainage Water for Irrigation, *ICID Bulletin* 40(1): 13-20.

Bhattarai, L N. (1992) GIS Technology in Projecting the Results of the Action Research Project on FMIS in Indrawati River Basin of Sindhupalchowk District, Nepal. Mimeo from author at Water and Energy Commission Secretariat, Kathmandu, Nepal, 15 p.

Biswas, A K. (1991) Water for Sustainable Development in the 21st Century: A Global Perspective. Presidential address for 7th World Congress in Water Resources, Rabat, Morocco, 13 May 1991, 15 p.

Boko, M. (1991) Valuation and Forecast of Climatic Risks in Hydroagricultural Settlements Management, *International Journal of Water Resources Development* 7(1): 60-63.

Branney, P., and Connelly, S. (1990) Irrigated Forestry in Northern Sudan, *Technical Reports*. Northern Region Irrigation Rehabilitation Project (Forestry Component). London: Overseas Development Administration.

Carney, J. (1991) Indigenous Soil and Water Management in Senegambian Rice Farming Systems, *Agriculture and Human Values* 8(1 and 2): 37-48.

Carney, J., and Watts, M. (1991) Disciplining Women? Rice, Mechanization and the Evolution of Mandinka Gender Relations in Senegambia, *Signs: Journal of Women in Culture and Society* 16(4): 651-681.

Claassen, E., and Salin, P. (1991) The Failure of Morocco's Development Strategy for Irrigation Development, in E Claassen and P Salin *The Impact of Stabilization and Structural Adjustment Policies in the Rural Sector: Case Studies of Cote D'Ivoire, Senegal, Liberia, Zambia and Morocco.* FAO Economic and Social Development Paper No 90. Rome: FAO, 175-198.

Cleveland, D A., and Soleri, D. (1991) Food from Dryland Gardens: An Ecological, Nutritional and Social Approach to Small-Scale Household Food Production. Tuscon, Arizona, USA: Centre for People, Food and Environment, 387 p.

Curtis, D. (1992) Development Intervention in Farmer-Managed Irrigation in Nepal, DAG Papers in the Administration of Development No 40. Birmingham, UK: Development Administration Group, Institute of Local Government Studies, University of Birmingham, 92 p.

Deshpande, R S. (January 1990) Irrigation: Impact on Employment and Income: Study of Krishna Raja Sagar Project, *Agricultural Situation in India*, pp 797-802.

Diemer, G., and Speelman, J J. (1992) Incorporating the Local Economy and Polity in the Conceptual Design of Farmer Managed Irrigation Schemes: A Case Study from the Senegal River Valley. Wageningen and Saint-Louis: WARDA - Water Management Project.

Ditton, S. (1991) Efficiency of Agricultural Production in Small and Medium Scale Farmers in Ogun State, Nigeria, in C R Doss and C Olson (eds) *Issues in African Rural Development* 1991. Arlington, USA: African Rural Sciences Research Networks, Winrock International Institute for Agricultural Development, pp 152-174.

Duchhart, I., and Povel, S. (1991) Landscape Analysis: A Design Tool for Sustainable Irrigation Development. An example from South-West Kano, Kenya, *Irrigation and Drainage Systems* 5: 191-212.

El-Ashry, M.T. (1991) Policies for Water Resource Management in Semiarid Regions, *Water Resources Development* 7(4): 230-234.

Essiet, E U. (1990) A Comparison of Soil Degradation under Smallholder Farming and Large-Scale Irrigation Land Use in Kano State, Northern Nigeria, *Land Degradation and Rehabilitation* 2(3): 209-124.

Fadl, O A A. (1991) Hydro-Agricultural Schemes and their Effects on Agricultural Production and Environment: The Case of the Irrigation in Sudan Gezira, in R Dellere and J J Symoens (eds) *Seminar on Intensification of Agriculture and the Environment*, Brussels, 5-6 June 1990, organised by CTA and Royal Academy of Overseas Students, 79-89 p.

Fraval, P. (1991) Problèmes de santé et d'environnement au niveau des petits projets d'irrigation dans le nord du Nigéria, *Bulletin de Liaison du Comité Interafricain D'Etudes Hydrauliques*, No 84-85: 72-85.

Groenfeldt, D. (1991) Building on Tradition: Indigenous Irrigation knowledge and Sustainable Development in Asia, *Agriculture and Human Values* 8(1 and 2): 114-120.

Haworth, J. (1991) Malaria in Man: Its Epidemiology, Clinical Aspects and Control: A Review of Recent Abstracts from Tropical Diseases Bulletin and Abstracts on Hygiene and Communicable Diseases, July 1988-June 1990, *Tropical Diseases Bulletin* 88(10): 80 p.

Hirji, R., and Ortolano, L. (1991) EIA Effectiveness and Mechanics of Control: Case Studies of Water Resources Development in Kenya, *Water Resources Development* 7(3): 154-167.

Hoek, B van den., Zanen, S., and Deng, P L. (1985) Social-Anthropological Aspects of the Jonglei Development Projects in South Sudan. Leiden, Netherlands: Institute for Cultural Anthropology, 108 p.

Hoerner, J M. (1977) L'eau et l'agriculture dans le sud-ouest de Madagascar, *Madagascar Revue de Geographie* 30: 63-104.

Hufschmidt, M M., and Kindler, J. (1991) Approaches to Integrated Water Resources Management in Humid Tropical and Arid and Semiarid Zones in Developing Countries, *Technical Documents in Hydrology*, IHP/UNESCO.

Hufschmidt, M M., and McCauley, D S. (1991) Strategies for Integrated Water Resources Management in a River/Lake Basin Context, Working Paper No 29. Honolulu, Hawaii, USA: Environment and Policy Institute, East-West Centre.

Iijima Shigeru. (1985) The Significance of Wet Rice Cultivation for Swidden Cultivators: The Case of the Karens, *East Asian Cultural Studies* 24(1-4): 93-96.

Ishag, K., Thornton, D., Tiffen, M., and Upton, M. (1991) Farm Location and Farmers' Performance on the Hamza Minor Canal, *International Journal of Water Resources Development* 7(1): 2-15.

Ittissa, A B. (1991) Toward a New Philosophy on Operation and Maintenance, *Waterlines* 10(2): 25-28.

Izac, A-M Z., Swift, M J., and Andriesse, W. (1990) A Strategy for Inland Valley Agroecosystems Research in West and Central Africa, *RCMP Research Monograph* No 5, Resource and Crop Management Programme, IITA, Nigeria.

Johansson, S. (1991) Ecological Implications for Tana River Basin Forestry and Irrigated Agriculture, in P T W Baxter (ed) *When the Grass is Gone: Development Initiatives in African Arid Lands*, Seminar Proceedings No 25. Uppsala, Sweden: Scandinavian Institute of African Studies, 115-140 p.

Jurriens, R. (October 1991) Irrigation Problems in India: A Matter of Water? Mimeo from author at ILRI, Wageningen, Netherlands, 14 p.

Kirmani, S S. (1991) Managing Indus Water: A Whole Basin Approach, *IIMI Review* 5(1): 5-8.

Kirpich, P Z. (1990) Foreign Aid for Irrigation Development, *ICID Bulletin* 39(1): 39-48.

Kolawole, A. (1991) Water Resources Development Projects in Nigeria: Farmers' Responses, *Water Resources Development* 7(2): 124-132.

Lansing, J S. (1987) Balinese Water Temples and the Management of Irrigation, *American Anthropologist* Vol 89: 326-341.

Lee, T R. (1990) Managing Water Resources in Latin America, *Natural Resources Journal* Vol 30: 581-607.

Long, R B. (1991) Short Run Marginal Returns from Irrigation Water, *International Journal of Water Resources Development* 7(1): 39-44.

Mahendrarajah, S., and Warr, P G. (1991) Water Management and Technological Change: Village Dams in Sri Lanka, *Journal of Agricultural Economics* 42(3): 309-324.

Mather, T H. (March 1989) Assessment of Progress in the Implementation of the Mar Del Plata Action Plan, and Formulation of a Strategy for the

1990s: Asian Pacific Region: Agricultural Water Use. Mimeo Mission Report (for FAO), 115 p.

McTaggart, W D. (1988) Hydrologic Management in Bali, *Singapore Journal of Tropical Geography* 9(2): 96-111.

Mohtadullah, K. (1991) A Plan for all Seasons (Pakistan's Water Sector Investment Planning Study), *IIMI Review* 5(1): 9-14.

Morgan, D. (1991) Efficient Irrigation, *African Farming* July 29-33 August 1991.

Mosselmans, G., van Driel, W., and Durand J M. (1991) Etude de la Gestion des Petits Périmètres irrigués gravitairement: expérience du Burkina Faso; (a) La distribution de l'eau; (b) L'organisation, la formation et l'encadrement des exploitants; (c) Le système de production, *Bulletin de Liaison du Comité Interafricain d'Etudes Hydrauliques* No 84-85: 2-34.

Muller, A M., and Hollingworth, B. (1991) Water Resources, Economics and the Future of Irrigation in Southern Africa - A Perspective. Paper presented at Southern Africa Irrigation Symposium, Durban 4-6 June 1991.

Nickum, J E. (draft 1991) *Major Irrigation Management Issues in China*, based on a November 1987 ADB Consultant's Report. Honolulu, Hawaii, USA: East-West Center.

Nickum, J E. (draft 1991) *Institutional Arrangements for the Sustainable Use of Natural Resources*, Prepared for Presentation at the Commemorative

Programme for the 20th Anniversary of the United Nations Centre for Regional Development Programme III, Matsusaka, Japan, Nov 1991. Honolulu, Hawaii, USA: East-West Center.

Nickum, J E. (1990) Volatile Waters: Is China's Irrigation in Decline? in T C Tso (Ed) *Agricultural Reform and Development in China - Achievements, Current Status and Future Outlook*, Chapter 19, Sixth Colloquium Proceedings.

Orr, A., Nazrul Islam, A S M., and Barnes, G. (1991) The Treadle Pump: Manual Irrigation for Small Farmers in Bangladesh. Dhaka, Bangladesh: Rangpur Dinajpur Rural Service, 96 p.

Ouedraogo, J B., and Quedraogo, D. (1984) Aménagement hydrauliques et hydro-agricoles et santé au Burkina Faso, *Notes et Documents Burkinabes* 15(4): 31-39.

Palmer, M D., and Duder, J N. (1991) Regulation Storage for Mini Hydro Schemes, *Water Resources Journal* March 1991: 81-84.

Perrier, E R., and Salkini, A B. (1991) Supplemental Irrigation in the Near East and North Africa. Proceedings of a Workshop on Regional Consultation on Supplemental Irrigation, organised by ICARDA and FAO, Rabat, 7-9 December 1987. Dordrecht, Netherlands: Kluwer Academic Publishers, 611 p.

Philipps-Howard, K D., and Schoeneich, K. (1992) The Irrigation Potential of Water Resources on the Jos Plateau: A Preliminary Analysis, Jos Plateau Environmental Resources Programme Interim Report No 27. Durham, UK: Department of Geography, University of Durham, 21 p.

Piepho, H P., and Alkamper, J. (1991) Effects of Integrated Rice-cum-Fish Culture and Water Regime on Weed Growth and Development in Irrigated Lowland Rice Fields of Northeast Thailand, *Journal of Agronomy and Crop Science* 166: 289-299.

Prasad, K., and Rao, P K. (1991) On Irrigation Water Pricing in India, *Water Resources Development* 7(4): 274-280.

Pradhan, N. (1989) Gender Participation in Irrigation System Activities in the Hills of Nepal, in Proceedings of 2nd Annual Workshop on Women in

Farming Systems, 27-29 September 1989, sponsored by Institute of Agriculture and Animal Science and USAID, pp 31-57.

Pradhan, N C., and Gautam, U. (1990) Irrigation and Environment: A Farmer-Managed Irrigation System Perspective. Mimeo prepared for seminar on Traditional Water Harvesting Systems in India, organised by Centre for Science and Environment, held in New Deli, India 9-11 November 1990, 14 p.

Raby, N. (1991) Participatory Management in Large Irrigation Systems: Issues for Consideration, *World Development* 19(12): 1767-1776.

Ramanathan, S. (1991) Rajasthan's Sorrow. A report on a workshop on the Indira Gandhi Canal, held in February 1991, *Economic and Political Weekly* August 3-10: 1842-1844.

Rao, P S. (1991) A Note on the Proceedings of the IFPRI/IIMI Seminar on Indicators of Irrigation Performance, IFPRI, Washington, USA, 18-19 March 1991. Mimeo, 13 p.

Rijks, Derk., and Gbeckor-Kove, N. (1990) Agrometeorological Information for Effective Irrigation Scheduling, published in *Acta Horticulturae* 278: 833-840.

Safadi, R., and Plusquellec, H. (1991) Research on Irrigation and Drainage Technologies: Fifteen years of World Bank Experience, World Bank Discussion Paper No 128. Washington DC, USA: World Bank, 56 p.

Sangal, S P. (1991) Pricing of Irrigation Waters in India, *Economic and Political Weekly* 26(46): 2645-2651.

Scott, A. (1991) Power and People: Aspects of Micro-Hydro, *Waterlines* 10(2): 11-14.

Serrano, V M B L., and Carter R C. (1991) Small Scale Irrigation in Angola: Potential and Promise, *Outlook on Agriculture* 20(3): 175-181.

Setting New Rules for Water Allocation in Hawaii and the American West: A Symposium. November 26, 1990, Project Paper. Honolulu, Hawaii, USA: Environment and Policy Institute, East-West Centre.

Smout, I. (1990) Farmer Participation in Planning, Implementation and Operation of Small-Scale Irrigation Projects, *Water Resources Journal SER C/167*, Economic and Social Commission for Asia and the Pacific.

Special issue of the role of small watershed hydrology in rainfed agriculture: A workshop held from 22-24 November 1988 at ICRISAT Centre, India, *Indian Journal of Dryland Agricultural Research and Development* 1988 3(2).

UNECLAC. (1990) Management for the Development on High Mountain River Basins in the Andean Region, UNECLAC Report LC/G 1533. New York, USA: United Nations Economic Commission for Latin America and the Caribbean, 225 p.

Webb, P. (1991) When Projects Collapse: Irrigation Failure in The Gambia from a Household Perspective, *Journal of International Development* 3(4): 339-353.

WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control. (1987) Effects of Agricultural Development on Vector-Borne Diseases. Rome, Italy: FAO, pp 82-86.

6. CONFERENCE AND WORKSHOP REPORTS

***Bas-fonds and Rice Cultivation Conference*, Tananarive, Madagascar, 9-14 December 1991**

A *bas-fond* is a small, flat-bottomed valley or depression, located between the tropics, 20-500 m wide, with low-velocity seasonal water flow.

Bas-fonds account for approximately 2.5% of the land available for rice cultivation worldwide, being 11% in sub-Saharan Africa, and 42% in Madagascar. The focus of the Conference was to discuss improved utilisation of this underdeveloped land area, so contributing to greater food security. Some 100 participants attended from Madagascar, Guinea Conakry, Mali, Burkina Faso, Senegal, Ghana, Cote D'Ivoire, Togo, Nigeria, Burundi, Rwanda, Philippines, China, France, Belgium and Germany. The Conference presentations were framed around five themes: *bas-fonds* and the human environment; *bas-fonds* and the physical environment; physical chemistry and microbiology of rice soils, the rice environment and rice physiology; agronomy and varietal improvement; and, *bas-fonds* and local distribution works. Proceedings are available from Michel Raunet, CIRAD/IRAT, Centre CIRAD, BP 5035, 34032 Montpellier CEDEX, France. Tel: (33)67-615943, Fax: 615988, Tlx: 480 762.

***Performance Measurement in Farmer Managed Irrigation Systems*, Mendoza, Argentina, 12-15 November 1991.**
This conference was organised jointly by IIMI and INCYTH (Instituto Nacional de Ciencia y Tecnica Hidricas). Its purpose was to raise debate on objectives for performance measures, criteria that can be used, and how information generated can be used in assistance or internalised by water users. The conference papers were in Spanish and English, and will have an important role in information exchange.

A wide range of papers were presented from Argentina, Mexico, Peru, Ecuador, Bolivia, Colombia, India, Pakistan, Nepal, Sri Lanka, China, Philippines, Indonesia, Tanzania, Senegal, Egypt, Portugal and Israel. They fell largely under three themes:

1. Studies on the institutional structures that have made farmer managed irrigation systems (FMIS) work and remain farmer managed. These are important in maintaining the role of existing FMIS and designing new interventions.

2. Criteria against which agency support options can be identified and their interventions assessed, including both socio-economic and technical criteria. Several papers looked only at examples of poor performance, whereas others did incorporate baseline data to evaluate interventions and discussed successes and failures in agency action.

3. Action to increase the level of farmer participation and responsibility in operations and maintenance. Descriptions of policies to 'turn over' management duties, and assess their impact was a strong theme. Papers from the Philippines looked at local adoption of self-monitoring as a component of programmes to both encourage better production gains to farmers and strengthen water organisations to levels where they can adopt increased agricultural responsibilities on the wide front.

For information on the Proceedings, contact Shaul Manor at IIMI, PO Box 2075, Colombo, Sri Lanka, Tel: (94)1-565601, Fx: 562919, Tx: 22318 IIMI HQ CE.

***Designing Irrigation Structures for Mountainous Environments*, Kathmandu, Nepal, 13-17 January 1992.**
This workshop was organised jointly by IIMI and ICIMOD (The International Centre for Integrated Mountain Development).

Participants presented information from Nepal, Indonesia, Philippines, India, Peru, China, Pakistan and Ethiopia. The focus of the workshop was exchange of experience on common design challenges in mountainous environments, following many problems in the extension of inappropriate technology from schemes in lowland locations. The papers raised many technical issues linked both to site problems and to the dynamics of mountain geomorphology and hydrology. Examples covered stream intake structure, conveyance issues, local distribution and drainage issues. Accompanying debate also touched on the problems of collecting relevant hydrological and geotechnical data to aid relevant design. For more information on the Proceedings, write to Jim Lenahan, Head of Information at IIMI.

7. FUTURE CONFERENCES AND WORKSHOPS

18-22 May 1992, Delft, The Netherlands
International Symposium on *Transboundary River Basin Management and Sustainable Development*. For further details contact Professor J Wessel, RBA-Centre, Kanaalweg 2B, 2628 EB Delft, The Netherlands, Tel: (31)15-783565/784066, Fx: 787105.

18-21 May 1992, Dhaka, Bangladesh
South Asian Regional Workshop on *Groundwater Farmer-Managed Irrigation Systems and Sustainable Groundwater Management*. The workshop is part of the FMIS Network Programme supported by IIMI. Sessions will be organised on aquifer and drawdown issues, sustainability of groups as groundwater irrigation managers, and the adequacy of irrigation support services to groundwater FMIS. For further information write to Shaul Manor, FMIS Network Coordinator, IIMI, PO Box 2075, Colombo, Sri Lanka. Tel: (94)1-565601/12, Fax: 562919, Tx: 22318 IIMI HQ CE.

15-19 June 1992, Gaborone, Botswana
International Symposium on *Groundwater in Arid and Semi-arid Regions*. Contact E Selado, Geological Survey Department, Private Bag 14, Lobatse, Botswana. Tel: (267)-330327, Fx: 332013, Tx: 2293 BD.

5-9 July 1992, Chengdu, China
International Symposium on *Erosion, Debris Flows and Environment in Mountain Regions.* Contact Dr Shang Xiangchao, Institute of Mountain Disasters and Environment, Chinese Academy of Sciences, PO Box 417, Chengdu, Sichuan 610015, China. Tel: (86)-581260-562, Fx: 582846.

24-28 August 1992, Oslo, Norway
International Symposium on *Erosion and Sediment Transport Monitoring Programmes in River Basins.* Details from Jim Bogen, Hydrology Department, Norwegian Water Resources and Energy Administration, PO Box 5091, Majorstua, N-301 Oslo 3, Norway, Tel: (47)2-959595, Fx: 959000.

13-15 October 1992, Manila, Philippines
Asian Regional Workshop on the *Inventory of Farmer-Managed Irrigation Systems and Management of Information Systems*, organised jointly by IIMI and the German Foundation for International Development (DSE). Write to: Shaul Manor, FMIS Network Coordinator, IIMI, PO Box 2075, Colombo, Sri Lanka. Tel: (94)1-567404, Fx: 566854, Tx: 22318 IIMI HQ CE.

20-23 October 1992, Jerusalem, Israel
The First Israeli/Palestinian *International Academic Conference on Water* will cover water resources conflicts between Israelis, Palestinians and others in the area, and approaches to their solution. For further information write to Dr Jad Isaac, co-Chairman, Applied Research Institute, PO Box 860, Bethlehem, Via Israel. Fax: (972)2-741889, or Professor Hillel Shuval, co-Chairman, Truman Institute for the Advancement of Peace, The Hebrew University of Jerusalem, Jerusalem, Israel. Fax: (972)2-322545/666804.

April 1993, Lahore, Pakistan
International Seminar on *Environmental Assessment and Management of Irrigation and Drainage Projects for Sustained Agricultural Growth.* A call for papers has been issued for submission by May 1992. Contact Dr M Latif, Secretary, Organising Committee of the International Seminar, Centre of Excellence in Water Resources Engineering, University of Engineering and Technology, Lahore 54890, Pakistan. Fax: (92)42-337344.

30 August - 12 September 1993, The Hague, Netherlands
15th International Congress on *Irrigation and Drainage: Water Management in the Next Century.* Contact Secretary-General, International Commission on Irrigation and Drainage, 48 Nyaya Marg, Chanakypuri, New Delhi 110021, India. Tel: (91)11-3016837, Tx: 031 65920 ICID IN.

8. TRAINING COURSES

The 5th *Annual Compendium of International Short Courses, Workshops and Conferences in Irrigation Management and Related Subjects* is being assembled under the Water Resources Management and Training Project in India. Last year 300 courses in 35 countries were listed. Distribution is by request. Contact Thomas O Kajer, Training Specialist, WRM & T Project, Louis Berger International Inc, 213 Ansal Chamber II, 6 Bhikaji Cama Place, R K Puram, New Delhi 110 066, India.

The Institute of Irrigation Studies, University of Southampton runs a range of MSc and short courses in irrigation planning and management, engineering and conservation aspects of irrigation. The short courses offered this year are *Rehabilitation and Management of Irrigation Projects*, 18 May - 25 July 1992, and *Effective Irrigation Management: Setting Targets, Monitoring Performance and Achieving Objectives*, 28 September - 16 October 1992. For information contact Mrs J Morris, Administrative Assistant, Institute of Irrigation Studies, University of Southampton, SO9 5NH, UK. Tel: (44)703-593728, Tx: 47661 (a/b sotonu), Fx: 677519.

The Department of Agricultural Economics, Wye College, University of London, is continuing its External Programme with distance learning materials. It will also be mounting an extended short course programme using these materials. These are overseas, in-country, professional updated courses for 10 or more participants. Specialised courses offered include *Economics of Water Resources*. Enquiries to The Registrar, Wye College, Ashford, Kent TN25 5AH, UK. Tel: (44)233 812401, Fx: 813320, Tx: 94017832 WYEC G.

The Department of Land and Water Management, Larenstein International Agricultural College, The Netherlands now offers a four year BSc in *International Land and Water Management*. The programme covers both technical and socio-economic aspects of land and water management in rural development. Contact Larenstein International Agricultural College, Laarweg 6, PO Box 9001, 6880 GB Velp, The Netherlands.

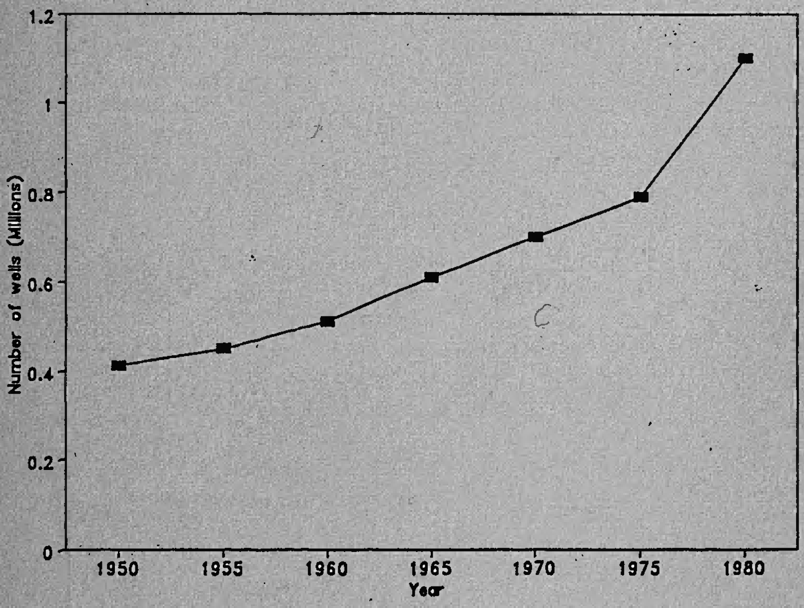
CEFIGRE organise courses in French and English, which will be of interest to engineers, water management and environmental protection executives. CEFIGRE is conducting these activities mainly in the fields of water resources, urban water supply and sanitation, rural development (water, sanitation, irrigation), environmental management, and institutional development. Countries hosting their courses include Thailand, Cote D'Ivoire, Burkina Faso, Niger, Cameroon and France. Write to CEFIGRE, Sophia Antipolis, BP 113, 06560 Valbonne Cedex, France. Tel: (33)92-945800; Fx: 93-654402; Tx: 461 311 F.

For courses run by the Water, Engineering and Development Centre (WEDC), write to Loughborough University of Technology, Leicestershire LE11 3TU. Tel: (44)0509-222885; Fx: 211079; Tx: 34319 UNITEC G.

9. ERRATA

In Network Paper 3/October 1991 (*Assessment of Conjunctive Use in Maharashtra Minor Irrigation Systems* by M M Sawant, R E Barrett, D J Molden and T S Sheng), we failed to include Figure 1 as refered to in the text on page 16. We apologise for any inconvenience caused.

Figure 1: Progressive Well Development in Maharastra



Overseas Development Institute
Regent's College, Inner Circle,
Regent's Park, London NW1 4NS
England.
Telephone: +44 71 487 7413
Telex: 94082191 ODIUK
Fax: +44 71 487 7590